STUDENTS' HANDBOOK

Department of Chemistry

GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR

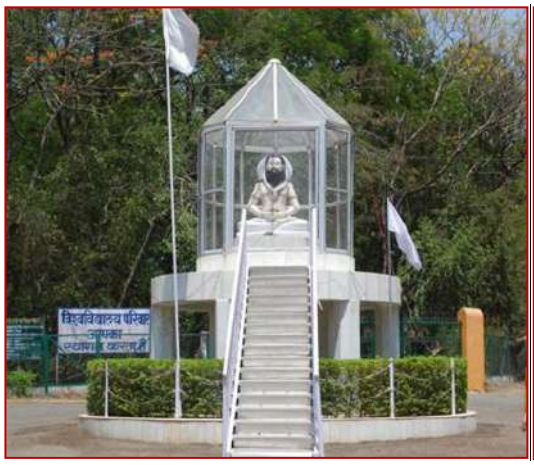
CHHATTISGARH

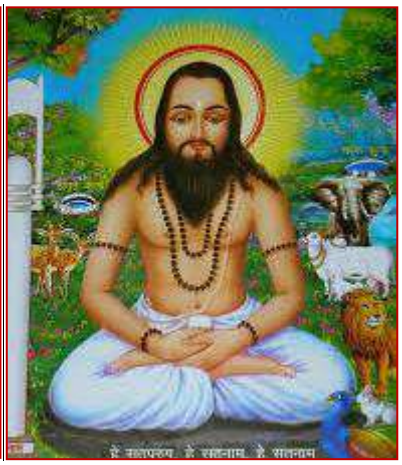
About The University

Guru Ghasidas Vishwavidyalaya is a Central University of India, located in Bilaspur C.G. State, established under Central Universities Act 2009, No. 25 of 2009. Formerly called Guru Ghasidas University (GGU), established by an Act of the State Legislative Assembly, was formally inaugurated on June 16, 1983. GGU is an active member of the Association of Indian Universities and Association of Commonwealth Universities. The National Assessment & Accreditation Council (NAAC) has accredited the University as B+. Situated in a socially and economically challenged area, the university is appropriately named to honor the great Satnami Saint Guru Ghasidas (born in 17th century), who championed the cause of the downtrodden and waged a relentless struggle against all forms of social evils and injustice prevailing in the society. The lush green sprawling campus of the university spread over an area of 875 acres is located 5 KM away from the main Bilaspur town, the city of Bilasa. The river Arpa, the lifeline of Bilaspur runs parallel to the University campus.

The city is well connected with all parts of the country by road and rail. Being a railway Zone, Bilaspur facilitates travel by train to and from any part of the country. Raipur, the capital of Chhattisgarh is only 120 KM away.

The University is a residential cum affiliating institution, having its jurisdiction spread over Bilaspur Revenue Division of the state of Chhattisgarh. The university covers almost total spectrum of higher education and offering various courses in area of Arts, Commerce, Education, Engineering and Technology, Law, Humanities, Life Sciences, Management, Pharmacy, Physical Sciences, and Social Sciences.





Department Profile

The Department of Chemistry has been established in 2009 as a new Science Department with the objective of providing quality education in the conventional areas of science and growing into a centre for teaching and research with an aim to acquire prominent position in the academic map of India. The Department offers both UG and PG level advanced courses in Chemical Sciences along with an integrated 5 years Master programme with exit option after completing 3 years B. Sc. (Hon's). The Department is also offering a Ph. D. Programme in different areas in Chemistry. There are four major specializations offered in M. Sc. such as Analytical Chemistry, Physical Chemistry, Inorganic Chemistry and Organic Chemistry. The students are monitored and evaluated by regular class tests, seminars, assignments, mid and end-semester examinations. The Department has 15 teaching faculty, including Professor (02), Associate Professors (02) and Assistant Professor (11).

The department has two laboratories possessing necessary and sufficient chemicals, reagents, glassware, lab wares and basic instruments for performing experiments in Physical, Inorganic, Organic and Analytical Chemistry, in general, and synthesis, analysis (qualitative and quantitative) and characterization of different inorganic and organic compounds in more particulars.

The departmental library has the sufficient number of books and fulfils the requirement of the faculty members and students. A number of reference books and access to online journals are also available in the Central Library.

The soul of the Department is its their teachers headed by Prof. G. K. Patra. The faculty members specialized in frontier areas of Chemical Sciences and have excellent expertise in their own fields. The faculty members of the Department have significantly contributed to the scientific world through scientific and research publications and have received many distinguished national and international awards and fellowships such as JSPS Postdoctoral Fellowships, ORISE, USA Postdoctoral Fellowship, NSC, Taiwan Postdoctoral Fellowship, BK21 and KOSEF postdoctoral

Fellowship, South Korea. A few faculty members are on the editorial boards of some journals and are referees for both national and international journals.

We Welcome You To Our Department

Faculty Profile

Prof. G. K. Patra
Professor & Head
Research Interest: Inorganic and Supra- molecular Chemistry, MOFs, Crystal Engineering, Electrochemistry

Email: patra29in@yahoo.co.in

Phone: 75873-12992, 94333-78801

Prof. Charu Aurora
Professor
Research Interest: Environmental Chemistry, Nanomaterials, Natural Product Chemistry

Email: charuarora77@gmail.com

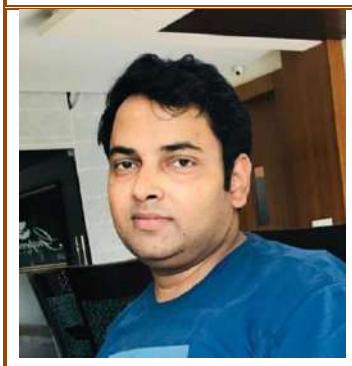
Phone: 7587709551

Dr Sunil K. Singh
Associate Professor

Research Interest: Biodegradable Natural Polymer Composites, Environmental Pollution and GreenSynthesis.

Email: singh.skumar@gmail.com

Contact No: 9406214262



Dr Ashish Kumar Singh
Associate Professor

Research Interest: Inorganic Chemistry, Catalysis, hydrogen energy, chemical sensors, electrochemical water splitting, oxygen reduction reaction

Email - ashish.bhuchem@gmail.com

Contact No.- 9450209554

Dr Bhaskar Sharma
Assistant Professor

Research Interest: Organic-polymer synthesis, Enzymatic and chemo-enzymatic assisted reactions, Polymers derived from biorenewables resources, Silicone-containing polymers, Polymers for drug delivery, Controlled radical polymerization, Non-isocyanate routes to polyurethanes.

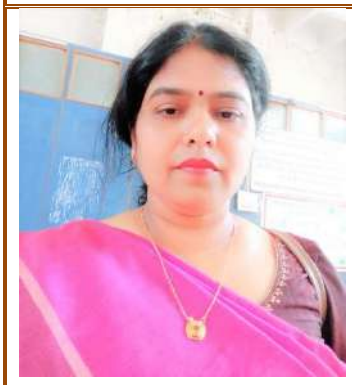
Email - bsharma05@gmail.com

Contact No.- 79991-82918

Dr. Santosh Singh Thakur
Assistant Professor

Research Interest: Organometallic Chemistry, Asymmetric Catalysis,
Computational Density Functional Theory etc.

Email: santosh.chirality@gmail.com
Phone: 99812-09738

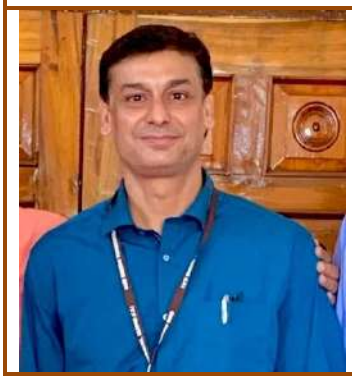


Dr Arti Srivastava
Assistant Professor

Research Interest: Polymer Synthesis by Free Radical polymerization (FRP) and controlled Radical polymerization (CRP) methodology, Graft and Copolymers Synthesis, Polymeric composite Synthesis, Drug delivery kinetics study etc.

Email: reach2arti@yahoo.co.uk

Phone: 74899-65977

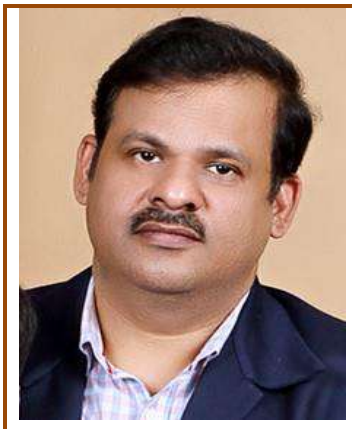


Dr Subhash Banerjee
Assistant Professor

Research Interest: • Green Synthesis, Nano-Catalysis, Heterogeneous Catalysis, On-Water Synthesis

Email: ocrb2009@yahoo.com

Phone: 8827516177



Dr Vijai K. Rai (on lein)
Assistant Professor

Research Interest: Heterogeneous Catalysis using nano-materials, Visible-Light Induced Organic Reactions, Stereo-controlled Construction of C-C and C-Hetero Bond, Small & Medium Ring Heterocyclic Syntheses, Homogeneous Catalysis, Ionic Liquids, Organocatalysis.

Email: vijaikrai@hotmail.com

Phone: 8827516191

Dr Manorama
Assistant Professor

Research Interest: Electroanalytical Chemistry, Nanocomposites, Electrochemical sensors/biosensors, Electrocatalysis, Modified electrodes, Carbon-based nanocomposites, Nanomaterials, Photocatalysis

Email: manoramabhu@gmail.com

Phone: 7587401982

Dr Bharat L Sahu
Assistant Professor

Research Interest: Environmental Chemistry § Green Chemistry § Rare Earth Elements § Heavy Metals § Phytochemicals

Email: bharatred007@gmail.com

Phone: 9907970312

Dr Uday P Azad
Assistant Professor

Research Interest: Nano Materials, Modified Electrodes, Electrochemical Sensors, Biosensors. Electroanalytical Chemistry, Fuel Cell, Oxygen reduction, Electrochemical Water Splitting (Oxygen evolution and hydrogen evolution reactions), Energy Storage.

Email: azadchembhu@yahoo.co.in
Phone: 8005304694

Dr Suryabhan Singh
Assistant Professor

Research Interest: Metal Organic framework, Applications of Time dependent density functional theory (TDDFT) calculations for metal complexes, Development of crystals, To study their catalytic, gas storage (in case of MOFs), electrical and optoelectronic properties

Email: sbs.bhu@gmail.com

Phone: 8318880990

Dr Niraj Kumari
Assistant Professor

Research Interest: Metal based Drugs, Supramolecular Chemistry, Metal Organic Framework.

Email: nirajchem@gmail.com

Phone: 9348002247

Dr Bijnaneswar Mondal
Assistant Professor

Research Interest: Discrete and functionalized porous organic cages, Experimental analysis of cage supported nanoparticles as heterogeneous catalyst in various organic transformation

Email: bijnaneswarm@gmail.com

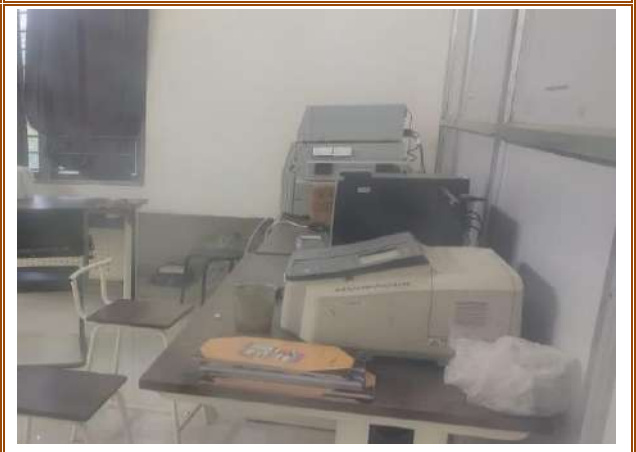
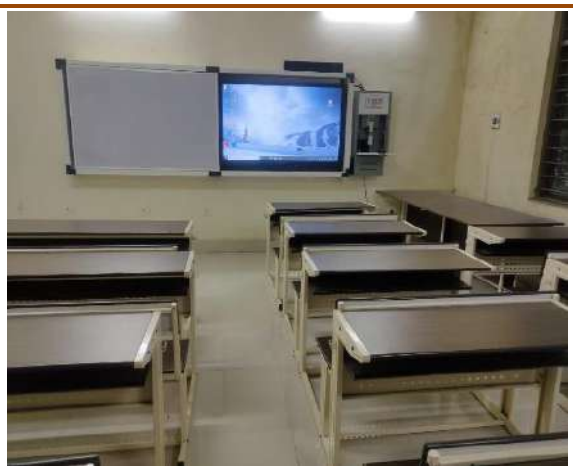
Phone: 9482946044

Technical and Support Staff

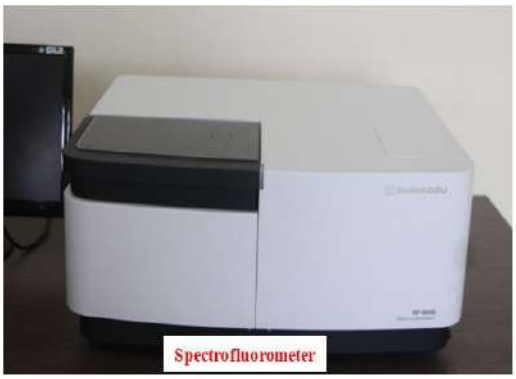
1.	Sri Satish Sarraf	Library & Office Assistant
2.	Sri Lambodar Bhardwaj	Office Assistant
3.	Sri Raju Meshram	Laboratory Assistant
4.	Sri Domendra Verma	Laboratory Assistant
5.	Sri Sant Kumar Surywanshi	Peon

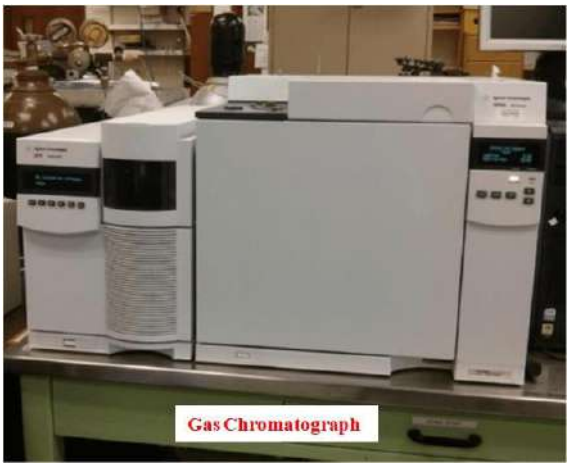
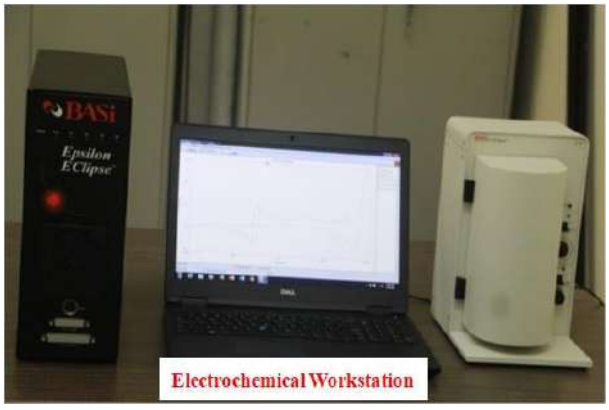
Departmental Facilities

S. N.	Name of Equipment	Equipment
1	Library	
2	Laboratory	
3	Smart Class room	

5	Departmental Auditorium	
6	Instrument Room	
7	Semi-smart class room	

INSTRUMENTAL FACILITIES

S. N.	Name of Equipment	Equipment
1	UV-VIS Spectrophotometer, UV-1800 (Shimadzu)	
2	Spectrofluorometer	
3	Fourier Transform Infrared Spectrophotometer, IRAffinity-1 (Shimadzu)	 FT-IR Spectrophotometer

4	Gel Permiation Chromatograph	
5	Gas Chromatograph 7820A (Agilent)	
7	Electrochemical workstation	

8	Rotary Evaporator, BUCHI	
9	Flash Chromatography, BUCHI	

Library Resources

- All the Indian Journal of Chemistry,
- All the journals of Chemistry of Elsevier,
- All the Journals of Chemistry of Taylor & Fransis.
- All the Journals of Chemistry of Wiley Intersience.
- J. Am. Chem. Soc., J. Chemical Education (ACS).
- Nature

E-Resources (Journals) Available

e-Shodh Sindhu: Consortium for Higher Education Electronic Resource

List of Resources made available through INFLIBNET

S. N.	Resource Name	Resource URL	No of Journals
1	Cambridge University Press	http://journals.cambridge.org/	224
2	Economic & Political Weekly	http://epw.in/	1

3	Emerald	http://www.emeraldinsight.com/	133
4	American Institute of Physics	http://journals.aip.org/	18
5	Institute of Physics	http://iopscience.iop.org/journals	46
6	Americal Physical Society	http://publish.aps.org/browse.php	13
7	Royal Society of Chemistry	http://www.rsc.org/	29 + 6 Database
8	Springer Link	http://www.springerlink.com	1389+
9	Taylor & Francis	http://www.informaworld.com/	1079
10	Wiley-Blackwell	http://onlinelibrary.wiley.com/	908
11	Science Direct [Subject Covered :(i) Agricultural and Biological Sciences (ii) Biochemistry, Genetics Molecular Biology, (iii) Chemistry, (iv) Computer Science, (v) Economics and Finance, (vi) Immunology and Microbiology, (vii) Mathematics, (viii) Physics and Astronomy, (ix) Psychology. (x) Social Sciences]	http://www.sciencedirect.com/	1036
12.	Americal Chemical Society	http://pubs.acs.org/	50
13	JSTOR	http://www.jstor.org/	2500+
14	Nature	http://www.nature.com/	1
15	SIAM	http://epubs.siam.org/	14
Bibliographic Database			
16	JCCC	http://www.jccc-ugcinfonet.in	Database

17	ISID	http://isid.org.in	Database
INDEST Consortium (Full Text)			
18	IEL Online	http://www.ieee.org/ieeexplore	
Full Text (Vishwavidyalaya Resources)			
19	Business Source Elite-EBSCO News Paper Source Plus—EBSCO	http://search.ebscohost.com/	
20	Indiastat.com	http://www.indiastat.com	
21	Oxford University Press	https://academic.oup.com/books/	
22	World TechnologIies	http://ebooks.wtbooks.com	
23	Tritech Digital Media (India)	http://tdmebooks.com	
24	Bibliotex India	http://www.bibliotex.com	
25	Bhasha Prakashan	https://bhashaprakashan.com	
26	IEEE e-journal package	http://www.ieeexplore.ieee.org	
27	ASME e-journal package	http://www.asmedigitalcollection.asme.org	
28	ASCE e-journal package	http://www.ascelibrary.org	
29	CMEI-Prowess (Management/Com)	http://www.ascelibrary.org	
eBOOK (Vishwavidyalaya Resources)			
30	Oxford University Press Social Sciences Package (9 Subject Collection) **	http://www.oxfordscholarship.com	No. of Books: 716
31	World Technologies (all subject collection) ***	http://ebooks.wtbooks.com	No. of Books: 4542

AWARDS AND SCHOLARSHIPS

- The topper of each batch is awarded a Gold medal and Merit Certificate during the convocation of the University**.**

OTHER AWARDS / SCHOLARSHIPS

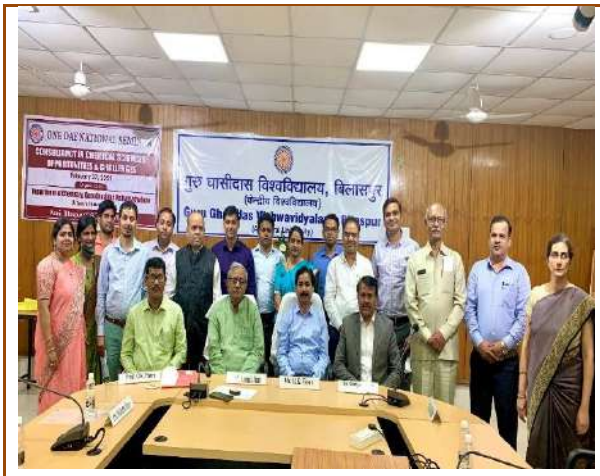
- Merit Scholarship of Rs. 10000/- per year may be extended to any one student from each School of Studies, who secures highest score in the examination of respective course at the end of each year. Such Scholarship will continue till the student maintains first position along with attendance record of 75% in classes and all clear status in Semester Examination and on the recommendation of the Director/ Dean. In case of otherwise the benefit will be shifted to the other highest scorer.
- Merit Scholarship of Rs. 15000/- per year may be extended to one student who secures highest score among all Schools in the examination of respective course. Other eligibility of student is same as mentioned in Point One.
- An amount of Rs. 5000/- may be extended to student for the particular session, who have participated in any national level Sport or games/ events as recommended by Director/ Dean.
- An amount of Rupees One Lac may be awarded to students for the particular session, who have participated in any International Sports/ Games/ Events as recommended by Director/ Dean.
- Full free ship may be extended to any one student in each department belonging to poor family background, subject to condition that the student maintains attendance record of 75% in classes, all clear status, secure minimum of 60% marks in Semester examinations (who is not a recipient of scholarship or financial aid from any other source) as recommended by Director/ Dean.
- Free Meal facility may be extended to all blind students (total blindness) residing in hostels of the University. There actual mess bill will be reimbursed under the Students Welfare Scheme. The Amount will be paid by drawing the bill in favor of the Warden of the concerned hostel.
- A sum of Rs. 5000/- per annum per student in the form of cash may be provided toall blind students (total blindness) of the University as financial assistance to purchase “Teaching Aid” every year, as recommended by Dean/ Director ofconcerned School of Studies.
- Hand Driven tricycle may be provided to physically handicapped students for movement in the campus in only once during their entire tenure of education in the University.

Further, students should have attendance record of 75% in classes and on the recommendation of Director/ Dean of concerned School of Studies.

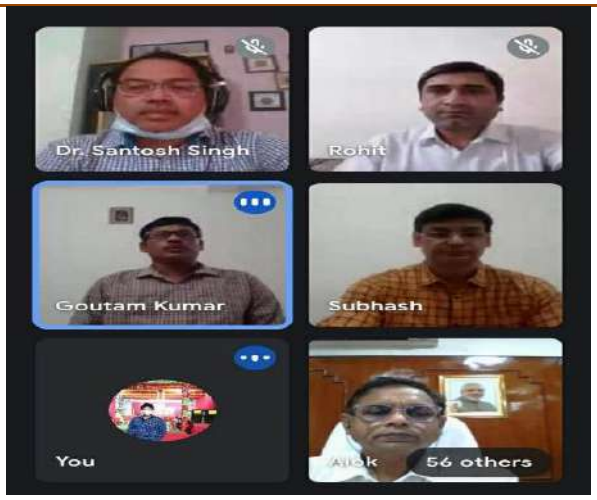
- An amount of Rs. 11000/- may be awarded to students who have set an example in the campus by their extraordinary task as recommended by DSW/ Chief Proctor/ Chief Warden.
- Full free ship of tuition fee is given to Single Girl Child for PG courses.
- Full free ship is given to the dependents of Martyrs.
- Full free ship for five poor students under VC Discretionary Category.

Conference/Seminar Organized

- One Day National Seminar On "Consultancy in Chemical Sciences: Oppurtunities & Challenges", Feb 27, 2022 (Online)
- One Day National Webinar On "Awareness and Training on Intellectual Property Rights", Apr 12, 2022
- One Day National Webinar On "Role of Physical Sciences in Combating COVID 19 Pandemic" 2021, Aug 11, 2021
- Two Days National Webinar, Recent Advancements in Chemical and Environmental Sciences & Technology (RACEST), November 23-24, 2020
- Two days International Webinar, Emerging Areas in Chemical Sciences: Opportunities and Challenges, August 12-13, 2020



One Day National Seminar On ‘Consultancy in Chemical Sciences: Oppurtunities & Challenges, 2022



One Day National Webinar on “Role of Physical Sciences in combating COVID 19 Pandemic, 2022

One Day National Webinar On “Awareness and Training on Intellectual Property Rights, 2022

RESEARCH PROJECTS

Details of Research Grant Received from different Agencies during last five years :-

S. No.	Name of the Investigator	Title of the Project	Year	Amount Sanctioned (Approx) (Rs. Lakhs)	Funding Agency
1.	Prof. G. K. Patra (Mentor of pdf fellow Dr Kalyani Rout)	PDF/2017/001365 National Post-Doctoral Fellowship	2017-18	19.20/-	DST, New Delhi
2	Dr. Subhash Banerjee	Development of normal rice husk feed stock supported nano meterials for the synthesis of privilidge medicinal scaffolds	2017-18	4.85/-	CCOST, Raipur, C.G.
3	Prof. G. K. Patra	Metal complexes of amide based clidents for efficient synthesis of degredable benign polymers and sensing applications	2018-19	49.00/-	DST, New Delhi
4	Dr Manorama	A Novel Electrocatalytic Sensing Scaffold For Nitroaromatic Compounds Based On Graphene Nanomaterial	2021-22	15.00/-	CSIR, New Delhi
4	Dr. Suryabhan Singh	UGC-BSR Research Start-Up-Grant	2021-22	10.00/-	UGC, New Delhi
5	Dr. Uday Pratap Azad	UGC-BSR Research Start-Up-Grant	2021-22	10.00/-	UGC, New Delhi
6	Dr. Niraj Kumari	UGC-BSR Research Start-Up-Grant	2021-22	10.00/-	UGC, New Delhi
7	Dr. Bijaneswar Mandal	UGC-BSR Research Start-Up-Grant	2021-22	10.00/-	UGC, New Delhi

Research publications

List Of Research Publications in SCI Journals Published from The Department During the Last Five Years (2018-2022)

S N	Title of Paper	Name of the Author/s	Name of Journal	Year of Publication
	2018-19			
1	Sucrose capped gold nanoparticles as a plasmonic chemical sensor based on non-covalent interactions: Application for selective detection of vitamins B1 and B6 in brown and white rice food samples	Shrivas K, Nirmalkar N, Thakur SS, Deb MK, Shinde SS, Shankar R.	Food Chem.	2018
2	Graphene Oxide as a Sustainable Metal and Solvent Free Catalyst for Dehydration of Fructose to 5-HMF: A New and Green Protocol	Melad Shaikh, Sunil K. Singh, Santimoy Khilari, Mahendra Sahu & Kalluri V.S.Ranganatha	Catalysis Communication	2018
3	Catalytic and Efficient Synthesis of Optically Active Terminal Epoxides and 1,2-Diols using a New Lanthanum Triflate Assisted C1-Symmetric Bimetallic Chiral Salen Cobalt Complex	Patel, D.; Thakur, S. S. Shinde, S. S.; Kumar, P.	Letters in Organic Chemistry	2018
4	Experimental and theoretical approach for selective detection of thymine in real samples using gold nanoparticles as a biochemical sensor	Shrivas, K. Nirmalkar, N. Thakur, S.S. Kurrey R. S. Sinha, D. Shankar R.	RSC Advances	2018
5	Virtual Screening, Molecular Docking, and DFT Studies of Some Thiazolidine-2,4-diones as Potential PIM-1 Kinase Inhibitors	Asati V, Thakur SS, Upmanyu N, Bharati S K	Chemistry Select	2018
6	On Water Cu@g-C3N4 Catalyzed Synthesis of NH-1,2,3-Triazoles Via [2+3] Cycloadditions of Nitroolefins/Alkynes and Sodium Azide	S. Payra, A. Saha, and Subhash Banerjee	Chem Cat Chem.	2018
7	On-Water NiFe2O4 Nanoparticle-Catalyzed One-Pot Synthesis of Biofunctionalized Pyrimidine-Thiazole Derivatives: In Silico Binding Affinity and In Vitro Anticancer Activity Studies	A. Sharma, S. Gudala, S. R. Ambati, SP Mahapatra, A. Raza, S. Payra, A. Jha, A. Kumar, S. Penta, S. Banerjee	Chemistry Select	2018
8	Hierarchical Mesoporous RuO2/Cu2O Nanoparticle-Catalyzed	A. Saha, S. Payra, B. Selvaratnam, S. Bhattacharya, S. Pal, R.T. Koodali, and Subhash Banerjee	ASC Sustainable Chemistry & Engineering	2018

	Oxidative Homo/Hetero Azo-Coupling of Anilines			
9	Magnetically Recoverable Fe3O4 Nanoparticle-Catalyzed One-Pot Synthesis Of Coumarin-3-Carboxamide Derivatives in Aqueous Ethanol	S Payra, A Saha, and Subhash Banerjee	Chemistry Select	2018
10	A MOF to CuONanospheres of Uniform Morphology for Synthesis of α-Aminonitriles under Solvent-Free Conditions along with Crystal Structure of the MOF	S. Singha, A. Saha, S. Goswami, S. K. Dey, S. Payra, Subhash Banerjee, S. Kumar, R. Saha	Crystal Growth & Design	2018
11	A new ICT based Schiff-base chemosensor for colorimetric selective detection of copper and its copper complex for both colorimetric and fluorometric detection of Cysteine	AK Manna, J Mondal, K Rout, GK Patra	Journal of Photochemistry and Photobiology A: Chemistry	2018
12	A benzohydrazide based two-in-one Ni2+/Cu2+ fluorescent colorimetric chemosensor and its applications in real sample analysis and molecular logic gate	Amit Kumar Manna, Jahangir Mondal, Kalyani Rout, Goutam Kumar Patra	Sensors and Actuators B: Chemical	2018
13	A guanidine based bis Schiff base chemosensor for colorimetric detection of Hg (II) and Fluorescent detection of Zn (II) ions	Kalyani Rout, Amit Kumar Manna, Meman Sahu, Goutam Kumar Patra	Inorganica Chimica Acta	2018
14	A simple Schiff base as selective and sensitive fluorescent-colorimetric hydrazine chemosensor	Jahangir Mondal, Amit K Manna, Kalyani Rout, Sunil K Singh, Jnan P Naskar, Goutam K Patra	International Journal of Environmental Analytical Chemistry	2018
15	Highly selective hydrazone based reversible colorimetric chemosensors for expeditious detection of CN− in aqueous media	Jahangir Mondal, Amit Kumar Manna, Goutam K Patra	Inorganica Chimica Acta	2018
16	A thio-urea based chromogenic and fluorogenic chemosensor for expeditious detection of Cu2+, Hg2+ and Ag+ ions in aqueous medium	Amit Kumar Manna, Jahangir Mondal, Rukmani Chandra, Kalyani Rout, Goutam K Patra	Journal of Photochemistry and Photobiology A: Chemistry	2018
17	A simple benzildihydrazone derived colorimetric and fluorescent 'on–off-on'sensor for sequential detection of copper (II) and cyanide ions in aqueous solution	Rukmani Chandra, Anupam Ghorai, Goutam K Patra	Sensors and Actuators B: Chemical	2018
18	A dipodal molecular probe for naked eye detection of trivalent cations (Al3+, Fe3+and Cr3+) in aqueous	Rukmani Chandra, Amit Kumar Manna, Kalyani Rout, Jahangir Mondal, Goutam K Patra	RSC Advances	2018

	medium and its applications in real sample analysis			
19	A fluorescent colorimetric azo dye based chemosensor for detection of S 2− in perfect aqueous solution and its application in real sample analysis and building a molecular gate	Amit Kumar Manna, Jahangir Mondal, Rukmani Chandra, Kalyani Rout, Goutam Kumar Patra	Analytical Methods	2018
20	A novel pyrene based highly selective reversible fluorescent-colorimetric sensor for the rapid detection of Cu 2+ ions: application in bio-imaging	Anupam Ghorai, Jahangir Mondal, Amit Kumar Manna, Shubhamoy Chowdhury, Goutam K Patra	Analytical Methods	2018
21	Bio-inspired unprecedented synthesis of reduced graphene oxide: a catalytic probe for electro-/chemical reduction of nitro groups in an aqueous medium	S. Mahata, A. Sahu, P. Shukla, A. Rai, Manorama Singh, Vijai K. Rai	New Journal of Chemistry	2018
22	Morita-Baylis-Hillman enal-based triple cascade strategy for anti-selective synthesis of highly functionalized tetrahydropyridines using iminium-enamine catalysis	Vijai K. Rai, F. Verma, M. Satnami, Manorama Singh, A. Rai	Tetrahedron Letters	2018
23	One-Pot Allan–Robinson/Friedländer Route to Chromen-/Quinolin-4-ones through the Domino Acetylative Cyclisation of 2-Hydroxy-/2-Aminobenzaldehyde	Vijai K. Rai, F. Verma, G. P. Sahu, Manorama Singh, A. Rai	European Journal of Organic Chemistry	2018
24	Visible-light driven regioselective synthesis of 1H-tetrazoles from aldehydes through isocyanide-based [3+2] cycloaddition	F. Verma, A. Sahu, P. K. Singh, A. Rai, Manorama Singh, Vijai K. Rai	Green Chemistry	2018
25	A novel and efficient reduction of graphene oxide using Ocimum sanctum L. leaf extract as an alternative renewable bio-resource	S. Mahata, A. Sahu, P. Shukla, A. Rai, Manorama Singh, Vijai K. Rai	New Journal of Chemistry	2018
26	Graphene oxide catalyzed C-N/C-S/[3+2] cyclization cascade for green synthesis of thiazolidinone in water	S. Mahata, A. Sahu, P. Shukla, A. Rai, Manorama Singh, Vijai K. Rai	Letters in Organic Chemistry	2018
27	Aqueous mortar-pestle grinding: An efficient, attractive, and viable technique for the regioselective synthesis of β-amino alcohols	N. Singh, Vijai K. Rai, A. Kumar	Comptes Rendus Chimie	2018
28	Developing a nontoxic and biocompatible polymeric self-assembly by using RAFT methodology for biomedical application	Deepak, Swati Sharma, Ashok Kumar, Rajesh Kumar, Koushik Nandy, Arti Srivastava, Munendra Singh Tomar, Arbind Acharya	Materials Today Communications	2018
29	Static and Dynamic Studies on removal of chlorophenol form aqueous solution usning Chitsan carbon nanocomposites	A. Bajpai, J. Bajpai, U. Soni, S. K. Singh	TACL	2019

30	Highly Efficient and Chemoselective Reduction of Nitroarenes Using Hybrid Ni@g-C3N4 as Reusable Catalyst	Soumen Payra, Subhash Banerjee	Chemistry Select	2019
31	Synthesis of Rice Husk Derived Activated Mesoporous Carbon Immobilized Palladium Hybrid Nano-Catalyst for Ligand-Free Mizoroki-Heck/Suzuki/Sonogashira Cross-Coupling Reactions	Ashok Raj Patel, Archana Asatkar, Geetika Patel, Subhash Banerjee	Chemistry Select	2019
32	Facile Synthesis of 1,3,5-Triarylbenzenes and 4-Aryl-NH-1,2,3-Triazoles Using Mesoporous Pd-MCM-41 as Reusable Catalyst	A. Saha, C. M. Wu, R. Peng, R. Koodali, S Banerjee	European Journal of Organic Chemistry	2019
33	Iron based metal organic framework for efficient removal of methylene blue dye from industrial waste	C. Arora, S. Soni, S. Sahu, J Mittal, P Kumar, PK Bajpai	Journal of Molecular Liquids	2019
34	A guanidine based bis Schiff base chemosensor for colorimetric detection of Hg (II) and fluorescent detection of Zn (II) ions	K Rout, AK Manna, M Sahu, GK Patra	Inorganic Chimica Acta	2019
35	Dual-mode highly selective and sensitive Schiff base chemosensor for fluorescent colorimetric detection of Ni2+ and colorimetric detection of Cu2+	AK Manna, K Rout, S Chowdhury, GK Patra	Photochemical &Photobiological Sciences	2019
36	Photocatalytic C(sp3)–H activation towards α-methylenation of ketones using MeOH as 1C source steering reagent	F. Verma, P. Shukla, S. R. Bhardiya, Manorama Singh, A. Rai, Vijai K. Rai	Advanced Synthesis & Catalysis	2019
37	A novel carbocatalytic hydride transfer strategy for efficient reduction of structurally different aldehydes and ketones in water	Vijai K. Rai,S. Mahata, S. R. Bhardiya, P. Shukla,A. Rai, Manorama Singh	Tetrahedron Letters	2019
38	Visible Light-Induced Direct Conversion of Aldehydes into Nitriles in Aqueous Medium Using Co@g-C_3N_4 as Photocatalyst	F. Verma, P. Shukla, S. R. Bhardiya, Manorama Singh, A. Rai,Vijai K. Rai	Catalysis Communication	2019
39	AuNPs/Neutral red-bio-functionalized graphenenanocomposite for nonenzymatic electrochemical detection of organophosphate via NO_2 reduction	Manorama Singh, H. Kashyap, P. K. Singh, S. Mahata, V. K. Rai, A. Rai	Sensors Actuators B. Chemical	2019
40	Efficient electrocatalytic oxidation of p-phenylenediamine using a novel PANI/ZnO anchored bio-reduced graphene oxide nanocomposite	Manorama Singh, A. Sahu, S. Mahata, P. Shukla, A. Rai, V. K. Rai	New Journal of Chemistry	2019

41	First bio-covalent functionalization of graphene with threonine towards drug sensing via electrocatalytic transfer hydrogenation	A. Sahu, P. Shukla, S. Mahata, V. K. Rai, A. Rai, Manorama Singh	Sensors & Actuators B: Chemical	2019
42	AcMIM]FeCl4: A Magnetically Separable Organocatalyst for the Clean Synthesis of Tetrahydrobenzo[b]pyran Derivatives	A. Saha, S. Payra, A. Asatkar, A. R. Patel, S. Banerjee*	Current Organocatalysis	2019
43	A Facile Iodine-Promoted Enals-Based cis-Selective Construction of Aziridine-2-aldehyde in Water	P. K. Singh, F. Verma, S. R. Bhardiya, Manorama Singh, V. K. Rai, A. Rai	ChemistrySelect	2019
44	Utilisation of cobalt doped Iron based MOF for enhanced removal and recovery of methylene blue dye from waste water	S Soni, PK Bajpai, J Mittal, C Arora	Journal of Molecular Liquids 314, 113642	2020
45	Triazole-based novel bis Schiff base colorimetric and fluorescent turn-on dual chemosensor for Cu2+ and Pb2+: application to living cell imaging and molecular logic gates	K. Rout, A.K. Manna, M. Sahu, J. Mondal, S.K. Singh and G.K. Patra	RSC Advances	2019
46	A dual-mode highly selective and sensitive Schiff base chemosensor for fluorescent colorimetric detection of Ni2+ and colorimetric detection of Cu2	A.K. Manna, K. Rout, S. Chowdhury and G.K. Patra	Photochem. & Photobiolo. Sciences	2019
47	A guanidine based bis Schiff base chemosensor for colorimetric detection of Hg (II) and fluorescent detection of Zn (II) ion	K Rout, AK Manna, M Sahu, GK Patra	Inorg. Chim. Acta.	2019
48	A highly selective thiosemi-carbazone based Schiff base chemo-sensor for colorimetric dete-ction of Cu2+ and Ag+ ions and turn-on fluorometric detection of Ag+ ions	M. Sahu, A. K.Manna, K. Raut, J. Mondal and G.K Patra	Inorg. Chim. Acta	2020
49	A novel hydrazide-based selective and sensitive optical chemosensor for the detection of Ni2+ ions: applications in live cell imaging, molecular logic gates and smart phone-based analysis	A. K. Manna, S. Chowdhury and G.K. Patra	Dalton Transactions	2019
50	Smartphone coupled with paper-based chemical sensor for on-site determination of iron (III) in environmental and biological samples	K. Shrivas, T. Kant, I. Karbhal, R. Kurrey, B. Sahu, D. Sinha, G. K. Patra, M. K. Deb and S. Pervez	Analytical and Bioanalytical Chemistry	2020
51	Simple salicylaldimine-functionalized dipodal bis Schiff base chromogenic and fluorogenic chemosensors for	R. Chandra, A,K. Manna, M. Sahu, K. Rout, G.K. Patra	J. Photochem. Photobiol A	2020

	selective and sensitive detection of Al3+ and Cr3			
52	A highly selective novel multiple amide based Schiff base optical chemosensor for rapid detection of Cu2+ and its applications in real sample analysis, molecular logic gate and smart phone	A. K.Manna, M. Sahu, , K. Raut, U.K.Das and G.K Patra	Microchemical Journal	2020
53	A novel dihydro phenylquinazolinone-based two-in-one colourimetric chemosensor for nickel(II), copper(II) and its copper complex for the fluorescent colourimetric nanomolar detection of the cyanide anion	M. Sahua, A.K. Manna,S. Chowdhury, G. K. Patra	RSC Advances	2020
54	Combined experimental and theoretical studies on a phenyl thiadiazole-based novel turn-on fluorescent colorimetric Schiff base chemosensor for the selective and sensitive detection of Al3+	A. K. Manna, S. Chowdhury and G.K. Patra	New Journal of Chemistry	2020
55	Facile protocol for the synthesis of benzothiazole, benzoxazole and N-benzimidazole derivatives using rice husk derived chemically activated carbon	A. Asatkar, T. L. Lambat, S. Mahmood, A. Mondal, M. Singh and S. Banerjee	Materials Today: Proceedings	2020
56	Halide bridged novel ternary copper(I) complexes with bis imino-quinolinyl ligand and triphenylphosphine: Synthesis, structure, luminescence, electrochemistry and theoretical studies	R. Chandra, A. Dutta, A.K. Manna, K. Rout, J. Mondal and G.K. Patra	Inorg. Chim. Acta	2019
57	Synthesis of Novel Coumarinyl-pyrido[2,3-d]pyrimidine-2,4-diones Using Task-Specific Magnetic Ionic Liquid, [AcMIm]FeCl4 as Catalyst	S. R. Ambati, J. L. Patel, G. Satish, K. Chandrakar, S. Penta, S. P. Mahapatra, S. Banerjee	Synthetic Communications	2020
58	Anionic natural graft copolymer used in removal of hazardous dye water pollutants, 27, 219-226, 2020	Arti Shrivastava	Indian Journal of Chemical Technology,	2020
59	The benzyl ethyl trithiocarbonate mediated control synthesis of a block copolymer containing N-vinyl Pyrrolidone by RAFT methodology: Influence of polymer composition on cell cytotoxicity and cell viability,	Koushik Nandy, Arti Srivastava, Shere Afgan, Deepak, Rajesh Kumar, , Arun Kumar Rawat, Rajan Singh, Rakesh K. Singh	European Polymer Journal	2020
60	Recent developments in luminescent coordination polymers: Designing strategies, sensing application and theoretical evidences	Jian-Qiang Liu, Zhi-Dong Luo, Ying Pan, Ashish Kumar Singh, Manoj Trivedi, Abhinav Kumar	Coord. Chem. Rev. 406,213145	2020

61	New 1D diorganotin(iv) dithiolate coordination polymers: crystallographic, computational, Hirshfeld surface and thermalanalyses	P. Singh, A. Singh, A. Singh, Ashish Kumar Singh, G. Kociok-Köhn, A. Alowais, N. A. Y. Abduh, M. Muddassir, and A. Kumar	Cryst Eng Comm, 22, 2049-2059	2020
62	Tertiary phosphine-appended transition metal ferrocenyl dithiocarbamates: Syntheses, Hirshfeld surface, and electrochemical analyses	Amita Singh, Archisman Dutta, Ashish Kumar Singh, Manoj Trivedi, Gabriele Kociok-Köhn, Mohd. Muddassir, Abhinav Kumar	Appl. Organomet. Chem.	2020
63	Groundwater hydrochemistry of Rajnandgaon district, Chhattisgarh, Central India	A. Yadav, A. Nanda, B. L. Sahu, Y. K. Sahu, K.S. Patel, S. Pervez, M. S. Gulgundi, J.A.C. Oterino, P. Martín-Ramos and P. Bhattacharya.	Groundwater for Sustainable Development	2020
64	Novel coronavirus disease 2019 (COVID-19) pandemic: considerations for the biomedical waste sector in India	S. Ramteke and B.L. Sahu	Case studies in chemical and environmental engineering	2020
65	Utilisation of cobalt doped Iron based MOF for enhanced removal and recovery of methylene blue dye from waste water	Sanju Soni, P K Bajpai, Jyoti Mittal and Charu Arora	Journal of Molecular Liquids	2020
66	A mechanistic approach for the thermal reaction of strontium oxalate with uranyl oxalate using TG technique	C. Arora, A. Sharma, S. Soni and Y. Naik	Research Journal of Chemistry and Environment	2020
67	A Novel Ternary Graphene-based Nanocomposite Modified Electrode for Acetaminophen Detection	Manorama Singh, A. Sahu, F. Verma, V.K. Rai, A. Rai	Electroanalysis	2020
68	silver hydroxyapatite (AgHAP) reinforced nanocomposites of poly	Rashmi Choubey, Raje Chouhan, A. K. Bajpai, Jaya Bajpai & Sunil Kumar Singh	International Journal Of Polymeric Materials And Polymeric Biomaterials	2020
69	Visible light-emitting diode light-driven one-pot four component synthesis of poly-functionalized imidazoles under catalyst-and solvent-free conditions	G. Patel, A. R. Patel, S. Banerjee	New Journal of Chemistry	2020
70	New main-group ferrocenyldithiocarbamates and conversion to ferrocene oxazolidine-2-Thione and-2-one	R. Yadav, Suryabhan Singh, M. Trivedi, G. Kociok-Ko¨hn, N.P. rath, R.D. kohn, Mohd. Mudassir, A. Kumar	New J. Chem.	2020
71	Bio-reduction of Graphene Oxide: Catalytic Applications of (Reduced) GO in Organic Synthesis	Vijai K. Rai, Suhasini Mahata, Hemant Kashyap, Manorama Singh, and Ankita Rai	Current Organic Synthesis	2020
72	Green synthesis of copper nanoparti -cles from an extract of Jatropha curcas leaves:	Mithun Kumar Ghosh, Sanjay Sahu, Indersh Guptaa and Tanmay Kumar Ghorai	RSC Adv.	2020

	characterization, optical properties, CT-DNA binding and photocatalytic activity			
73	Food safety monitoring of phenthoate pesticide using smartphone-assisted paper-based sensor with bimetallic Cu@Ag core-shell nanoparticles	Shrivas, K; Sahu, M; Patel, S; Thakur, S; Shankar, R	Lab on a Chip	2020
74	Developing a nontoxic and biocompatible polymeric self-assembly by using RAFT methodology for biomedical application	Deepak, Swati Sharma, Ashok Kumar, Rajesh Kumar, Koushik Nandy, Arti Srivastava, Munendra Singh Tomar, Arbind Acharya,	Material today communications	2019
75	Mesoporous PbO Nanoparticles-catalyzed Arylbenzodioxy Xanthenedione Scaffolds under Solvent-less Conditions in a Ball Mill	T. L. Lambat, R. G. Chaudhary, A. A. Abdala, R. K. Mishra, S. M. and S. Banerjee	RSC Advances	2019
76	Sulfamic acid promoted one pot multicomponent reaction: A facile synthesis of 4-oxo-tetrahydroindoles under ball milling conditions.	T. L Lambat, A. A Abdala, Sami Mahmood, Pankaj V Ledade, R. G Chaudhary, Subhash Banerjee	RSC Advances	2019
77	Visible LED Light Driven Cu0.9Fe0.1@RCAC-Catalyzed Highly Selective Aerobic Oxidation of Alcohols and Oxidative Azo-Coupling of Anilines: Tandem One Pot Oxidation-Condensation to Imidazoles and Imines	A. R. Patel, G. Patel, S. Banerjee	ACS Omega	2019
78	Efficient electrochemical determination of p-aminophenol using a novel tricomponent graphene-based nanocomposite	Manorama Singh, A. Sahu, V.K.Rai, A. Rai	New J Chem	2019
79	Adsorption of hazardous dye crystal violet from industrial waste using low cost adsorbent Chenopodium album,	C. Arora, D. Sahu, D Bharti, V. Tamrakar, S. Soni, S. Sharma	Desalination and Water Treatment	2019
80	Phytochemical Screening, proximate and elemental analysis of plant species Curcuma caesia, Curcuma longa and Chenopodium album,	Vinita Tamrakar, Dhruv Arora and Charu Arora	Research Journal of Chemistry and Environment	2019
81	Metal free C-H activation over graphene oxide toward direct synthesis of structurally different amines and amides in water	Prashant Shukla, Ambika Asati, Smita R. Bhardiya, Manorama Singh, Vijai K. Rai, and Ankita Rai	J. Org. Chem.	2020
82	Cu/Cu2O@g-C3N4 : Recyclable photocatalyst under visible light to acess 2-aryl-/benzimidazoles/benzothiazoles in water	Puneet K. Singh, Smita R. Bhardiya,Ambika Asati,Vijai K. Rai,Dr. Manorama Singh,Dr. Ankita Rai	Chemistry Select	2020

83	Facile Syntheiss of γ-Ketonitriles in water via C(Sp2)-H Activation of Aromatic Aldehydes over Cu@g-C3N4 under Visible light	V. K Rai, F. Verma, S. R. Bhardiya, H. Sheshma, A. Rai, Manorama Singh	Eur. J. Org. Chem.	2020
84	Cu(I)-Induced Activation of Furan for Inverse Electron Demand ADAR with Alkenes toward Regioselective Synthesis of Tetrahydropyridine	Prashant Shukla, Ambika Asati, Smita R. Bhardiya, Manorama Singh, Vijai K. Rai, and Ankita Rai	J. Org. Chem.	2020
85	Silver hydroxyapatite (AgHAP) reinforced nanocomposites of poly (methyl methacrylate)-poly (ε-caprolactone) as hybrid orthopedic materials	Rashmi Choubey, Raje Chouhan,A. K. Bajpai,Jaya Bajpai &Sunil Kumar Singh	International Journal of Polymeric Materials and Polymeric Biomaterials	2020
86	Microwave Assisted One-Pot Multicomponent Synthesis Using ZnO-β Zeolite Nanoparticle: An Easy Access to 7-Benzodioxolo [4, 5-b] xanthene-dione and 4-Oxo-tetrahydroindole Scaffolds	TL Lambat, SH Mahmood, PV Ledade, S Banerjee	Chemistry Select	2020
87	CuBr2@g-C3N4-Catalyzed Highly Selective Aerobic Oxidation of Alcohol and Toluene Derivatives	Padma Rani Verma, Dr. Soumen Payra,Prof. Fahmida Khan,Dr. Santosh Penta,Dr. Subhash Banerjee	Chemistry Select	2020
88	Visible light-emitting diode light-driven one-pot four component synthesis of poly-functionalized imidazoles under catalyst- and solvent-free conditions	Geetika Patel, Ashok Raj Patela and Subhash Banerjee	New J. Chem	2020
89	Rice husk derived nano-NiFe2O4@CAGC-catalyzed direct oxidation of toluene to benzyl benzoate under visible LED light	Geetika Patel, AshokRaj Patel,Trimurti L.Lambat, Sami H.Mahmood, SubhashBanerjee	Flat Chem	2020
90	Review on Synthesis of Bio-Active Coumarin-Fused Heterocyclic Molecules	G Patel, S Banerjee	Current Organic Chemistry	2020
91	Modern Strategies for Synthesis of Functionalized Bio-molecules	S Banerjee	Current Organic Chemistry	2020
92	Direct Oxidative Azo Coupling of Anilines Using a Self-Assembled Flower-like CuCo2O4 Material as a Catalyst under Aerobic Conditions	AR Patel, G Patel, G Maity, SP Patel, S Bhattacharya, A Putta, S Banerjee	ACS omega	2020
93	Imino-pyridyl and PPh3 mixed ligand complexes of Cu (I) X (X: I, Br, and Cl): Synthesis, structure, DFT and Hirshfeld surface studies	Jahangir Mondal, Amit Kumar Manna, Goutam Kumar Patra	Eur J Chem.	2020
94	A highly selective novel multiple amide based Schiff base optical chemosensor for rapid detection of Cu2+ and its applications in real	Amit Kumar Manna, Meman Sahu, Kalyani Rout, Uttam K Das, Goutam K Patra	Microchem. J	2020

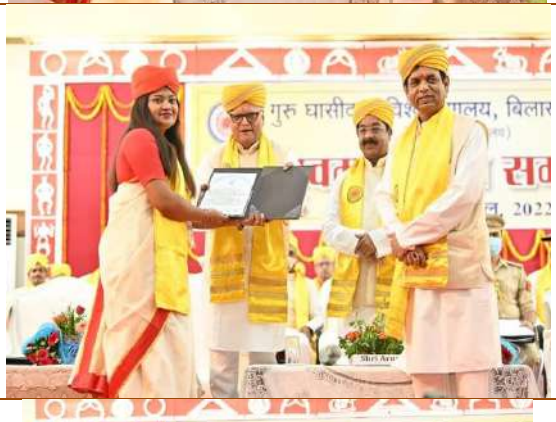
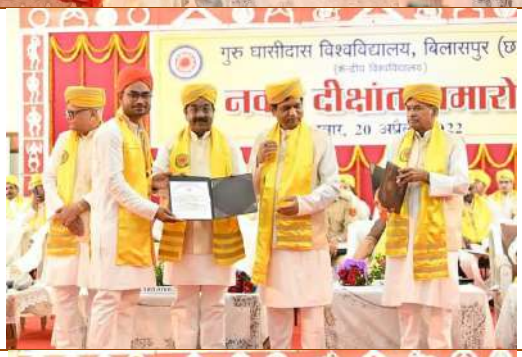
	sample analysis, molecular logic gate and smart phone			
95	A highly selective thiosemicarbazone based Schiff base chemosensor for colorimetric detection of Cu2+ and Ag+ ions and turn-on fluorometric detection of Ag+ ions	Meman Sahu, Amit Kumar Manna, Kalyani Rout, Jahangir Mondal, Goutam K Patra	Inorg. Chim. Acta	2020
96	Removal of crystal violet from aqueous solution using iron based metal organic framework	Sanju Soni, P. K. Bajpai, Dipti Bharti, Jyoti Mittal, Charu Arora	Desalination and Water Treatment	2020
97	Chenopodium album Linn.: Phytoconstituents, Medicinal and Biological Properties, Research Journal of Chemistry and Environment	C Arora and V. Tamrakar	Research Journal of Chemistry and Environment	2020
98	Utilisation of cobalt doped Iron based MOF for enhanced removal and recovery of methylene blue dye from waste water	Sanju Soni, P K Bajpai, Jyoti Mittal and Charu Arora	Journal of Molecular Liquids	2020
99	Applications of artificial intelligence to drug design and discovery in the big data era: a comprehensive review	N. Tripathi, M K Ghoshisht, S K Sahu, C. Arora	Chemistry Select	2020
100	Feasibility Analysis of Coal Combustion Residues as Fertilizer for Agricultural Use	R. Kumar, A. Kumar, M. Sundararajan, S. Sharma and C. Arora	Eur. J. Org. Chem.,	2020
101	Study on effect of variation of geographical and climatic conditions on chemical constituents and biological activity of Emblica officinalis	D. Bharti, R. Singh and C Arora	J. Org. Chem.	2020
102	Sequestration of crystal violet from aqueous solution using ash of black turmaric rhizome	A. Patel, Sanju Soni, J. Mittal, A. Mittal, Charu Arora	International Journal of Polymeric Materials and Polymeric Biomaterials	2020
103	Efficient removal of malachite green dye from aqueous solution using Curcuma caesia based activated carbon	Charu Arora, Pramod Kumar, Sanju Soni, Jyoti Mittal, Alok Mittal and Bhupender Singh	Chemistry Select	2020
104	Synthesis, designing strategies and photocatalytic charge dynamics of Metal-Organic Frameworks (MOFs): A catalyzed Photo-degradation approach towards Organic Dyes	Ayushi Singh, Ashish Kumar Singh, J.-Q. Liu and Abhinav Kumar	Chemistry Select	2020
105	Lanthanide Based Double Perovskites: Bifunctional Catalysts for Oxygen Evolution/Reduction Reactions	S. Kumar, M. Singh, R. Pal, Uday Pratap Azad, Ashish Kumar Singh, D. P. Singh, V. Ganesan, A. Kumar S. and R. Prakash	New J. Chem	2020

106	Halide bridged organophosphorus complexes of HgX2 (X: I, Br and Cl): Synthesis, structure and theoretical studies	J Mondal, AK Manna, GK Patra	Eur J Chem.	2021
107	Ferrocene decorated unusual mercury(II) dithiocarbamate coordination polymers: crystallographic and computational	Amita Singh, Ayushi Singh, Suryabhan Singh, Gabriele Kociok-Köhn, Mohd. Muddassir and Abhinav Kumar	Cryst Eng Comm	2021
108	Evolution of metal-thiocarboxylate chemistry in 21st century	Suryabhan Singh	Journal of Molecular Structure	2021
109	Lanthanide Based Double Perovskite: Bifunctional Catalysts for Oxygen Evolution/Reduction Reactions	Sachin Kumar, Monika Singh, Raj Pal, Uday Pratap Azad, Ashish Kumar Singh, Divya Pratap Singh, Vellaichamy Ganesan, Akhilesh Kumar Singh, Rajiv Prakash	International Journal of Hydrogen Energy	2021
110	Direct one-pot synthesis of imines/benzothiazoles/benzoxazoles from nitroarenes via sequential hydrogenation-condensation using Nano-NiFe2O4 as catalyst under microwave irradiation	G Patel, AR Patel, TL Lambat, S Banerjee	Current Research in Green and Sustainable Chemistry	2021
111	Sulfamic Acid as Versatile Green Catalyst Used For Synthetic Organic Chemistry: A Comprehensive Update	PKPG Chopra, TL Lambat, SH Mahmood, RG Chaudhary, S Banerjee	Chemistry Select	2021
112	Synthesis, crystal structure, and theoretical studies of a macrocyclic silver (I) complex of imino-pyridyl Schiff base ligand	Jahangir Mondal, Meman Sahu, Bhaskar Sharma, Rakesh Ganguly, Shubhamoy Chowdhury, Goutam Kumar Patra	Eur J Chem.	2021
113	Synthesis, crystal structure, CN–ion recognition property and computational studies of a novel hydrazinyl-dihydroimidazole Schiff base	Meman Sahu, Amit Kumar Manna, Kalyani Rout, Dipti Nikunj, Bhaskar Sharma, Goutam K Patra	Inorg. Chim. Acta	2021
114	Synthesis, Crystal Structure, and Properties of Heteroleptic Cu(I) dithiocarbamate complex containing diphenyl phosphinoferrocene (dppf)	Vinod Kumar, Suryabhan Singh	Journal of Structural Chemistry	2021
115	In situ transformed three heteroleptic Co (II)-MOFs as potential electrocatalysts for the electrochemical oxygen evolution reaction	Durgesh Singh, Krishna K Raj, Uday Pratap Azad, Rampal Pandey	Electrochemica Acta	2021
116	Ni(II) dithiolate anion composites with two-dimensional materials for electrochemical oxygen evolution reactions (OER)	A. Singh, A. Singh, G. Kociok-Köhn, K. C Molloy, Ashish Kumar Singh, A. Kumar and M.. Muddassir	New J. Chem	2021
117	Syntheses, Characterization and Oxygen Evolution Reaction (OER)Electrocatalytic Properties of	Chiteri Gautam, Ayushi Singh, Anar Singh, Ashish Kumar Singh, Vinod Kumar Sharma and Pramod Kumar	J. Mol. Str.	2021

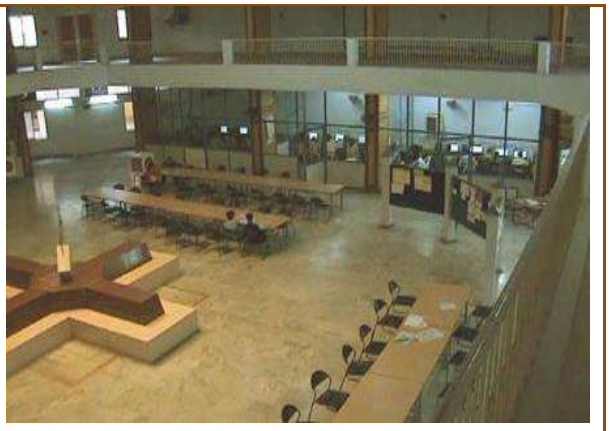
	M(II) based Bromo-Salophen Complexes			
118	Sensitive electrocatalytic determination of p-phenylenediamine using bimetallic nanocomposite of Cu-Ag nanoalloy and ionic liquid-graphene oxide	Manorama Singh, S. R Bhardiya, A. Asati, H. Sheshma, V. K. Rai, A. Rai	J Electroanal Chem	2021
119	Ferrocenyl thiazolidine-2-thione ornamented 1D coordination polymers derived from coinage metal halide and pseudohalide	Ayushi Singh, Manoj Trivedi, Gabriele Kociok-Köhn, Ashish Kumar Singh, Mohd. Muddassir and Abhinav Kumar	CrystEngComm	2021
120	Co-operative influence of co-crystallized solvent in sustaining supramolecular architectures of Zn(II)/Cd(II) homoleptic pyridyl functionalized dithiocarbamate complexes via noncovalent interactions	Vinod Kumar, Suryabhan Singh	Journal of sulfur chemistry	2022
121	A fluorescent colorimetric vanillin di-Schiff base chemosensor for detection of Cu(II) and isolation of trinuclear Cu(II)–dihydrazide	Meman Sahu, Amit Kumar Manna and Goutam Kumar Patra	Journal of Materials Advances	2022
122	Fluorescent Schiff base sensors as a versatile tool for metal ion detection: strategies, mechanistic insights, and applications	Manoj Kumar Goshisht, a Goutam Kumar Patra b and Neetu Tripathi	Journal of Materials Advances	2022
123	Synthesis, crystal structure, DFT studies, and Hirshfeld surface analysis of 2,2'-(((methylene-bis(4,1-phenylene))bis(azanylylidene)) bis(methanylylidene))diphenol	Goutam Kumar Patra 1 and Dinesh De	Eur J Chem	2022
124	Synthesis, characterization, X-ray crystal structure and Hirshfeld surface analysis of Ni(II) complex of 1,2-bis(pyridin-2-ylmethylene)hydrazine	Meman Sahu, Amit Kumar Manna, Dinesh De and Goutam Kumar Patra	Eur J Chem	2022
125	Hydrogen bonded molecular rectangle of N, N¢-bis (3-quinolyl-methylene) diphenylethanedionedihydrazone	G K Patra, AK Manna, D De	Ind J Chem Sect A	2022
126	Synthesis, Characterization, Crystal Structure, And Theoretical Studies of A Mixed-Ligand Copper(I) Iodide Complex of An Asymmetric Schiff Base Ligand 2-((Pyridin-4-Yl)Methelenamino)- 3-	G.K. Patra	J Structural Chem	2022

	Aminomaleonitrile And Triphenylphosphine Co-Ligand			
127	Synthesis & characterization of tri arm Indole based ATRP Polymer and antibacterial study with its silver nanocomposite	Ambika Srivastava, Shere Afgan Paramjeet Yadav, Rajesh Kumar, Arti Srivastava, Ravindra Nath Kharwar	Journal of Polymer Research	2022
128	Trithiocarbonate-mediated RAFT synthesis of a block copolymer: Silver nanoparticles integration and sensitive recognition of Hg2+	Koushik Nandy, Arti Srivastava, Shere Afgan, Rajesh Kumar, Dharmendra Kumar Yadav, Vellaichamy Ganesan	Polymer Bulletin	2022
129	Fabrication of self-assembled Co3O4 nano-flake for one-pot synthesis of tetrahydrobenzo [b] pyran and 1, 3-benzothazole derivatives	G Patel, AR Patel, G Maity, S Das, SP Patel, S Banerjee	Current Research in Green and Sustainable Chemistry	2022
130	Functionalized Hybrid Nanomaterials for Biomedical and Analytical Applications	S. Banerjee	Current Nanoscience	2022
131	Development of Nanomaterials-fabricated Paper-based Sensors for the Analysis of Environmental and Biological Samples: A Review	K Shrivas, TK Patle, R Jamunkar, VK Jain, S Banerjee, A Kumar	Current Nanoscience	2022
132	Application of Silver Nanoparticles as a New Alternative Antiviral Agent for SARS-CoV-2: A Review	R Jamunkar, K Shrivas, D Sinha, S Patel, A Patle, A Kumar, S Banerjee	Current Nanoscience	2022
133	One-pot, three-component synthesis of novel coumarinyl-pyrazolo [3, 4-b] pyridine-3-carboxylate derivatives using [AcMIm] FeCl4 as recyclable catalyst	SR Ambati, JL Patel, K Chandrakar, U Sarkar, S Penta, S Banerjee	Journal of Molecular Structure	2022
134	Graphene-based Nanomaterials for Electrochemical Sensing of Hydrazine: A Review	Manorama Singh, S. R. Bhardiya, A. Rai, V. K Rai	Current Analytical Chemistry	2022
135	Regioselective installation of enolizable ketones and unprotected mercaptoacetic acid into olefins using GO as phase transfer catalyst	P. Shukla, Manorama Singh, V. K. Rai, A. Rai	New J Chemistry	2022

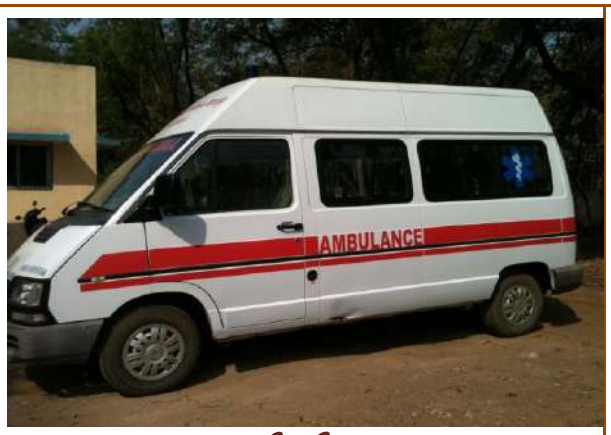
LIST OF TOPPERS

1	**Ms Medhakiran Patel, MSc Gold Medalist, 2020**	
2	**Ms Amisha Sahu, BSc Gold Medalist, 2020**	
3	**Mr Devendra Dewangan, MSc Gold Medalist, 2021**	
4	**Ms Prerna Sinha, BSc Gold Medalist, 2021**	

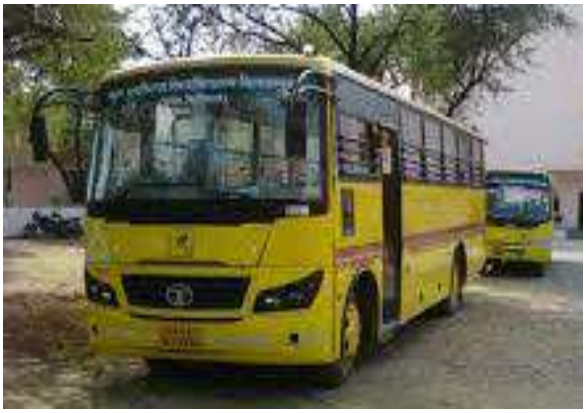
Facilites Available in the Campus



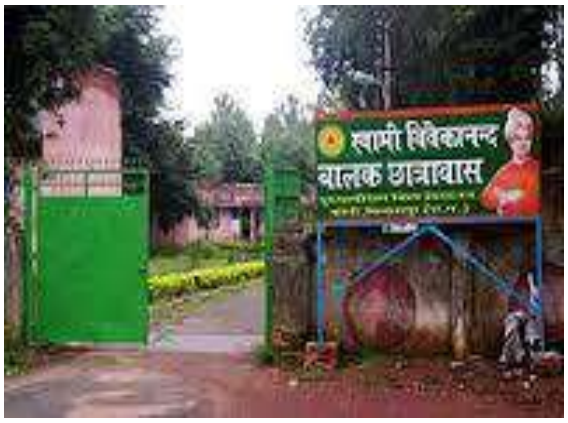
Central library



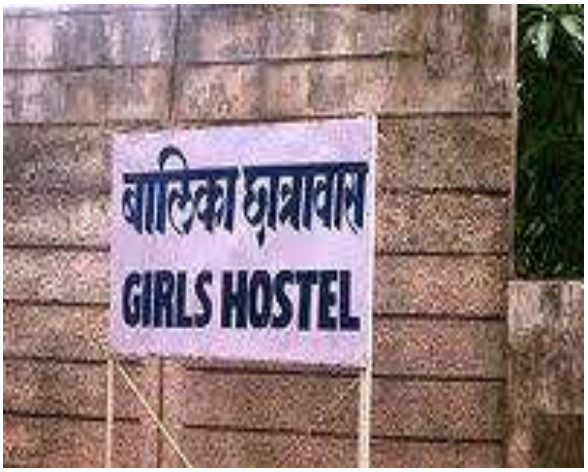
Ambulance



Bus



Boys Hostel



Girls Hostel

Health Centre

ATM

Cafeteria

Other facilities to the students in the University

- Tarang- The University Musical Band
- Student Creativity Centre
- Sports centre
- Udaan-The Official Student Magazine
- Urchins-University's Theatre and Nukkad Play Group
- Abhitartan- University's Dance Group
- Gymnasium
- Psychological Counselling Centre
- Grievance Redressal Mechanism
- Centre Placement Cell
- National Service Scheme (NSS)
- National Cadet Corp (NCC)

Course Offered

- BSc (Honours) in Chemistry (LOCF)
- MSc in Chemistry (CBCS)
- Ph. D Prgramm

The detail structure of syllabus are as follows:

SCHEME AND SYLLABUS

FOR

Learning Outcomes-based Curriculum Framework

(LOCF)

For

CHEMISTRY HONOURS

(To be implemented from Session 2021-2022)

DEPARTMENT OF CHEMISTRY

SCHOOL OF PHYSICAL SCIENCES

GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (CG)

1. Introduction

Chemistry is referred to as the science that systematically studies the composition, properties, and reactivity of matter at atomic and molecular levels. The scope of chemistry is very broad. The key areas of study of chemistry comprise Organic chemistry, Inorganic Chemistry, Physical Chemistry and Analytical Chemistry. Organic chemistry deals with study of substances containing carbon mostly, whereas inorganic chemistry deals with study of all other elements/compounds/substances and their chemical properties. Physical chemistry deals with applications of concepts, laws to chemical phenomena. Analytical chemistry, in general, deals with identification and quantification of materials. Development of new interdisciplinary subjects like nano-materials, biomaterials, etc., and their applications from chemistry point of view added new dimension to materials chemistry. Thus, the degree programme in chemistry also intended to cover overlapping areas of chemistry with physics, biology, environmental sciences. Further, a broad range of subjects such as materials chemistry, biomaterials, nanomaterials, environmental chemistry, etc., has also been introduced which can be helpful for students/faculty members to broaden the scope of their studies and hence applications from job prospective point of view. Therefore, as a part of efforts to enhance employability of graduates of chemistry, the curricula also include learning experiences with industries and research laboratories as interns. In addition, industrial visits/industrial projects are encouraged and added to the curriculum to enhance better exposure to jobs/employment opportunities in industries, scientific projects and allied sectors.

This modified syllabus has been drafted to enable the students to equip for national-level competitive exams that they may attempt in the future. To ensure implementation of a holistic pedagogical model, several allied disciplines are covered/introduced in this framework, including Physics, Mathematics, Biology and some generic, and ability enhancement electives. In addition, employability of B.Sc. Chemistry graduate is given due importance such that their core competency in the subject matter, both theoretical and practical, is ensured. To expand the employability of graduates, several skill development courses are also introduced in this framework.

2. About the department

The Department of Chemistry was established in 2009 as a new Science Department to provide quality education in the conventional areas of Science and grow into a center for teaching and research with an aim to acquire prominent position in the academic map of India. The Department offers both UG and PG level advanced courses in Chemical Sciences along with an integrated 5 years Master programme with exit option after completing 3 years B. Sc. (Hon's). The Department is also offering a Ph. D. programme in different areas in Chemistry. There are four major specializations offered in M. Sc. such as Physical Chemistry, Inorganic Chemistry, Analytical Chemistry and Organic Chemistry. The students are monitored and evaluated by regular class tests, seminars, assignments, mid and end-semester examinations. The Department already has fifteen regular faculties [Professor (01) Associate Professor (03) and Assistant Professor (11)].

The department has two laboratories possessing necessary chemicals, reagents, glassware, lab wares and basic instruments for performing experiments in physical, inorganic, organic and analytical chemistry, in general, and synthesis, analysis (qualitative and quantitative) and characterization of different inorganic and organic compounds in more particulars.

The departmental has its own library in addition to central library of the University. Sufficient number of books is available in departmental library to fulfill the requirement of the faculty members and students. A number of reference books and access to online journals are also available in the Central Library.

Over the period, the Department has been nurtured under the able guidance of Prof J S Dangi and Prof G K Patra. The soul of the department is their teachers headed by Dr. Santosh Singh Thakur, The faculty members are specialized in frontier areas of Chemical Sciences and have excellent expertise in their own field. The faculty members of the department have significantly contributed to the scientific world through scientific and research publications and have received many distinguished national and international awards and fellowships such as JSPS Postdoctoral Fellowships, ORISE, USA Postdoctoral fellowship, NSC, Taiwan postdoctoral fellowship, BK21 and KOSEF postdoctoral fellowship, South Korea, DST – Inspire faculty fellowship, National Postdoctoral fellowship, DS Kothari Postdoctoral fellowship etc. Department has got several research projects from funding agencies DST, UGC, CSIR, CGCOST etc. during past 12 years. Department has produced good number of publications in reputed national and international journals. Faculty members of the department are on the editorial boards of some journals and are referees for both national and international journals. Recognizing the research outcome, the Department has received special financial assistance under DST-FIST phase I. This has helped the Department in establishing a number of modern, sophisticated instruments.Department has also organized Several National as well as International Seminar/Symposium on various areas of Chemical Sciences. We are proud that our collective enthusiasm is continuously generating a good number of bright students.

3. Learning Outcome Based Curriculum planning:

Curriculum is the heart of any educational system. It can be focused either to achieve the

objectives of each course of the programme or on the expected learning outcomes from each course. The objective-based curriculum refers to the overall targets to be achieved through the curriculum which may be long-term or immediate. On the other hand, the learning outcome based curriculum is very specific in nature in terms of changes in the cognitive, affective and psychomotor behavior of the students as a result of their exposure to the curriculum. The outcome-based curriculum provides the teacher very specific targets which he can achieve through the selected instructional process as compared to the objective-based curriculum which provides general outcomes. The learning outcome-based curriculum has very close relationship with the learning of the students whereas the objective-based curriculum focuses on only providing knowledge to the students. In other words, higher cognitive skills are developed through learning outcome-based curriculum. Hence, it is preferred to develop learning outcome-based curriculum which will provide specific directions to the teacher concerning the transaction process and expected changes in the behavior of the students as well

4.Learning outcomes-based curriculum framework for B.Sc. Chemistry(Honours)

a) Attributes of a ChemistryGraduate

Attributes of chemistry graduates under the outcome-based teaching-learning framework may encompass the following:

- **Core competency:** The chemistry graduates are expected to know the fundamental concepts of chemistry and applied chemistry. These fundamental concepts would reflect

the latest understanding of the field, and therefore, are dynamic in nature and require frequent and time-boundrevisions.

- **Communication skills:** Chemistry graduates are expected to possess minimum standards of communication skills expected of a science graduate in the country. They are expected to read and understand documents with in-depth analyses and logical arguments. Graduates are expected to be well-versed in speaking and communicating their idea/finding/concepts to wideraudience
- **Critical thinking:** Chemistry graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientificarguments.
- **Psychological skills:** Graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Psychological skills may include feedback loops, self-compassion, self-reflection, goal-setting, interpersonal relationships, and emotionalmanagement.
- **Problem-solving:** Graduates are expected to be equipped with problem-solving philosophical approaches that are pertinent across thedisciplines;
- **Analytical reasoning:** Graduates are expected to acquire formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoningetc.
- **Research-skills:** Graduates are expected to be keenly observant about what is going on in the natural surroundings to awaken their curiosity. Graduates are expected to design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logicaldeduction.
- **Teamwork:** Graduates are expected to be team players, with productive co- operations involving members from diverse socio-culturalbackgrounds.
- **Digital Literacy:** Graduates are expected to be digitally literate for them to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
- **Moral and ethical awareness:** Graduates are expected to be responsible citizens of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough to distinguish what is construed as illegal and crime in Indian constitution. Emphasis is given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and soon.
- **Leadership readiness:** Graduates are expected to be familiar with decision-making process and basic managerial skills to become better leader. Skills may include defining objective vision and mission, how to become a charismatic inspiring leader and soon.

b) QualificationDescriptors for B.Sc. Chemistry(Honour)

The qualification descriptors for a Bachelor's degree in Chemistry (Honours) may include following:

(i). Systematic and fundamental understanding of chemistry as a discipline.

(ii). Skill and related developments for acquiring specialization in the subject.

(iii). Identifying chemistry-related problems, analysis and application of data using appropriate methodologies.

(iv). Applying subject knowledge and skill to solve complex problems with defined solutions.

(v). Finding the opportunity to apply subject-related skills for acquiring jobs and self-employment.

(vi). Understanding new frontiers of knowledge in chemistry for professionaldevelopment.

(vii). Applying subject knowledge for solving societal problems related to application of chemistry in day-to-day life.

(ix). Applying subject knowledge for sustainable environment-friendly green initiatives.

(x). Applying subject knowledge for new research and technology.

5. TYPES OF COURSES

5.1. Core Course:

A course, which is to be studied compulsorily by a candidate as a core requirement is termed as a Core Course. The credits for the core courses will be 5. The distribution of credits is as per Table 1 of clause 7.10.

5.2. Elective Course:

Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables exposure to some other discipline/subject / domain or nurtures the candidate's proficiency/skill is called an Elective Course. The distribution of credits is as per Table 1 of clause 7.6.

5.2.1. Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. These courses will be offered to the students of the same department in which they have been admitted. These courses may be interdisciplinary. The credit for each core course will be 5.

5.2.2. Generic Elective (GE) Course: An elective course chosen generally from other disciplines/subject offered by sister departments, to seek additional exposure of the subject, is called a Generic Elective. A core course offered in a discipline/subject may be treated as an elective by another discipline/subject and vice versa and such electives may also be referred to as Generic Elective. The credit for each Generic course will be 5.

5.2.3. Ability Enhancement Courses (AEC): The Ability Enhancement Courses are the

courses based upon the content that leads to Knowledge enhancement. The credit for each AEC course will be 2. There will be five AEC courses in each Honors Program out of which one course on Environmental Science, one on English Language/ Hindi Communication. The other three courses will be selected by the students from the pool of AEC courses, as notified by the University.

5.2.4. Skill Enhancement Courses (SEC): SEC courses are skill-based courses, which are aimed to provide hands-ontraining, competencies, skills etc. These courses may be chosen from a pool of SEC courses, as notified by the University. There will be two SEC courses in each Honors Program. The credit for each SEC course will be 2.

5.3 Project work / Dissertationis considered as a special course involving the application of knowledge in solving/analyzing/exploring a real-life situation / difficult problem. A Project/Dissertation work would be of 7 credits. These courses are designed to acquire special/advanced knowledge, such as supplement study/support study to project work, and a candidate studies such a course on his own with advisory support by a faculty member. Project work / Dissertation submission will be followed by a presentation and Viva-voce.

5.4 Seminar: Seminar will be conducted by the faculty members of the department in which a student has to defend/present a topic allotted to him/her by the course coordinator. Every student has to present minimum of 2 presentations. The seminar classes will preferably be conducted for 2 hours during a working day in a week.

5.5 Internship: An internship is a professional learning experience that offers meaningful, practical work related to a student's field of study or career interest. An internship gives a student the opportunity for career exploration and development, and to learn new skills. It offers the employer the opportunity to bring new ideas and energy into the workplace, develop talent and potentially build a pipeline for future full-time employees.

An internship consists of

- a part-time work schedule that includes a part of written documentation as the report.
- Provides a clear project description for the work experience related to a specific field.
- Orients the student to the organization, its culture and proposed work assignment(s), etc for professional courses.
- Helps the student develop and achieve learning goals.

The internship may include Project Work, Subject-specific skill course, Internship, summer internship, Visits to field sites, Excursions, Industrial Visits, Industrial training, Research activities, and any other as may be required for specific degree programs on practical grounds.

The credits for the internship will be 4-6 for BA/BSc/BCom/other basic degree programs.

The technical and professional degree programs may opt for internship or apprenticeship in full semester with 24 credits.

5.6 Additional Credit courses: University Additional Credit Electives (UACE), Value Added Courses (VAC), Certificate courses (CC), Online Certificate Courses (OCC), and others as notified by the University from time to time. The credits for such courses will be 2 – 4 as notified by the university. A separate regulation for these courses is designed by the university.

5.7. The Board of Studies of each department will decide the course structure and syllabus for a specific program and update in the information in Table 3.

5.8. The minimum credits for the award of Undergraduate degree program in BA/BSc/BCom will be 133. The maximum credits for such programs should not exceed 150.

5.9. An undergraduate degree with Honors in a discipline will be awarded the following course structure as per the UGC guidelines

- 14 Core Courses
- 04 Generic Elective Courses (GE)
- 03 Discipline Specific Elective (DSE) Courses
- 05 Ability Enhancement Courses (AEC)
- 02 Skill Enhancement Courses (SEC)
- 01 Dissertation / Project
- 01 Seminar
- 01 Internship
- Additional Credit Courses (as notified by the University)
- Online MOOC’s Courses (As per UGC/University guidelines)

5.10. The credits of the courses are given in the following tables:

Table 1: Credit Distribution

Courses	Credits
	Theory + Practical
Core Courses (14 courses)	(3 + 2) x 14 = 70
Generic Elective (4 courses)	(3 + 2) x 4 = 20
Discipline Specific Elective (3 courses)	(3 + 2) x 3 = 15
Ability Enhancement Course (5 Courses)	(2+0) x 5 = 10
Skill Enhancement Course (2 Courses)	(2+0) x 2 = 4
Dissertation (1 Course)	7
Seminar (1 Course)	2
Internship (1 Course)	6
Additional Credit Courses (Optional)	(As per UGC/University guidelines and notification)
MOOC's Courses**	(As per UGC/University guidelines) 2-5
Total	**134**

Table 2: Structure of Courses

Semester	Core Courses (14)	GE (4)	DSE (4*)	AEC (5)	SEC (2)	Seminar (1)	Dissertation (1)	Internship (1)	Additional Credit Courses (Optional)
I	C1 C2	GE1		AEC1	SEC1				
II	C3 C4	GE2		AEC2	SEC2				
III	C5 C6 C7	GE3		AEC3					
IV	C8 C9 C10	GE4		AEC4					
V	C11 C12		DSE1 DSE2	AEC5					
VI	C13 C14		DSE3			Seminar	Dissertation		
Summer								Internship	
MOOC's**									

* May be offered during summer. Summer Internship: duration will be 2-4 weeks (minimum 90 working hours).

** MOOC's courses may be offered at least one time during entire PG programme for the any of Core Course, Generic elective, Discipline specific elective, AEC course, Skill enhancement course available on MOOC's platform time to time. If any such course related to your subject is not available on MOOC's platform, department may continue with regular courses.

Credit Distribution and Structure of the Courses: B .Sc.Chemistry (Honors)

Semester	Core Courses (CC)	Ability Enhancement Courses (AEC)	Skill Enhancement Courses (SEC)	Discipline Specific Elective (DSE)	Generic Elective Course (GEC)		Credit hour load
1	CC-I CC-II	AEC-1	SEC-1	-	GEC-1		19
2	CC-III CC-IV	AEC-2	SEC-2	-	GEC-2		19
3	CC-V CC-VI CC-VII	AEC-3	-	-	GEC-3		22
4	CC-VIII CC-IX CC-X	AEC-4	-	-	GEC-4	Internship* (6 credit)	22+6
5	CC-XI CC-XII	AEC-5		DSE-1 DSE-2	-		22
6	CC-XIII CC-XIV			DSE-3	-	Seminar (02 credits); Dissertation/ Project (7 credits)	24
MOOCs**							
Credits	42 (T) +28 (P)=70	10	4	9(T) + 6 (P)=15	12(T)+ 8(P)=20	6+2+6=15	134
% Course	52.24	7.46	2.99	11.19	14.93	11.19	100

* May be offer during summer

** MOOC's courses may be offered at least one time during entire UG programme for the any of Core Course, Generic elective, Discipline specific elective, AEC course, Skill enhancement course available on MOOC's platform time to time. If any such course related to the subject is not available on MOOC's platform, department may continue with regular courses..

Courses Structure

1. Core Courses (CC)

Sr.No.	Name of the course	L	P	Credits
CC 1	Inorganic Chemistry-I	3	0	**3**
	Inorganic Chemistry Practical	0	2	**2**
CC 2	Organic Chemistry-I	3	0	**3**
	Organic Chemistry Practical	0	2	**2**
CC 3	Physical Chemistry-I	3	0	**3**
	Physical Chemistry Practical	0	2	**2**
CC 4	Organic Chemistry-II	3	0	**3**
	Organic Chemistry Practical	0	2	**2**
CC 5	Physical Chemistry-II	3	0	**3**
	Physical Chemistry Practical	0	2	**2**
CC 6	Organic Chemistry-III	3	0	**3**
	Organic Chemistry Practical	0	2	**2**
CC 7	Molecular Spectroscopy &Photochemistry	3	0	**3**
	Spectroscopy practicals	0	2	**2**
CC 8	Physical Chemistry-III	3	0	**3**
	Physical Chemisry practical	0	2	**2**
CC 9	Inorganic Chemistry-II	3	0	**3**
	Inorganic Chemistry practical	0	2	**2**
CC 10	Introduction to Quantum Chemistry	3	0	**3**
	Chemistry Practical	0	2	**2**
CC 11	Inorganic Chemistry-III	3	0	**3**
	Inorganic Chemistry practical	0	2	**2**
CC 12	Analytical Chemistry	3	0	**3**
	Analytical chemistry practical	0	2	**2**
CC 13	Green Chemistry	3	0	**3**
	Green chemistry practical	0	2	**2**
CC 14	Chemistry of Materials	3	0	**3**
	Chemistry of Materials practical	0	2	**2**

2. Discipline Specific Elective (DSE)Course (Any three of the followings)

Sr No	Name of the course	L	P	Credits
1	Medicinal Chemitry	3	2	**5**
2	Electrochemistry	3	2	**5**
3	Polymer Chemistry	3	2	**5**
4	Environmental Chemistry	3	2	**5**
5	Advanced Materials Chemistry	3	2	**5**
6	Advaned Analytical Chemistry	3	2	**5**
7	Nuclear & Radiation Chemistry	3	2	**5**
8	Organic spectroscopy	3	2	**5**
9	Heterocyclic chemistry	3	2	**5**
10	Biochemistry	3	2	**5**
11	Organometallics and Bioinorganic chemistry	3	2	**5**
12	Introduction to Nanochemistry & applications	3	2	**5**

3. Generic Elective Courses (GEC) (for PCM & PCB combination)

Sr. No.	Name of the course	L	P	Credits
1	Mathematics-I:Mathematical methods in Chemistry	5	0	**5**
2	Life Science/Biology-I	3	2	**5**
3	Physics-I	3	2	**5**
4	Mathematics-II	5	0	**5**
5	Biology/Life Science-II	3	2	**5**
6	Physics-II	3	2	**5**

4. Generic Elective Courses (offered by Department of Chemistry, GGV for other departments)

Sr. No.	Name of the course	L	P	Credits
1	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	3	2	**5**
2	Kinetic Theory of Gases, Chemical Energetics, Equilibria & Functional Group Organic Chemistry	3	2	**5**
3	Solid, Solutions, Phase Equilibrium & Chemical kinetics, Conductance, Periodic Properties and Chemistry of s-, p-, and d- block elements	3	2	**5**
4	Analytical Chemistry, Co-ordination compounds, Organometallics and Molecules of life	3	2	**5**

5. Ability Enhancement Courses (Any five of the followings)

Sr. No.	Name of the course	L	Credits
1	English for communication	2	2
2	Intellectual Property Rights	2	2
3	History of Indian Science	2	2
4	Good Laboratory Practices	2	2
5	Introduction to Forensic Science & Technology	2	2
6	Renewable Energies (Solar & Biogas)	2	2
7	Cheminformatics	2	2
8	Water remediation and conservation studies	2	2
9	Research methodology	2	2
10	Chemistry in Everyday life	2	2
11	Chemistry of food, nutrtion and preservation	2	2

6. Skill Enhancement Courses (Any two of the followings)

Sr. No.	Name of the course	L/ P	T	P	Credits
1	Personality Development	2	0	0	**2**
2	Computer Applications in Chemistry	2	0	0	**2**
3	Science Communication and Popularization	2	0	0	**2**
4	Biofertilizer	2	0	0	**2**
5	Herbal Science & Technology	2	0	0	**2**
6	Fermentation Science & Technology	2	0	0	**2**
7	Environment Impact Analysis	2	0	0	**2**
8	IT Skill for Chemist	2	0	0	**2**
9	IPR and business skill for chemist	2	0	0	**2**
10	Analytical Clinical Biochemistry	2	0	0	**2**
11	Mushroom Culture Technology	2	0	0	**2**

7. Additional Credit Courses (Optional)or **Value Added Courses**

S. N.	Name	Course Coordinator	L	P	Credit
1.	Fuel Chemistry	Dr. S. S. Thakur and Prof. G. K. Patra	1	1	2
2.	Polymer Chemistry	Dr. A. Srivastava	1	1	2
3.	Cosmetic Formulation	Dr. S. Banerjee	1	1	2
4.	Efficient Technologies for Food Processing and Shelf Life Extension	Dr. Niraj Kumari and Dr. A. Srivastva	1	1	2
5.	Eco-Friendly Lubricants-Chemistry And Application	Dr. Bharat Lal Sahu (Assistant Professor) Dr. Bijnaneswar Mondal (Assistant Professor)	1	1	2

CORE COURSES

Semester	Course	Name of the course	Credits
I	CC 1	Inorganic Chemistry-I	Theory 3
			Practical: 2

Learning objective:

After completing this course, the students will be able to:

- Develop an understanding on atomic theory, concept of wavefunction.
- Elements in periodic table; physical and chemical characteristics,periodicity.
- To predict the atomic structure, chemical bonding, and molecular geometry based on acceptedmodels.
- To understand atomic theory of matter, composition ofatom.
- Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form differentatoms.
- Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodictable.
- Characterize bonding between atoms, molecules, interaction and energetics (ii) hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
- Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
- Importance of hydrogen bonding, metallicbonding.

Inorganic Chemistry-I (Theory)

Unit I: Atomic Structure **10 Lectures**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and $\psi 2$. Quantum numbers and their significance.Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s, p, d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Unit II: Periodicity of Elements **10 Lectures**

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following

properties of the elements, with reference to *s* and*p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van'derWaals)

(c) Ionic and crystalradii.

(d) Covalent radii (octahedral andtetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionizationenthalpy.

(f) Electron gain enthalpy, trends of electron gainenthalpy.

(g) Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron densityratio.

Unit III: Chemical Bonding 14 Lectures

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvationenergy.

(ii) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Ionic character from dipole moment andelectronegativities.

UNIT IV: Metallic bonding and Weak chemical forces 6 Lectures

(iii) *Metallic Bond:* Qualitative idea of free electron model, Semiconductors,Insulators.

(iv) *Weak Chemical Forces:* vander Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility,dissolution.

Recommended Books/References:

1. Lee, J. D. *Concise Inorganic Chemistry,* Wiley, $5^{th}Ed^{n}$.
2. Douglas, B.E., McDaniel, D.H., Alexander J.J., *Concepts & Models of Inorganic Chemistry, (Third Edition)* John Wiley &Sons,1999.
3. Atkins, P. W. and DePaula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press, 2014.
4. Rodger, G. E. *Inorganic and Solid State Chemistry*, Cengage Learning,2002.

Inorganic Chemistry-I (Practical)

(A) TitrimetricAnalysis

(i) Calibration and use of apparatus.

(ii) Preparation of solutions of different Molarity/Normality oftitrants.

(iii) Use of primary and secondary standardsolutions.

(B) Acid-BaseTitrations

(i) Estimation of carbonate and hydroxide present together inmixture.

(ii) Estimation of carbonate and bicarbonate present together in amixture.

(iii) Estimation of free alkali present in differentsoaps/detergents

(C) Oxidation-ReductionTitrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$solution.

(ii) Estimation of oxalic acid and sodium oxalate in a givenmixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and externalindicator.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson,2009.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

Semester	Course	Name of the course	Credits
I	CC 2	Organic Chemistry-I	Theory:3
			Practical: 2

Learning objectives:

On completion of this course, the students will be able to understand:

- Basic of organic molecules, structure, bonding, reactivity and reactionmechanisms.
- Stereochemistry of organic molecules – conformation and configuration, asymmetricmolecules andnomenclature.
- Aromatic compounds and aromaticity, mechanism of aromaticreactions.
- Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, identifying chiral centers.
- Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
- Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs*.elimination.

OrganicChemistry-I (Theory)

UNIT I: Basics of Organic Chemistry **10 Lectures**

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric,resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples.Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes).Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT II: Stereochemistry **6 Lectures**

Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis–trans andsyn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

UNIT III: Chemistry of Aliphatic Hydrocarbons **18 Lectures**

A. Carbon-Carbon sigmabonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.

B. Carbon-Carbonpi-bonds

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions.Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2- and 1,4- addition reactions in

conjugated dienes and, Diels- Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilicadditions.

C. Cycloalkanes and ConformationalAnalysis

Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

UNIT IV: Aromatic Hydrocarbons 6 Lectures

Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups.

Recommended Books/References:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
2. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill,(2007)
3. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill(2008).
4. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford UniversityPress.
5. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher,(2000).

Organic Chemistry-I (Practical)

1. Checking the calibration of thethermometer.
2. Purification of organic compounds by crystallization using the followingsolvents:

   a.Water b. Alcohol c. Alcohol-Water
3. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting pointapparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillarymethod)
6. Chromatography
   a. Separation of a mixture of two amino acids by ascending and horizontal paper Separation of a mixture of two sugars by ascending paperchromatography
   b. Separation of a mixture of *o*-and *p*-nitrophenol or o-and p-aminophenol by thin layer chromatography(TLC).
   c. chromatography

Recommended Books/Reference:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson(2012)

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
II	CC 3	Physical Chemistry-I	Theory:3
			Practical: 2

Learning objective:

On completion of this course, the students will be able to understand:

- Familiarization with various states ofmatter.
- Physical properties of each state of matter and laws related to describe thestates.
- Calculation of latticeparameters.
- Electrolytes and electrolytic dissociation, salt hydrolysis and acid-baseequilibria.
- Understanding Kinetic model of gas and itsproperties.
- Maxwell distribution, mean-free path, kineticenergies.
- Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of correspondingstates.
- Liquid state and its physical properties related to temperature and pressurevariation.
- Properties of liquid as solvent for various household and commercialuse.
- Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simplesalts.
- Ionic equilibria – electrolyte, ionization,dissociation.
- Salt hydrolysis (acid-base hydrolysis) and its application inchemistry.

Physical Chemistry-I (Theory)

UNIT I: Gaseous state **12 Lectures**

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behavior.van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and theircomparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

UNIT II: Liquid state **5 Lectures**

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

UNIT III: Ionic equilibria **13 Lectures**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of

ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-proticacids.

Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts.Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubilityproduct.

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations.Multistage equilibria in polyelectrolytes.

UNIT IV: Solid state **10 Lectures**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitativeidea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals, Glasses and liquid crystals.

Recommended Text books/references:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India(2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa(2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009). 5 G. M. Barrow, Tata McGraw Hill (Fifth Edition)(2007)

Physical Chemistry-I (Practical)

1. Surface tensionmeasurements.

a. Determine the surface tension by (i) drop number (ii) drop weightmethod.

b. Study the variation of surface tension of detergent solutions withconcentration.

2. Viscosity measurements using Ostwald'sviscometer.

a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at roomtemperature.

b. Viscosity of sucrose solution with the concentration ofsolute.

3. pH metry

a. Effect on pH of addition of HCl/NaOH to solutions of aceticacid,sodium acetate and their mixtures.

b. Preparation of buffer solutions of differentpH

   i. Sodium acetate-aceticacid

   ii. Ammonium chloride-ammoniumhydroxide

c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strongbase.

d. Determination of dissociation constant of a weakacid.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended text books/references:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi(2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York(2003).
3 Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York(2003).
4 Athawale V. D. amd Mathur P. Experimental Physical Chemistry,, New Age Intenational (2001)

Semester	Course	Name of the course	Credits
II	CC 4	Organic Chemistry-II	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Familiarization about classes of organic compounds and their methods ofpreparation.
- Basic uses of reactionmechanisms.
- Name reactions, uses of various reagents and the mechanism of theiraction.
- Preparation and uses of various classes of organiccompounds.
- Organometallic compounds and theiruses.
- Organic chemistry reactions and reactionmechanisms.
- Use of reagents in various organic transformationreactions.

OrganicChemistry-II (Theory)

UNIT I: Chemistry of Halogenated Hydrocarbons 8 Lectures

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_N^i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li and their use in synthesis.

UNIT II: Alcohols, Phenols, Ethers and Epoxides 6Lectures

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

UNIT III: Carbonyl Compounds 10 Lectures

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC);

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT IV: Carboxylic Acids and their Derivatives **10 Lectures**

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtiusrearrangement.

UNIT V: Sulphur containing compounds **6 Lectures**

Preparation and reactions of thiols, thioethers and sulphonic acids.

Recommended Books/references:

1 Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry*, John Wiley & Sons, Inc(2009).

2 McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013. 3 P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, NewDelhi.

4 Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India,2003.

OrganicChemistry-II (Practical)

1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.
2. Organic preparations:
   i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistryapproach)
   ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumannreaction.
   iii. Oxidation of ethanol/ isopropanol (Iodoformreaction).
   iv. Bromination (anyone)
      a. Acetanilide by conventionalmethods
      b. Acetanilide using green approach (Bromate-bromidemethod)
   v. Nitration: (anyone)
      a. Acetanilide/nitrobenzene by conventionalmethod
      b. Salicylic acid by green approach (using ceric ammoniumnitrate).
   vi. Selective reduction of *meta*dinitrobenzene to*m*-nitroaniline.
   vii. Reduction of *p*-nitrobenzaldehyde by sodiumborohydride.
   viii. Hydrolysis of amides andesters.
   ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
   x. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid,

oxalic acid, phenyl acetic acid and phthalicacid).

xi. Aldol condensation with either conventional or greenmethod.

xii. Benzil-Benzilic acidrearrangement.

Collected solid samples may be used for recrystallization, melting point and TLC.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1 Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education(2009)

2 Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson(2012)

3 Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press(2000)

4 Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press(2000).

Semester	Course	Name of the course	Credits
III	CC 5	Physical Chemistry-II	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Laws of thermodynamics andconcepts.
- Partial molar quantities and itsattributes.
- Understanding the concept of system, variables, heat, work, and laws ofthermodynamics.
- Understanding the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy,etc.
- Understanding the concept of entropy; reversible, irreversible processes. Calculation of entropy using 3nd law ofthermodynamics.
- Understanding the application of thermodynamics: Joule Thompson effects, partial molar quantities.
- Understanding theories/thermodynamics of dilutesolutions.

Physical Chemistry-II (Theory)

UNIT-I: Introduction to thermodynamics **6 Lectures**

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.*First law:* Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabaticconditions.

UNIT II: Thermochemistry **6 Lectures**

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions.

UNIT III: Second Law **6 Lectures**

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy.Calculation of entropy change for reversible and irreversible processes.

UNIT IV: Third law of thermodynamics **4 Lectures**

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.

UNIT V: Free Energy Functions **6 Lectures**

Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation ofstate.

UNIT VI: Partial molar quantities **6 Lectures**

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

UNIT VII: Dilute solutions **6 Lectures**

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amountof solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Recommended Books/References

1 Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.

2 Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa, 2004.

3 Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall,2012.

4 McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.

5 Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001

6 *Commonly Asked Questions in Thermodynamics.* CRC Press,2011.

7 Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010. 8 Metz, C.R. *2000 solved problems in chemistry*, Schaum Series,2006.

Physical Chemistry-II (Practical)

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities onit.
2. Study the equilibrium of at least one of the following reactions by the distribution method:
   (i) I_2 (aq)+$I^- \rightarrow I_3^-$(aq)
   (ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$
3. Study the kinetics of the followingreactions.
   a. Acid hydrolysis of methyl acetate with hydrochloricacid.
   b. Saponification of ethylacetate.

Adsorption

Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand, New Delhi,2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry,* Eighth Edition,McGraw-Hill(2003).
3 Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry,* Third Edition, W, H. Freeman (2003).

Semester	Course	Name of the course	Credits
III	CC 6	Organic Chemistry-III	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Nitrogen containing functional groups and theirreactions.
- Familiarization with polynuclear hydrocarbons and theirreactions.
- Heterocyclic compounds and theirreactions.
- Alkaloids andTerpenes
- Understanding reactions and reaction mechanism of nitrogen containing functional groups.
- Understanding the reactions and mechanisms of diazoniumcompounds.
- Understanding the structure and their mechanism of reactions of selected polynuclear hydrocarbons.
- Understanding the structure, mechanism of reactions of selected heterocycliccompounds.
- Classification, structure, mechanism of reactions of few selected alkaloids andterpenes.

OrganicChemistry-III (Theory)

UNIT I: Nitrogen Containing Functional Groups 8 Lectures

Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium salts: Preparation and synthetic applications.

UNIT II: Polynuclear Hydrocarbons 8 Lectures

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.**UNIT III:Heterocyclic Compounds 12 Lectures**

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid.

UNIT IV: Alkaloids 6 Lectures

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of

Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

UNIT V: Terpenes **6 Lectures**

Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol.

Recommended Text Books/references:

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7thEdn., Pearson.
2 Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* John Welly & Sons (1976).
3 Solomons, T.W., Fryhle Craig, *Organic Chemistry*, John Wiley & Sons, Inc(2009).
4 McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
5 Kalsi, P. S. *Organic reacations and their mechanisms*, New Age Science(2010).
6 Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press Inc., New York(2001).
7 Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan(2010).
8 Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, Third Edition (1999).
9. Clayden J., Greeves N., Warren S., Organic Chemistry, (2nd Ed)., (2012), Oxford University Press.

Organic Chemistry-III (Practical)

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols,etc.
2. Identification of functional groups of simple organic compounds by IR spectroscopy and NMR spectroscopy
3. Preparation of methylorange.
4. Extraction of caffeine from tealeaves.
5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars using simple labprocedures.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Vogel, A.I. *Quantitative Organic Analysis,* Part 3, Pearson(2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education(2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson(2012).
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press(2000).
5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press(2000).

Semester	Course	Name of the course	Credits
III	CC 7	Molecular Spectroscopy & Photochemistry	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Interaction between radiation and molecules at various energy levels.
- About various type of spectroscopic techniques.
- Characterization of molecules using various spectroscopic techniques.
- Law of Photochemistry, quantum yield and Franck-Condon Principle.
- About photochemical reaction, Fluorescence and Phosphorescence.

Molecular Spectroscopy &Photochemistry (Theory)

Unit-I **15 Lectures**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Unit-II **10 Lectures**

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

Unit-III **15 Lectures**

Photophysical and photochemical processes: laws of photochemistry, quantum yield. Jablonski diagrams: Franck-Condon principle, Law of photochemical equivalence, quantum efficiency, low and high quantum efficiency. kinetics of photochemical reactions ($H_2 + Br_2 = HBr$, $2HI = H_2 + I_2$), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, Discussion of Electronic spectra and photochemistry (Lambert-Beer law and itsapplications).

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition(International)1999
2. Levine I. N., *Physical Chemistry*, Fourth Edition), McGraw-Hill (International),1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,*University Science Books,1998
4. Rohatgi-Mukherjee K. K. Fundamentals of Photochemistry, New age (revised second

edition).

5. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi(2006).

Molecular Spectroscopy & Photochemistry (Practical)

(i) Determination of indicator constant-colorimetry.

(ii) Verification of Beer's Law - Determination of concentration of solution by colorimetry.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested books/reference books:

1. Practicals in physical chemistry – a modern approach, P.S.Sindhu,Macmillan,
2. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.

Semester	Course	Name of the course	Credits
IV	CC 8	Physical Chemistry-III	Theory:3
			Practical: 2

Learning objective:

After completion the course, the learner shall be able to understand:

- Phases, components, Gibbs phase rule, Phase diagrams andapplications.
- Chemical kinetics: type of reactions, determination of rate, theories of reaction rate, steady stateapproximation.
- Catalyst – mechanism, acid base catalysis, enzymecatalysis.
- Adsorptionisotherms.
- Understanding phases, components, Gibb's phase rule and its applications, construction of phase diagram of different systems, the application of phasediagram.
- Understanding the basics of chemical kinetics: determination of order, molecularity, and understanding theories of reaction rates, determination of rate of opposing/parallel/chain reactions with suitable examples, application of steady state kinetics, Steady-state approximation.
- Catalyst – mechanism of catalytic action, enzymecatalysis.
- Langmuir, Freundlich – adsorption isotherms, significance, multilayer adsorption – theory andsignificance.

PhysicalChemistry-III (Theory)

UNIT-I: Phase Equilibria **10 Lectures**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water- chloroform-acetic acid system, triangular plots.*Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-II: Chemical Kinetics **10 Lectures**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT-III: Catalysis **10 Lectures**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts.Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

UNIT-IV: Surface chemistry **10 Lectures**

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Recommended books/References:

1. Atkins P. W. and De Paula J., *Physical Chemistry, (*tenth edition) Oxford University Press, 2014.
2 Castellan, G. W. *Physical Chemistry,* 4th Ed., Narosa,2004.
3 McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics,* Viva Books,2004.
4 Engel, T. & Reid, P. *Physical Chemistry* Third Edition,Prentice-Hall,2012.
5 Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011
6 Ball, D. W. *Physical Chemistry* Cengage India, 2012.
7 Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP, 2009.
8 Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill, 2011.
9 Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill,2009.

PhysicalChemistry-III (Practical)

Conductometry

1 Determination of cellconstant

2 Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

3 Conductometric titrations of: (i) Strong acid Vs. strong base, (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and weak acid vs. strong base.

Potentiometry

Potentiometric titrations of: (i) Strong acid vs. strong base, (ii) Weak acid vs. strong base (iii) Dibasic acid vs. strong base, (iv) Potassium dichromate vs. Mohr'ssalt.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommend books/References:

1 Khosla, B. D.; Garg, V. C. and Gulati, A. *Senior Practical Physical Chemistry,* R. Chand New Delhi,2011.
2 Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* Eighth Edition*;* McGraw-Hill: New York,2003.
3 Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York,2003.

Semester	Course	Name of the course	Credits
IV	CC 9	Inorganic Chemistry-II	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Oxidation-Reductions and their use inmetallurgy.
- Chemistry of s and p-blockelements.
- Chemistry of noblegases.
- Inorganic polymers and theiruse.
- Understanding redox reactions in hydrometallurgyprocesses.
- Structure, bonding of s and p block materials and theiroxides/compounds.
- Understanding chemistry of boron compounds and theirstructures.
- Chemistry of noble gases and their compounds; application of VSEPR theory in explaining structure andbonding.
- Understanding chemistry of inorganic polymers, their structures anduses.

Inorganic Chemistry-II (Theory)

UNIT-I: Oxidation-Reduction and general principle of metallurgy 8 Lectures

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel- de Boer process and Mond's process, Zonerefining.

UNIT-II: Chemistry of *s* and *p* Block Elements 16 Lectures

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation.Complex formation tendency of *s* and *p* block elements.Hydrides and their classification ionic, covalent and interstitial.Basic beryllium acetate andnitrate.

Structure, bonding, preparation, properties and uses.Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine.Per-oxo acids of Sulphur inter-halogen compounds, poly-halide ions, pseudo-halogens, properties of halogens.

UNIT-III: Noble Gases 8 Lectures

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory).

UNIT-IV: Inorganic Polymers 8 Lectures

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes.Borazines, silicates and phosphazenes, and polysulphates.

Recommended books/references:

1 Lee, J.D. *Concise Inorganic Chemistry*, ELBS,1991.

2 Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y.1994.

3 Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.

4 Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH,1999.

5 Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.

6 Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010

7 Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

Inorganic Chemistry-II (Practical)

(A) Iodo / IodimetricTitrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution(Iodimetrically).

(ii) Estimation of (i) arsenite and (ii) antimonyiodimetrically

(iii) Estimation of available chlorine in bleaching powderiodometrically.

(B) Inorganicpreparations

(i) Cuprous Chloride,Cu_2Cl_2

(ii) Preparation of Aluminium potassium sulphate (Potash alum) or Chromealum.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/references:

Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* Sixth Edition Pearson, 2009.

Semester	Course	Name of the course	Credits
IV	CC 10	Introduction to Quantum Chemistry	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Basics of Quantum Chemistry
- Basic idea about operators, Schrodinger equation and its applications.
- Use of Schrodinger equation in simple harmonic oscillator model, hydrogen atom and hydrogen like atoms.
- Quantum mechanical approach towards valence bond and molecular orbital theory.

Introduction to QuantumChemistry (Theory)

Unit-I **15 Lectures**

Introduction to black-body radiation and distribution of energy, photo-electic effect, concept of quantization, wave particle duality (de-Broglie's hypothesis), The uncertainty principle, The wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, eigen function and values, Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation in polar coordinates, radial and angular parts of the hydrogenic orbitals, degeneracies, spherical harmonics, representations of hydrogenic orbitals.

Unit-II **15 Lectures**

Quantitative treatment of simple harmonic osciallator model, setting up of Schodinger equation and discussion of solution of wave functions.Rigid rotator model and discussion of application of Schrodinger equation.idea about transformation to spherical polar coordinate, discussion on solution.

Unit-III **10 Lectures**

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Valence bond and molecular orbital approaches, LCAO-MO treatment of H_2, H_2^+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations.

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition(International)1999
2. Levine I. N., *Physical Chemistry*, Fourth Edition), McGraw-Hill (International),1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach*,UniversityScience Books, 1998.
4. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill(2001).
5. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA(2004).

Introduction to Quantum Chemistry (Practical)

i. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine π bonds.

ii. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans*2-butene.

iii. Visualize the electron density and electrostatic potential maps for LiH, HF, N_2, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules. (Software: ChemSketch, ArgusLab(www.planaria-software.com),TINKER 6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similarsoftware.

- Determination of indicator constant -colorimetry.
- Verification of Beer's Law - Determination of concentration of solution bycolorimetry.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested books/reference books:

1. Essentials of computational chemistry – Theories and models, C. J. Crammer, Wiley, 2nd Edn., 2.Principle and applications of quantum chemistry, V.K.Gupta, Elsevier, 2016.
3. Practicals in physical chemistry – a modern approach, P.S.Sindhu,Macmillan,
4. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.
5. A.R. Leach, *Molecular Modelling Principles and Application*, Longman,2001.
6. J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons,1997.
7. Gupta, S.P. *QSAR and Molecular Modeling*, Springer - Anamaya Publishers,2008.

Semester	Course	Name of the course	Credits
V	CC 11	Inorganic Chemistry-III	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Coordination compounds – its nomenclature, theories, d-orbital splitting in complexes, chelate.
- Transition metals, its stability, color, oxidation states andcomplexes.
- Lanthanides, Actinides – separation, color, spectra and magneticbehavior
- Bioinorganic chemistry – metal ions in biological system, its toxicity;hemoglobin.
- Understanding the nomenclature of coordination compounds/complexes, Molecular orbital theory, d-orbital splitting in tetrahedral, octahedral, square planar complexes, chelate effects.
- Understanding the transition metals stability in reactions, origin of colour and magnetic properties.
- Understanding the separation of Lanthanoids and Actinoids, its color, spectra and magneticbehavior.
- Understanding the bioinorganic chemistry of metals in biologicalsystems.
- Hemoglobin and its importance in biologicalsystems.

Inorganic Chemistry-III (Theory)

UNIT-I: Coordination Chemistry **10 Lectures**

Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, , weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbitalsplitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series, Qualitative aspect of Ligand field theory, MO diagrams of representative coronation complexes, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelateeffect,

UNIT-II: Transition Elements **10 Lectures**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams).Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

UNIT-III: Lanthanoids and Actinides **10 Lectures**

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide

contraction, separation of lanthanides (ion-exchange method only).

UNIT-IV: Bioinorganic Chemistry **10 Lectures**

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on distribution of metals.Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), toxicity, chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

Recommended text books/References:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
2. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
3. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
4. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
5. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

Inorganic Chemistry-III (Practical)

1. Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given on understanding of the chemistry of different reactions. Following radicals may be analyzed:

   Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium. Mixtures containing one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-,Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot analysis/tests should be done whenever possible.
2. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
3. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. (Also find the λ_{max} of the prepared complex usinginstrument).
4. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitutionmethod.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended text books/references:

1. Vogel's *Qualitative Inorganic Analysis,* Revised by G. Svehla. Pearson Education,2002.
2. Marr & Rockett *Practical Inorganic Chemistry.* John Wiley & Sons1972.

Semester	Course	Name of the course	Credits
V	CC 12	Analytical Chemistry	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the student shall be able to understand:

- Familiarization with fundamentals of analyticalchemistry.
- Basics of spectroscopic, thermal, electrochemicaltechniques
- Learning basics of separation techniques and itsapplications.
- Understanding analytical tools, statistical methods applied to analyticalchemistry.
- Understanding principle of UV-Vis spectroscopy and itsapplications.
- Understandingprinciplesofthermo-gravimetric analysis and study of thermaldecomposition of materials/characterization ofmaterials.
- Understanding basics of electro-analytical techniques and itsapplications.
- Understandingprinciplesofseparationtechnology andits use in advanced instrumentations.

Analytical Chemistry (Theory)

UNIT-I: Qualitative and quantitative aspects of analysis **4 Lectures**

Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.

UNIT-II: Spectroscopy **8Lectures**

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

Vibration spectroscopy: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra

UV-Visible Spectrometry: Basic principles of instrumentation, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

UNIT-III: Thermal analysis **6 Lectures**

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from theirmixture.

UNIT-IV: Electroanalytical methods **6 Lectures**

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. determination of pKa values.

UNIT-V: Separation techniques **16 Lectures**

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction

of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC andHPLC.

Recommended Books/Reference Books:

1 Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson,2009.

2 Willard, H.H. *et al*.: *Instrumental Methods of Analysis*, 7th Ed. WardsworthPublishing California, USA,1988.

3 Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

4 Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.

5 Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis, Saunder College Publications,(1998).*

6 Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, EllesHarwood John Wiley1979.

7 Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand,1974.

8 Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998

9 Skoog D.A., Holler F.J., Nieman T.A., Principles of instrumental analysis, 5thEdn., Brooks & Cole(1997).

Analytical Chemistry (Practical)

At least two experiments from each section

I. Chromatography:

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, andCr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the $R_f$values.

(iii) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their $R_f$values.

(iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

(i) To separate a mixture of Ni^{2+}& Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.

(ii) Determine the pH of the given aerated drinks fruit juices, shampoos andsoaps.

(iii) Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

III. Analysis of soil:

(i) Determination of pH ofsoil.

(ii) Total solublesalt

(iii) Estimation of calcium, magnesium, phosphate,nitrate

IV. Ionexchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchangeresins.

(ii) Separation of metal ions from their binarymixture.

(iii) Separation of amino acids from organic acids by ion exchangechromatography.

V. Spectrophotometry

(i) Determination of pKa values of indicator using spectrophotometry.

(ii) Structural characterization of compounds by infraredspectroscopy.

(iii) Determination of dissolved oxygen inwater.

(iv) Determination of chemical oxygen demand(COD).

(v) Determination of Biological oxygen demand(BOD).

(vi) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended text books/references:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson,2009.
2. Willard, H.H. *et al*.: *Instrumental Methods of Analysis,* 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York,2004.
4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New AgeInternational Publisher,2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning IndiaEdition.
7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd.London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, NewYork, 1974.

Semester	Course	Name of the course	Credits
VI	CC 13	Green Chemistry	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Green chemistry and itsprinciples.
- Green synthesis andreactions.
- Green chemistry for sustainablesolutions.
- Understanding principles of greenchemistry.
- Understanding design of chemical reactions/chemical synthesis using green chemistry principles.
- Atom economy and design of chemical reactions using theprinciple.
- Understanding the use of green chemistry principle and processes in laboratoryreactions.

Green Chemistry (Theory)

UNIT-I: Introduction to Green Chemistry **4 Lectures**

Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry

UNIT-II: Principles of Green Chemistry and Designing a Chemical synthesis 12 Lectures

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts;maximumincorporationofthematerialsusedintheprocessintothefinalproducts,Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions).

UNIT-III: Green Synthesis / Reactions **16 Lectures**

1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).
2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylationreaction).
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative toIodine)
4. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning ofgarments.
5. Designing of Environmentally safe marineantifoulant.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made fromcorn.
7. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats andOils

UNIT-IV: Future Trends in Green Chemistry **8 Lectures**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C_2S_3); Green chemistry in sustainabledevelopment.

Recommended Books/References:

1. Ahluwalia, V.K., Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers(2005).
2. Anastas, P.T. & Warner, J.K, *Green Chemistry- Theory and Practical*, Oxford University Press(1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker(2001).
4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS(2000).
5. Ryan, M.A. and Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010.

Green Chemistry (Practical)

Any six experiments may be conducted

1. Preparation and characterization of nanoparticles of gold using tealeaves.
2. Preparation of biodiesel from vegetable/ waste cookingoil.
3. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates GreenChemistry.
4. Reactions like addition, elimination, substitution and rearrangement may also be studied for the calculation of atomeconomy.
5. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead ofcyanide).
6. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dryice.
7. Mechanochemical solvent free synthesis ofazomethines
8. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II)complex.
9. Photoreduction of benzophenone to benzopinacol in presence ofsunlight.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC(2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC(2002).
4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph, International Publishing ISBN 978-93-81141-55-7(2013).
5. Cann, M.C. and Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society(2008).

6. Cann, M. C. and Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society(2008).
7. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010.
8. Pavia, D. L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach,* W.B.Saunders,1995.

Semester	Course	Name of the course	Credits
VI	CC 14	Chemistry of Materials	Theory:3
			Practical: 2

Learning objective:

After completiton of the course, the learner shall be able to understand:

- Crystalline solids – parameters,symmetry.
- Silica based materials inapplications.
- Technological importance of ionic liquids, preparation of materials– using sol-gel technique.
- Nano-structured materials, self-assembledstructure.
- Composites and itsapplications
- Understanding basic parameters of crystalline solids, symmetry and crystalstructures.
- Mesoporous/microporous silica based materials, functionalized hybrid materials and its applications.
- Preparation of inorganic solids, host-guest chemistry, ionic liquids and itssignificance.
- Understanding self-assembled structures, nano-structured materials, carbon nanotubes, applications.
- Understanding composites and their industrialapplications.

Chemistry of Materials (Theory)

UNIT-I: Basics of crystalline solids **8 Lectures**

Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors – cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances, directions, types of bonding , lattice energy, Madelung constants, Born Haber cycle, cohesive energy, Symmetry elements, operations , translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals, polymorphism,twinning.

UNIT-II: Silica based materials **8 Lectures**

Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications

UNIT-III: Inorganic solids/ionic liquids of technological importance **8 Lectures**

Preparation of inorganic solids: Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydro-thermal method, Ion-exchange and Intercalation methods. Introduction to Solid electrolytes, inorganic liquid crystals. Ionic liquids, forces responsible for ionic liquids, synthesis and application of imidazolium and phosphonium based ionic liquids. Host-guest chemistry (elementaryideas).

UNIT-IV: Nanomaterials **8 Lectures**

Overview of nanostructures and nano-materials: classification. Preparation of gold and silver

metallic nanoparticles, self-assembled nanostructures-control of nano-architecture-one dimensional control.Carbon nanotubes and inorganic nanowires.

UNIT-V: Composite materials **8 Lectures**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

Recommend books/References:

1. Atkins P, Overton T., Rourke J. Weller M. and Armstrong F *Shriver and Atkins. Inorganic Chemistry* Oxford University Press, Fifth Edition,2012.
3. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. JohnWiley,1974.
4. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley2003.
5. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning,2002.

Chemistry of Materials (Practical)

1. Preparation of urea-formaldehyderesin
2. Preparations of novalac resin/resolresin
3. Synthesis of materials/porous materials (Sol-gel, hydrothermal, microwave). (Similarly other materials synthesis can bedesigned).
4. Preparation of silver nano material. (Similarly other nano materials of other metals synthesis can bedesigned).
5. Analysis of XRD pattern ofcrystals.
6. Interpretation of FTIR, NMR and UV-Vis data of givenmaterial.
7. Estimation of particle size from the BET, SEMtechniques.
8. Density measurement of ionicliquids
9. Determining dynamic viscosities of given ionicliquids
10. Determination of hydration number IRspectra.

Note: Experiments may be added/deleted subject to availability of time and facilities

DISCIPLINE SPECIFIC ELECTIVE COURSES

Semester	Course	Name of the course	Credits
V,VI	DSE1	Medicinal Chemistry	Theory: 3
			Practical: 2

Learning objective:

After completion of the course, the learner can be able to understand:

- The basics of medicinal chemistry, biophysicalproperties
- Biological activityparameters
- Drugmetabolism
- Biophysical and chemical properties of enzymes, hormones, vitamins
- Concept of rational drug design

Unit 1: Bio-physicochemical properties

Acidity/Basicity, Solubility, Ionization, Hydrophobic properties, Hydrophilic properties, Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as K_i, K_d, LD_{50}, EC_{50}, IC_{50}, CC_{50}, ADMET properties.

Unit 2: Structural properties

Isosterism, Bioisosterism, Nonclassical isosteres, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of Configuration and Conformation with examples, Concept of stereochemistry in terms of biological response with examples, Stereoselective receptors or enzymes such as muscarinic receptor, Stereochemically pure drug and recemates, Examples such as catecholamines, etc.

Unit 3: Drug target understanding

Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist, Examples.

Unit 4: Medicinal Chemistry of Therapeutic Agent

Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents such as Anti-infective agent, Antimalarials, Antibacterial, Antiviral, Anticancer, CNS acting drugs, Adrenergic Agents, Cholinergic Drugs, Diuretics, Cardivascular, local anesthetic agent, Analgesic Agents, Histamine and Antihistamine agents.

Unit 5: Steroids, Prostaglandins, Enzyme, Hormone and Vitamins

Biophysico-chemical properties, Steroid Hormone Receptors, Chemical Contraceptive agents, COX-2 inhibitors, Prostaglandins for Ophthalmic use, pharmaceutically important enzyme products such as Pancreatin, Trypsin, Insulin. Classification of vitamins with examples.

Unit 6: Concept of rational drug design

Structure activity relationship, Drug-receptor understanding, Molecular modeling, Structure based drug design. QSAR.

Recommended books/References:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...by Charles Owens Wilson, John H. Block, Ole Gisvold, John MarloweBeale
2. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William O. Foye (2008), Kluwerpublication.
3. Remington: The Science and Practice of Pharmacy Vol 1, Ed. 19 by Joseph Price Remington, Alfonso R. Gennaro. (1995), MACKPublishing.
4. Burgers Medicinal Chemistry by Manfred E. Wolff, AlfredBurger
5. Burgers Medicinal Chemistry and Drug Discovery by Abraham D. J., Lewis F. L., Burger A., vol.5, 6th Edn., 2003, HobokenN.J.Wiley,
6. The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2nd Edn., Academic Press.2012.
7. Exploring QSAR: Fundamental and applications in Chemistry and Biology by Hansch C. and Leo, A American Chemical Society(1995)
8. Patrick, G. Medicinal Chemistry, Oxford.University Press(2000).

Suggested list of Experiments

1. Purification Techniques of Solvents by Fractional Distillation and Vacuum Distillation.
2. Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by ColumnChromatography.
3. Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties.(Benzilic Acid & SodiumBenzoate)
4. Synthesis & Purification of following Compoundsusing:

   (i) Precipitation or Recrystallization. (ii) Synthesis of Benzimidazole. (iii) Synthesis of Anthranilic Acid. (iv) Synthesis of Sulphanilamide. (v) Synthesis of benzoic acid from benzyl alcohol. (vi) Synthesis of 1,4 – dihydropyridine.
5. Computational modeling of drug design/use of softwares may be demonstrated tostudents.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested books/references:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D.Barnes, M. J. K Thomas, 6th Edition, Pearson's Education Ltd.
2. Advanced Practical Medicinal Chemistry, Ashutosh Kar, New Age International Ltd. (2004).
3. Vogel"sTextbookofPracticalOrganicChemistry,B.S.Furniss,A.J.Hannaford,P. W. G. Smith, A. R. Tatchell, 5th edition (2008), Pearson's Education Ltd

Semester	Course	Name of the course	Credits
V,VI	DSE2	Electrochemistry	Theory: 3
			Practical: 2

Learning objective:

After completion of the course, the learner can be able to understand:

- Basic principle of laws ofelectrochemistry.
- Understanding about chemical cells and theirfunction.
- Understanding about electrodes, EMFmeasurement.
- Understanding about potentiometric titrations and their applications.

Unit-I

Arrhenius theory of electrolytic dissociation.Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Molar conductivity at infinite dilution.Kohlrausch law of independent migration of ions.Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants ofsalts.

Unit-II

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.Chemical cells, reversible and irreversible cells with examples.Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and withouttransference,liquidjunctionpotential;determinationofactivitycoefficientsand transference numbers.Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Unit-III: Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKavalues.

Unit-IV: Electrical & Magnetic Properties of Atoms and Molecules: Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecularinterpretation.

Recommended books/reference books

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP

(2009).
4. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
6. Rogers, D. W. Concise Physical Chemistry Wiley(2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc.(2005).

List of suggested laboratory experiments

1. Determination of pH of a given solution using glasselectrode.
2. Determination of cellconstant.
3. Determination of equivalent conductance, degree of dissociation, and dissociation constant of weak acid.
3. Conductometric titration: strong acid *vs*. strong base, weak acid *vs*. strongbase.
4. Potentiometric titration: strong acid *vs*. strong base, weak acid *vs*. strong base,potassium dichromate vs. mohr'ssalt.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/reference books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi(2011).
2. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.
3. Garland,C.W.;Nibler,J.W.&Shoemaker,D.P.*ExperimentsinPhysicalChemistry8thEd.;* McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York(2003).

Semester	Course	Name of the course	Credits
V,VI	DSE3	Polymer Chemistry	Theory: 3
			Practical: 2

Learning objective:

After completion of the course, the learner can be able to understand:

- The mechanism of polymer materialformation.
- Molecular weight and structure propertyrelationship
- Polymerization procedure and Zigler-Nattacatalysis.
- Characterization ofpolymers

Unit 1: Introduction

Polymer, monomer, examples of polymers, biopolymers, classification, polymerization process, degree of polymerization, condensation, addition polymers, kinetics of addition polymerization process.

Unit 2: Polymeric Structure and Property Relationship

Structure of polymers - Linear, branched, cross linked, and network polymers, molecular weight (number average, weight average, viscosity average) and distribution of molecular weight, polydispersity index, crystallinity in polymer, melting temperature and glass transition temperature, Volumetric properties - molar volume, density, Van der Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

Unit 3: Polymerization Chemistry

Industrial methods of polymerization such as a bulk, solution, emulsion, suspension.Stereochemistry of polymers and stereo-specific polymerization, Catalysts-their utility in polymers and stereo-specific polymerizations, Catalysts their utility in polymer manufacture, Zieglar-Natta, Metallocene and others.

Unit 4: Characterization of Polymers

Molecular Weight Determination by Light Scattering, Osmometry, End-Group Analysis, Viscosity, Gel Permeation Chromatography; Application, of FTIR, UV-visible, NMR, and Mass Spectroscopy for Identification of polymers.

Recommended books/References:

1. D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company Amsterdam - Oxford - Newyork.1990.
2. J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996.
3. Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press,1987
4. Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York(1970).
5. W. Billmeyer, Text book of polymer science, 3rdEdn., 2007,Wiley.
6. J.R.Fried, Polymer Science and Technology, (2005), PHIpublication.
7. Billmeyer Jr.; Fred W., Textbook of Polymer Science, Wiley- Interscience Publishers,

New York(1962).

List of suggested laboratory practicals

1. Free radical solution polymerization of any one: Styrene, methylmethacrylate, methyl acrylate, methacrylic acid (using free radical initiators). (purification of monomer should betaught)
2. Preparation of phenol-formaldehyderesins.
3. Emulsion polymerization ofpolymethylmethacrylate.
4. Use of viscometer for molecular weight determination – (any known polymer, example: polyvinyl pyrrolidone in water/polyacrylamide in $NaNO_2$ solution) by viscometry. (students should be explained regarding principles and use of ubblohde/ostwaldviscometer).
5. Estimation of amount of HCHO in a given solution by sodium bisulphitemethod.
6. Use of FTIR/TGA/DSC – for polymer characterization (may be demonstrated tostudents)
7. Determination of exchange capacity of cation exchange resins and anion exchangeresins.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/Reference books

1. P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. John Wiley & Sons (2002).
2. M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press (2005).
3. L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons(2005)

Semester	Course	Name of the course	Credits
V,VI	DSE4	Environmental Chemistry	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Compositon of atmosphere
- Biogeochemical cycles
- Hydrological cycle
- Water qualityparameters
- Atomospheric chemical phenomon and environmentalpollution
- Water pollution, parameters of water pollution, treatment of pollutedwater.

Unit 1: Environment

Composition of atmosphere, temperature variation of earth atmospheric system (temperature vs. altitude curve), biogeochemical cycles of C, N, P, S and O system.

Unit 2:Hydrosphere

Hydrological cycle, aquatic pollution and water quality parameters – Dissolve oxygen, biochemical oxygen demand, chemical oxygen demand, Analytical methods for the determination fluoride, chromium and arsenic, residual chlorine and chlorine demand, purification and treatment of municipal water and waste water.

Unit 3: Atmosphere

Chemical composition of atmosphere – particle, ions, and radicals in their formation, chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, and O and their effect, pollution by chemicals, CFC, Green House effect, acid rain, air pollution and control.

Unit 4: Aquatic chemistry

Water and its necessities, various water quality parameters (DO, BOD, COD, conductivity, pH, alkalinity, hardness) and its determination, Industrial, municipal water treatment processes, Waste water treatment procedure (primary, secondary and tertiary), Solid waste treatment. Soil pollution and Noisepollution.

Recommended Books/References:

1. De.A.K.Environmental Chemistry, Wiley Eastern Ltd,1990.
2. Miller T. G. Jr., Environmental Science, Wadsworth publishing House, Meerut Odum. E. P. 1971.
3. Odum, E.P. (1971) Fundamentals of Ecology. Third Edition, W.B. Saunders Co., Philadelphia
4. S. E. Manahan, Environmental chemistry, 1993, Boca Raton, Lewispublisher
5. Environmental chemistry, Sharma and Kaur, 2016, Krishnapublishers
6. Environmental Pollution, Monitoring and control, S.M. Khopker, 2007, New Age International.

7. Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W.H.Freemanpublication.
9. G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa(2009).
10. Principles of instrumental analysis: D. A. Skoog, Fifth Edition, Sauns College Publishing (London)
11. Basic concepts of analytical chemistry: S. M. Khopkar, Wiley Eastern(1995)

List of suggested laboratory practicals

Determination of water quality parameters in following aspect:

1. Determination of dissolved oxygen in given water (chemical method/instrumentation method).
2. Determination of Biological Oxygen Demand (BOD_5).
3. Determination of Chemical Oxygen Demand(COD).
4. Finding out percentage of available chlorine in bleachingpowder.
5. Measurement of chloride, sulphate and salinity of water samples by titration method ($AgNO_3$ and potassiumchromate).
6. Estimation of total alkalinity of water samples (carbonate, bicarbonate) by titrationmethod.
7. Estimation of SPM in airsamples.

Note: Experiments may be added/deleted subject to availability of time and facilities

List of Recommended books/Reference Books:

1. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, John Wiley & Sons, Inc. Publishers, New Delhi.(2005 edition).
2. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, NewDelhi.
3. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
4. A. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, NewDelhi.
5. S. M. Khopkar, *Environmental Pollution Analysis*: New Age Int. Publisher, NewDelhi.

Semester	Course	Name of the course	Credits
V,VI	DSE5	Advanced Materials Chemistry	Theory: 3
			Practical: 2

Learning Objectives

After completion of the course, the learner can be able to understand:

- Structure of molecules in solid state. How the atoms/molecules arranged in solid state and crystals.
- Characterizations of solid materials.
- Fundamentals of nanomaterials.
- Synthesis and characterization of nanomaterials.
- Different types of polymers.
- Synthesis and characterization of polymers.

Unit 1: Crystal structure of solids

Fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing efficiency, radius ratios; few important crystal structures. Synthesis of Inorganic solids; solid state, solution phase and vapor phase synthesis; precipitation, hydrothermal, sol-gel, surfactant based synthesis. Growth of single crystals.

Crystal structure determination by X-ray diffraction, d-spacing formula, symmetrically absent reflections, Multiplicities, Scattering of X-rays by an atom and a crystal.Single crystal and powder diffraction.Electron and neutron diffraction.Concept of reciprocal lattice.Electron microscopy techniques.

Unit 2: Nanomaterial fundamentals

Synthesis: Bottom-up vs. Top-down Methods. Solution phase synthetic methods. Role of surfactant in shape and size control of nanomaterials.Synthesis of nanowires and nanotubes by CVD and MOCVD method.

Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy.

Nanomaterial properties and applications: Magnetic properties of nanoparticles; superparamagnetism, ferromagnetism in antiferromagnetic nanoparticles and single domain to multidomain transition. magnetic nanoparticles as MRI contrast agents.

Unit 3: Frontier areas of polymer science and technology

Conducting polymers: basic principles of conducting polymers, delocalized electronic states of conjugated polymers, polyanilines, polyacetylenes, polythiophene, applications of conducting polymers.

Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, poly(vinyl alcohol), polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells.

Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA.

Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.

Recommended books/References:

1. Zhen Guo and Li Tan, *Fundamentals and Applications of Nanomaterials*.2009, Artech House, LondonPublication.

2. Physical methods for chemistry: R. S. Drago, 1992, Saunders collegepublication.

3. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International (P) Ltd., 2015.

4. P. J. Flory, Principle of polymer chemistry, Cornell UniversityPress.

5. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.

6. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int.Publication, 2019.

List of suggested Laboratory Experiment

1. Preparation of gold and silvernano-particles.
2. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) andphenolphthalein
3. Determination of composition of dolomite (by complexometrictitration).
4. Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given powder diffraction pattern of a cubic crystallinesystem.
5. Interpretation of FTIR, NMR and UV-Vis data of givenmaterial.
6. Estimation of particle size from the BET, SEMtechniques.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/Reference Book:

1. Fahlman, B.D. *Materials Chemistry,* Springer, 2004.

Semester	Course	Name of the course	Credits
V,VI	DSE6	Advanced Analytical Chemistry	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Methods in chemical analysis.
- Polarography: Instrumentation and applications.
- Theory and application of atomic spectroscopy.
- Theory and application thermogravimetric analysis.
- Theory and principle of chromatography.
- Analysis of fuel and drugs.

Unit 1: Statistical methods in chemical analysis

Theory of error and treatment of quantitative data, accuracy and precision, ways of expressing accuracy and precision, Normal error curve and its equation. Useful statistical tests with equation, test of significance, the F-test, the students t-test, the Chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis (least square method).

Unit 2: Polarography

Current-voltage relationship, theory of polarographic waves, instrumentation, qualitative and quantitative applications.

Unit 3: Atomic spectroscopy

Atomic absorption spectroscopy, theory and application (with some examples).

Unit 4: Thermal analysis

Theory, methodology, instruments and applications of theromogravimetric analysis (TGA/DTA), and differential scanning calorimetry (DSC).

Unit 5: Chromatography

Principles of chromatography, paper, column and thin layer chromatography, Gas-liquid chromatography, HPLC.

Unit 6: Analysis of fuel and drugs

Fuel analysis: Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel, Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point.

Drug analysis: Classification of drugs, Analysis of some standard drug using various chromatographic techniques.

Recommended books/references:

1 Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson,2009.

2 Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing California, USA,1988.

3 Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4 Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5 Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*
6 Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, EllesHarwood John Wiley1979.
7 Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand,1974.
8 Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998

List of suggested laboratory experiments

1. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures. Preparation of buffer solutions of different pH (i. Sodium acetate-acetic acid, ii. Ammonium chloride-ammoniumhydroxide

2. Principles involved in chromatographic separations. Paper chromatographic separation of following metalions:

   i. Ni (II) and Co(II)
   ii. Fe (III) and Al(III)

3. Chromatographic separation of the active ingredients of plants, flowers and juices byTLC.
4. IR/DSC analysis of known polymer sample (for students demonstrationonly)
5. Determination of flash point & fire point of given fuelsample.
6. Determination of viscosity index, cloud point, pour point of given fuelsample.
7. Determination of calorific value of given fuel sample/coal sample using bombcalorimeter.
8. Proximate analysis of given coalsample.
9. Determination of the iodine number ofoil.
10. Determination of the saponification number ofoil.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/Reference books:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
3. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009
4. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning IndiaEdition.

Semester	Course	Name of the course	Credits
V,VI	DSE7	Nuclear & Radiation Chemistry	Theory: 3
			Practical: 2

Learning Objectives

After completion of the course, the learner can be able to understand:

- Nuclear forces, nuclear stability, binding energy.
- Radioactive elements and general characteristics.
- Measurement of radioactivity.
- Radiation chemistry.
- Nuclear pollution and Radiological safety.

Unit 1: Nucleus and its classification, nuclear forces, nuclear stability, binding energy, nuclear models. Radioactive decay (Radioactive elements, general characteristics of radioactive decay, decay kinetics - decay constant, half-life, mean life period), units of radioactivity, Transient and secular equilibria, Carbon dating and itsusefulness.

Nuclear reactions: Bethe notation, types of nuclear reactions (n, p, α, d and γ), conservation of quantities (mass-energy and linear momentum) in nuclear reactions, reaction cross-section, compound nucleus theory and nuclear reactions. Nuclear fission: the process, fragments, mass distribution, and fission energy.

Unit 2: Measurement of radioactivity, idea about accelerator and detectors, Van de Graaaf and linear acceletors, synchrontrons, Geiger-Muller detector, Scintillaton detectors, Type of nuclear reactions, Nuclear fission, Nuclear fusion, Nuclear reactor: classification of reactors, the natural uranium reactor, breeder reactor. Nuclear fusion and stellarenergy.

Unit 3: Radiation chemistry: Elementary ideas of radiation chemistry, radiolysis of water and aqueous solutions, unit of radiation chemical yield (G-value), radiation dosimetry (Fricke's dosimeter), units of radiation energy (Rad, Gray, Rontgen, RBE, Rcm,Sievert)

Unit 4: Nuclear pollution and Radiological safety: Interaction of radiation with matter, Radiolysis of water, Radiation dosimetry. Radioactive isotopes and their applications, Isotopic dilution analysis, Neutron activation analysis, disposal of nuclear waste, nuclear.

Recommended Books/references:

1. Friendlander G, Kennedy G and Miller J. M. Nuclear and Radiochemistry, Wiley Interscience
2. Harvey, B. G. Introduction to Nuclear Physics & Chemistry, Prentice –Hall,
3. Overman R. T, Basic concept of Nuclear Chemistry, Chapman &Hall.
4. A. N. Nesmeyanov, Radiochemistry, MIR Publication,Moscow.
5. Spinks J. W. T. and Woods R. J. An Introduction to Radiation Chemistry,Wiley
6. Arnikar H. J., Essentials of Nuclear Chemistry, Wiley Eastern, SecondEdition.

Suggested laboratory practicals:

1. The safe laboratory use of radionuclide andradioisotopes
2. demonstration of activity on Geiger-Muller and scintillation basedcounter.

3. liquid scintillation counting, alpha spectrometry, gamma spectrometry – to identify and quantify radioisotopes.

4. occurrence of radon daughter particles in environmentalsamples.

5. Liquid-liquid separation/extraction of radio nuclide from environmental samples/water samples.

6. Isotopic application in removal process adsorption / ionexchange.

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
V,VI	DSE8	**Organic Spectroscopy**	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Spectroscopic techniques used for characterization of organic compounds.
- Basic Principles of UV, IR and NMR Spectroscopy and Mass Spectrometry.
- Application of various spectroscopy in characterization of chemical compounds.

Unit 1: Basic Principles of UV Spectroscopy

Application of Woodward-Fiser rule in interpretation of Organic compounds: Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λmax & εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax of conjugated dienes and α,β – unsaturated compounds.

Unit 2: Basic principles of IR Spectroscopy

Identification of Functional groups of various classes of organic compounds: Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Unit 3: NMR (^{1}H and ^{13}C NMR)

Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect in interpretation of NMR spectra, Isotopic exchange

Unit 4: Basic principles Mass Spectrometry

Application of fragmentation rule in characterization of organic compounds.Problems on structure elucidation of organic compounds based on spectral data.

Recommended Books/References:

1. R.M. Silverstein, G.C. Bassler & T.C. Morrill*: Spectroscopic Identification of Organic Compounds*, John Wiley &Sons.
2. John R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall India(2012).

Suggested laboratory experiments

1. Purification method for liquid, solid organic substance (distillation, recrystallization, chromatorgrapy)
2. Analysis of spectra of UV-Vis, FTIR, NMR and Mass of simple organic compounds. (azodyes, acetanilides, benzoic acid, etc.)

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
V,VI	DSE9	**HeterocyclicChemistry**	Theory: 3
			Practical: 2

Learning Objectives

After completion of the course, the learner can be able to understand:

- Chemistry of heterocyclic compounds.
- Synthesis, structures and characterizations of three to five membered rings.
- Chemistry of Condensed five-memberedHeterocycles.

Unit 1

Three-membered rings with one heteroatom: Chemistry of oxiranes, aziridines and episulphides - synthetic approaches andreactivities.

Unit 2

Three-membered heterocycles with two heteroatoms: oxaziranes, diaziridines and diazirines - synthetic approaches andreactivities.

Unit 3

Four-membered heterocycles: oxitanes, azatidanes and thietanes - synthetic approaches and reactivities. natural products:synthesis of Peniciline andcephalosporine.

Unit 4: Five-membered aromatic heterocycles:

1. With one heteroatom: furans, pyrroles and thiophenes - general synthetic approaches, properties and reactivities.
2. With two heteroatoms: oxazoles, isoxazoles, imidazoles, thiazoles, pyrazoles and isothiazoles - general synthetic approaches andreactivities.
3. With three and four heteroatoms: triazoles and tetrazoles - synthetic approaches, properties andreactivity.

Unit 5: Condensed five-memberedHeterocycles:

Benzofuran, indoles and benzothiazoles - general synthetic approaches, with greater emphasis on the chemistry ofIndoles.

Recommended Books/references:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley,2010.
2. The Essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication,
3. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York,1968.
4. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London,1978.
5. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees),.Vol 1-8, Pergamon Press,1984.
6. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press,1985.
7. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic

Press,1974.

List of suggested laboratory experiments

1. Identification of hetero atoms (S, N, X) in given organic compounds inlab.
2. Identification/separation of simple organic compounds containing hetero atoms using column chromatorgapy/TLC) inlab.
3. Spectroscopic identification of simple organic compounds
4. Teacher may guide the students for preparation of : Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basiccondition).

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
V,VI	DSE10	**Biochemistry**	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Biological importance of carbohydrates.
- Classification, biological importance of proteins.
- Nomenclature, Characteristics, Classification of enzymes.
- Biological importance of lipids.
- Structure of DNA/RNA and their role in living organisms.

Unit 1: Carbohydrates: 8 Lectures

Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle.

Unit 2: Proteins: 8 Lectures

Classification, biological importance; Primary, secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Denaturation of proteins.

Unit 3: Enzymes: 8 Lectures

Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes,Coenzymes and cofactors, Enzyme inhibitors, Biocatalysis in Green Chemistry" and ChemicalIndustry

Unit 4: Lipids: 8 Lectures

Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications.

Unit 5: Structure of DNA/RNA: 8 Lectures

Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.

Recommended Books/References:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman andCo.
2. Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) principles of Biochemistry.IVEdition.W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/McGraw-Hill

Suggested Practical in Biochemistry

1. Quantitative estimation of protein using Lowry's method. Determine the concentration of the unknownsample.
2. Action of salivary amylase at optimumconditions
3. Effect of pH on the action of salivaryamylase
4. Effect of temperature on salivaryamylase

5. Effect of inhibitor on salivaryamylase
6. Study of the activity of Trypsin using fresh tissueextracts.
7. Effect of temperature, organic solvents, on semi-permeablemembrane.
8. Isolation of Genomic DNA from EColi

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
V,VI	DSE11	**Organometallics and BioinorganicChemistry**	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Chemistry of coordination compounds.
- Characteristics of organometallic compounds.
- Structures and characterizations of organometallic compounds.
- Applications of organometallic compounds.
- Role of metals in biological systems.

Unit 1:Chemistry of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$,$Na_3[Co(NO_2)_6]$.

Unit 2: Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type.Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity.Comparison of aromaticity and reactivity with that of benzene.

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals.p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit 3: Bioinorganic chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy

production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

Recommended books/reference books

1. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH,1999
3. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
4. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann,1997

List of Laboratory experiments

1. Rection of metal with halide – preparation of Grignard reagent.

2. Grignard preparation of dye (malachite green (using methylbenoate)/crystal violet (using diethylcarbonate) (starting material as p-bromo N, N-dimethyl aniline)

3. Preparation of various Schiff base-metal complexes and their identification using spectroscopy.

4. Preparation of any two of the following complexes and measurement of their conductivity measurement:

   a. tetraamminecarbonatocobalt (III)nitrate
   b. tetraamminecopper (II)sulphate
   c. potassium trioxalatoferrate (III)trihydrate

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/reference books

1. Synthesis of organometallic compounds: A practical guide, S. Komiya,Wiley.
2. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7thEdn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*,Prentice-Hall.

Semester	Course	Name of the course	Credits
V,VI	DSE12	**Introduction to Nanochemistry & Applications**	Theory: 3
			Practical: 2

Learning objectives:

After completion of the course, the learner can be able to understand:

- Idea of nanoscience.
- Chemistry of nanostructures and nano-materials.
- Properties of nano-materials.
- Synthesis of nano-materials.
- Characterizations of nano-materials.

Unit-I: Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures -Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

Unit-II: Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties.

Unit-III: Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-controlof nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

Unit-IV: Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique, diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed).

Recommended Books/References books:

1. C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Willey-VCH Verlag, Germany, 2005.
2. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Appications, Imperial College Press, London, 2004
3. R.W.Kelsall,I.W.Hameley,M.Geoghegan,Nanoscale Science and Technology, John Wiley& Sons, England,2005.
4. Charles P. Poole and Frank J Owens, *Introduction to nano technology*, Wiley Interscience, 2003.
5. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi,2012.

List of Laboratory Experiments suggested:

1. Synthesis of ZnOnanoparticles.
2. Preparation of Silvernanoparticles.
3. Verification of Beer-Lambert law using nano-particles

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended/Ref. Books:

1. Pradeep T., A text book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012 edition.

GENERIC ELECTIVE COURSES

Generic Elective Course (GE) (any four) for other Departments/Disciplines:

Semester	Course	Name of the course	Credits
I	GE-I	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	Theory: 3
			Practical: 2

Theory: 45Hours

Section – A: Inorganic Chemistry – 1

Unit – 1: Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matterand radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it.Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom.Radial and angular parts of the hydogenicwavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation).Radial and angular nodes and their significance.Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms.Stability of half-filled and completely filled orbitals, concept of exchange energy.Relative energies of atomic orbitals, Anomalous electronic configurations.

(9Hours)

Unit – 2: Chemical Bonding

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionicbonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds.Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basisof VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonalbipyramidal and octahedral arrangements, such as $BeCl_2$, BF_3, SiF_4, PCl_5, SF_6, NH_3, H_2O, OF_2, CIF_3, SF_4, XeF_4, XeF_6, H_3O^+, I_3^-, I_3^+, ICl_2^-, XeF_5^+.

Concept of resonance and resonating structures in various inorganic and organic compounds.

(7Hours)

Unit – 3: Molecular Orbital Theory

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

(7Hours)

Section – B: Organic Chemistry – 1

Unit – 1: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

(6Hours)

Unit – 2: Stereochemistry

Conformations with respect to ethane, butane and cyclohexane.Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations.Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis - trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

(7Hours)

Unit – 3: Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons).*Preparation:*Catalytic hydrogenation, Wurtz reaction, Kolbe'ssynthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons)*Preparation:*Elimination reactions: Dehydration of alkenes anddehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:*cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons)*Preparation:*Acetylene from $CaC_2$and conversion into higheralkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$,ozonolysis and oxidation with hot alk. $KMnO_4$.

(9Hours)

Reference Books:

- J. D. Lee: *A new Concise Inorganic Chemistry*, E L. B. S.
- F. A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- Douglas, McDaniel and Alexader: *Concepts and Models in Inorganic Chemistry*, John

Wiley.
- James E. Huheey, *Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principlesof Structure and Reactivity*, Pearson Publication.
- T. W. Graham Solomon: *Organic Chemistry, John Wiley and Sons*.
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
- E. L. Eliel: *Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
- I. L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry*, S. Chand

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GE PRACTICAL – I (Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons)

(30Hours)

Section – A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section – B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)

2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
- Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.
- Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
- Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

Semester	Course	Name of the course	Credits
II	GE-II	Kinetic Theory of Gases, Chemical Energetics, Equilibria& Functional Group Organic Chemistry	Theory: 3
			Practical: 2

Theory: 45Hours

Section – A: Physical Chemistry – 1

Unit – 1: Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation.Andrews isotherms of CO_2.

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.

Temperature dependence of these distributions.Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(8 Hours)

Unit – 2: Chemical Energetics

Chemical Energetics: Introduction of different terms and processes in thermodynamics: [systems (isolated, closed, open) and surrounding, macroscopic properties, state and path functions and their differentials.

First Law: concept of heat, *q*, work, *w*, internal energy, *U*, sign convention for heat and work, nature of work, path dependence of work and heat; statement of first law; enthalpy, *H*, heat changes at constant volume and constant pressure; heat capacities (C_v, C_p) and relation between them for ideal gases. Reversible and irreversible processes, maximum work, thermodynamic quantities (w, q, ΔU, ΔH) and its calculation for isothermal and adiabatic reversible expansion of ideal gases. Ideal gas law for adiabatic reversible expansion, comparison of adiabatic and isothermal reversible expansion. Joule-Thomson effect, JouleThomson coefficient in ideal and real (van der Waal) gases, inversion temperature.

Thermo-chemistry: Standard state, standard enthalpy of formation, Hess's Laws of constant heat summation and its application. Change in internal energy (ΔU) and enthalpy (ΔH) of chemical reactions, relation between ΔU and ΔH, variation of heat of reaction with temperature (Kirchhoff's equation). Enthalpy of neutralization. Bond Energy – Bond dissociation energy and its calculation from thermo-chemical data.– Kirchhoff's equation.

Second law of thermodynamics, concept of entropy, free energy work functions, Gibbs Helmholtz equation and its applications

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

(9 Hours)

Unit – 3: Chemical and Ionic Equilibrium

Free energy change in a chemical reaction.Thermodynamic derivation of the law of chemical

equilibrium.Distinction between G and G^o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect.Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.Buffer solutions.Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

(6 Hours)

Section – B: Organic Chemistry – 2

Functional group approach for the following reactions (preparations & reactions) to bestudied in context to their structure.

Unit – 1: Aromatic Hydrocarbons & Alkyl and Aryl Halides

Aromatic Hydrocarbons**:** *Preparation* (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation andacylation) (upto 4 carbons on benzene).Side chain oxidation of alkyl benzenes (upto 4carbons on benzene); aromatic hydrocarbon side chain reactions.

Alkyl Halides (upto 5 Carbons): Types of Nucleophilic Substitution (S_N2, S_N1, S_Ni)reactions. *Preparation:* from alkenes *and* alcohols. *Reactions:* hydrolysis, nitrite & nitroformation, nitrile &isonitrile formation. Williamson's ether synthesis: Elimination vssubstitution.

Aryl Halides**:** *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer &Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilicsubstitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 or $NaNH_2/NH_3$ reagent system. Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(7 Lectures)

Unit – 2: Alcohols, Phenols, Ethers, Aldehydes and Ketones (Upto 5 Carbons)

Alcohols**:** *Preparation:* Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc.HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols**:** (Phenol case) *Preparation:* Cumenehydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten–Baumann Reaction.

Ethers (Aliphatic and Aromatic)**:** Cleavage of ethers with HI.

Aldehydes and Ketones (Aliphatic and Aromatic): (Formaldehye, acetaldehyde, acetone andbenzaldehyde); *Preparation:* from acid chlorides and from nitriles. *Reactions* -Reaction withHCN, ROH, $NaHSO_3$, NH-G derivatives. Iodoform test.Aldol Condensation, Cannizzaro'sreaction, Wittig reaction, Benzoin condensation.Clemensen reduction and Wolff Kishnerreduction.Meerwein-PondorffVerley reduction.

(9 Hours)

Unit – 3: Carboxylic acids and their derivatives& Amines salt

Carboxylic acids (aliphatic and aromatic):*Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction. *Preparation:* Acid chlorides, Anhydrides, Esters and Amides from acids and theirinterconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction,Perkin condensation.

Amines and Diazonium Salts: Amines (Aliphatic and Aromatic): (Upto 5 carbons), *Preparation*: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamidereaction. *Reactions:* Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2,Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts:*Preparation:*from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.

(6Hours)

Reference Books:

- T. W. Graham Solomons: *Organic Chemistry, John Wiley and Sons*.
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman.
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry*, S. Chand.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel& J. R. Townsend: *General Chemistry*CengageLening India Pvt. Ltd., New Delhi (2009).
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).

GE PRACTICAL – II(Kinetic Theory of Gases, Chemical Energetics, Equilibria& Functional Group Organic Chemistry)

(30Hours)

Section – A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of *H*.

Ionic Equilibria

pH measurements

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
b) Preparation of buffer solutions:
(i) Sodium acetate-acetic acid
(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section – B: Organic Chemistry

I Systematic Qualitative Organic Analysis of Organic Compounds possessingmonofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

II

1. Criteria of Purity: Determination of melting and boiling points.
2. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
3. Preparations: Mechanism of various reactions involved to be discussed.
Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline
(b) Benzoylation of amines/phenols
(c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry*, UniversitiesPress
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

Semester	Course	Name of the course	Credits
III	GE-III	Solid, Solutions, Phase Equilibrium & Chemical Kinetics, Conductance,Periodic Properties and Chemistry of *s*-, *p*-, and *d*-block elements	Theory: 3
			Practical: 2

Section – A: Physical Chemistry – 2

Unit – 1: Solids

Forms of solids.Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices.X–Ray diffraction by crystals, Bragg's law.Structures of NaCl, KCl and CsCl (qualitative treatment only).Defects in crystals.Glasses and liquid crystals.

(6Hours)

Unit – 2: Solutions, Phase Equilibrium&Chemical Kinetics

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions.Lever rule.Azeotropes.Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation.Nernst distribution law and its applications, solvent extraction.

Phases, components and degrees of freedom of a system, criteria of phase equilibrium.Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H2O and Na-K only).

The concept of reaction rates.Effect of temperature, pressure, catalyst and other factors on reaction rates.Order and molecularity of a reaction.Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants).Half–life of a reaction.General methods for determination of order of a reaction.Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

(11Hours)

Unit – 3: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods.Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

(5 Hours)

Section – B: Inorganic Chemistry – 2
Unit – 1: Periodic Properties & Acid-Base Concepts

Periodic Properties***:*** Division of elements into *s*, *p*, *d*, and *f* blocks, covalent radii, van der Waals radii and ionic radii; ionization enthalpy, electron gain enthalpy, and electronegativity (Pauling, Mulliken, and Alfred-Rochow scales: Definition, methods of determination, trends in periodic table, and applications in predictingand explaining chemical behavior).
Acids and Bases: Arrhenius, Brønsted-Lowry, Lux-Flood and Lewis concepts of acids and bases. Factors affecting strengths of Lewis acids and bases, Classification of acids and bases as hard and soft, Pearsons HSAB concept, acid-base strength and hardness and softness,symbiosis, application of HSAB theory.

(7Hours)

Unit – 2: Oxidation-Reduction
Redox equations, Standard electrode potentials, Ellingham diagrams for reduction of metal oxides using carbon as reducing agent, Nernst equation, redox potentials to explore the feasibility of reaction and calculation of values of equilibrium constant. Reversible and irreversible cells.Concept of EMF of a cell.Measurement of EMF of a cell.

(5Hours)

Unit – 3: *Chemistry*of *s*-,*p*-and *d*- Block Elements
s-Block Elements: General characteristic properties, complexes of alkali metals, comparative study of hydrides, oxides, hydroxides, halides, carbonates and bicarbonates of group I and II, Diagonal relationship, Biological role of alkali and alkaline earth metals.
p-Block Elements: General characteristic properties, comparative study (including diagonal relationship and inert pair effect) of groups 13-17 (B, C, N, O, F) elements and group trends of compoundslike hydrides, oxides, halides, and oxy acids; preparation properties and structure, of diborane, borazine, alkalimetalborohydrides,fullerenes, silicates and silicones, inter-halogensand polyhalides.
Chemistry of Noble Gases: Isolation and separation of noble gases from air, chemical properties of noble gases, chemistry of xenon, structure and bonding in xenon compounds.
d-Block Elements: Characteristic properties of *d*-block elements. Properties of the elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry.Comparative treatment with their 3d-analogues in respect of ionic radii, oxidation states and stereochemistry.

(11Hours)

Reference Books:

- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Ed. Narosa (2004).
- J. C. Kotz, P. M. Treichel, J. R. Townsend, *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- B. H. Mahan: *University Chemistry*, 3rd Edn. Narosa (1998).
- R. H. Petrucci, *General Chemistry*, 5th Edn., Macmillan Publishing Co.: New York (1985).
- E. S. Gilreath, Fundamental Concepts of Inorganic Chemistry, McGraw Hill Edu. Pvt. Ltd.

- R. Sarkar (Part-I & II), General & Inorganic Chemistry, Central.
- R. L. Dutta (Part-I & II), Inorganic Chemistry, The New Book Stall.
- J. D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley.
- D. F. Shriver and P. W. Atkins: *Inorganic Chemistry,* Oxford University Press.
- Gary Wulfsberg: *Inorganic Chemistry,* Viva Books Pvt. Ltd.

GE PRACTICAL – III (Solid, Solutions, Phase Equilibrium,Chemical Kinetics, Conductance & Periodic Properties and Chemistry of s-, p-, and d- block elements)

(30 Hours)

Section – A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$

$Cu^{2+}(aq) + xNH_3(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$

Phase equilibria

a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

(I) Surface tension measurement (use of organic solvents excluded).

a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
b) Study of the variation of surface tension of a detergent solution with concentration.

(II) Viscosity measurement (use of organic solvents excluded).

a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

(III) Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
   c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Conductance

a) Determination of cell constant
b) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

c) Perform the following conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

a) Strong acid vs. strong base
b) Weak acid vs. strong base
c) Potassium dichromate vs. Mohr's salt

Section – B: Inorganic Chemistry

Semi-micro qualitative analysis using H_2S of mixtures- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations : NH^{4+}, Pb^{2+}, Ag^{+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^{+}, Anions : CO_3^{2-}, S^{2-}, SO^{2-}, $S_2O_3^{2-}$, NO_3^{-}, NO_2^{-},Cl^{-}, Br^{-}, I^{-},SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^{-}

(Spot tests should be carried out wherever feasible)

Reference Books:

- B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011
- V. K. Ahluwalia, S. Dhingra& A. Gulati, College Practical Chemistry, University Press, Delhi.

Semester	Course	Name of the course	Credits
IV	GE-IV	**Analytical Chemistry, Co-ordination compounds, Organometallics and Molecules of life**	Theory: 3
			Practical: 2

Theory: 60 Hours

Section – A: Analytical Chemistry – 3

Unit – 1: Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature.Balances, burettes, volumetric flasks, pipettes, calibration of tools, sampling. Errors andStatistics: significant figures, rounding off, accuracy and precision, determinate andindeterminate errors, standard deviation, propagation of errors, confidence limit, test ofsignificance, rejection of a result.

(5Hours)

Unit – 2:Volumetric Titration

Standard solution, primary standard and secondary standard, titration, end point, indicator, concentration of standard solution- moles, Normality, molarity, Molality, parts per million(PPM), volumetric calculation, acid base titration and use of indicators,titration curves for strong acid vs strong base, weak acid with strong base, weak base with strong acid, theory of acid base indicator, Redox titration- titration of Mohr salt against $KMnO_4$, Titration of Oxalic acid against $KMnO_4$, Titration of $FeSO_4$ against $K_2Cr_2O_7$.

(6 Hours)

Unit – 3: Chromatography

Chromatographic Techniques:classification, theory of chromatographic separation, distribution coefficient, retention,sorption, efficiency and resolution. - Column, ion exchange, paper, TLC & HPTLC chromatography etc.

***Solvent Extraction*:** Distribution Coefficient, distribution ratio, percent extracted, solvent extraction of metals ions, extraction of ion association complex, extraction of metal chelates, multiple batch extraction and applications.

***Ion-exchange*:** Column, ion-exchange chromatography etc.Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

Gas Chromatography: retention time or volume, capacity ratio,partition coefficient, theoretical plate and number, separation efficiency and resolution,instrumentation and application.

(8Hours)

Section – B: Inorganic Chemistry – 3

Unit – 1: Coordination Compounds

Werner's coordination theory and its experimental verification,effective atomic number concept, chelats, nomenclature of co-ordination compounds,isomerism in coordination compounds.

Crystal Field Theory: Crystal field effect, octahedral symmetry. Crystal field stabilization

energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry.Factors affecting the magnitude of D. Spectrochemical series.Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry.Jahn-Teller distortion, Square planar coordination.

(7 Hours)

Unit – 2: Organometallics

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of

mononuclear and polynuclear carbonyls of 3d metals. p-acceptorbehaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

(6Hours)

Section – C: Organic Chemistry – 3

Molecules of Life

Unit – 1: Carbohydrates

Classification of carbohydrates, reducing and non reducing sugars, and General Properties, Glucose and Fructose,their open chain structure. Epimers, mutarotation and anomers, Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

(5Hours)

Unit – 2: Amino Acids, Peptides, ProteinsandNucleic Acids

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis.Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$group, complexationwith Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins.Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme).Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

Components of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides **(nomenclature**), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA(**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

(8 Hours)

Reference Books:

- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6thEd.,* Saunders College Publishing, Fort Worth (1992).
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7thEd.*, Prentice Hall.
- Vogel, A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Prentice Hall.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel& J. R. Townsend: *General Chemistry*CengageLening India Pvt. Ltd., New Delhi (2009).
- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
- J. D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley.
- D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
- R. L. Dutta (Part-I & II), Inorganic Chemistry, The New Book Stall.
- Gary Wulfsberg: *Inorganic Chemistry,* Viva Books Pvt. Ltd.
- S. Chand. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7thEd.,* W. H. Freeman.
- Berg, J. M., Tymoczko, J. L. &Stryer, L. *Biochemistry 7thEd.,* W. H. Freeman

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GEPRACTICAL – IV (Electrochemistry, Chemical Kinetics, Co-ordination compounds, Organometallics and Molecules of life

(30 Hours)

Section – A: AnalyticalChemistry

1. Estimation of the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oxinate in a given solution gravimetrically.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.
4. To draw calibration curve (absorbance at λ_{max} vs. concentration) for various concentrations of a given coloured compound and estimate the concentration of the same in a given solution.
5. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} -

phenanthroline complex in solution by Job's method.

6. Determination of concentration of Na+ and K+ using Flame Photometry.

Section – B: Inorganic Chemistry

1. Separation of mixtures by chromatography: Measure the R_f value in each case. (Combination of two ions to be given)

   Binary mixture of nickel and cobalt, copper and nickel, zinc and magnesium, iron and copper; aluminium and nickel.

2. Preparation of any two of the following complexes:
   (a) tetraaammine copper (II) sulphate
   (b)tetraamminecarbonatocobalt (III) nitrate
   (c) potassiumtrioxalatochromate (III)
   (d) potassiumtrioxalatoferrate (III)
   (e) sodiumhexanitritocabaltate (III)
   (f) prussin blue

Section – C: Organic Chemistry

1. Determination of the concentration of glycine solution by formylation method.
2. Titration curve of glycine
3. Action of salivary amylase on starch
4. Effect of temperature on the action of salivary amylase on starch.
5. Determination of the saponification value of an oil/fat.
6. Determination of the iodine value of an oil/fat
7. Differentiation between a reducing/nonreducingsugar.
8. Extraction of DNA from onion/ cauliflower

Reference Books:

- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6thEd.*, Saunders College Publishing, Fort Worth (1992).
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7thEd.*, Prentice Hall.
- Vogel, A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Prentice Hall.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011
- V. K. Ahluwalia, S. Dhingra& A. Gulati, College Practical Chemistry, University Press, Delhi.

Ability EnhancementCourses

Semester	Course	Name of the course	Credits
I,II	AEC 1	English for communication	Theory:2

Learning Objective:

On completion of this course, the students will be able to understand about:

- The features of communication
- The various writing skills
- The scientific and technical writings

Unit I: Communication **3 Lectures**

Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing.

Unit II: Writing Skills **5 lectures**

Selection of topic, thesis statement, developing the thesis; introductory, developmental, transitional and concluding paragraphs, linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing.

Unit III: Technical Writing **4 lectures**

Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, manuals, letters, memorandum, notices, agenda, minutes; common errors to be avoided.

Semester	Course	Name of the course	Credits
I,II	AEC 2	Intellectual Property Rights	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Understand the concept of IPR
- Differentiate between various agreements ofIPR
- Compare copyrights, patents and GeographicalIndicators
- Examine various legal issues related toIPR
- Relate to various cyber issues concerning IPR

Keywords:

Copyright act, IPR and WTO, Patents, Bioprospecting, Biopiracy, Database

Unit I: Introduction to Intellectual PropertyRight(IPR) (7 lectures)

Copyright Act and IPR, Economic importance. IPR in India and world: Genesis and scope, some important examples. IPR and WTO (TRIPS, WIPO).Objectives, Rights, Patent Act 1970 and itsamendments.

Unit II: Patents, CopyrightsandTrademarks (7lectures)

Procedure of obtaining patents, working of patents. Infringement of patents, Copyrights: work protected under copyright laws, Rights, Transfer of Copyright, Infringement. Trademarks: Objectives of trademarks, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name.

Unit III: Protection of Traditional Knowledge, Industrial Designs and Plant Varieties

(7 lectures)

Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bioprospecting and Bio-piracy, Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Plant varieties protection in India. Rights of farmers, National gene bank, Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit IV: Information Technology Related IPR (7 lectures)

Computer Software and Intellectual Property, Database and Data Protection, Protection of Semiconductor chips, Domain Name Protection. Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, and Moral Issues in Patenting Biotechnological inventions.

Practical:

The students are expected to prepare some project report based on the Success stories of Traditional Patents secured by India. Likewise, prepare a database for Indian products wherein is issue is still under consideration of the competent authorities. Prepare the dos and don'ts on Patents for Botanists.

Suggested Readings

1. N.S. Gopalakrishnan and T.G. Agitha, (2009) Principles of Intellectual Property Eastern Book Company,Lucknow.

2. David Kitchin QC , David Llewelyn , James Mellor , Richard Meade , Thomas Moody-Stuart,and D. Keeling, Robin Jacob (2005). Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet &Maxweel.
3. Ajit Parulekar and Sarita D' Souza, (2006) Indian Patents Law – Legal & Business Implications; Macmillan IndiaLtd.
4. B.L.Wadehra (2000) Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd.,India.
5. P. Narayanan (2010) Law of Copyright and Industrial Designs; Eastern law House,Delhi.

Semester	Course	Name of the course	Credits
I,II	AEC 3	History of Indian Science	Theory:2

Learning outcomes

On completion of this course, the students will be able to:

- Develop understanding of various branches of science during differenteras
- Analyze the role played by different Indian organizations inscience
- Learn about the science and techniques used in ancient India
- Appraise the contribution of different Indian Scientists inscience

Keywords:

Astronomy, Ancient India, Colonial India, Modern India, Agricultural techniques, Green revolution

Unit I: Science in Ancient and MedievalIndia 8 Lectures

History of development in astronomy, mathematics, engineering and medicine subjects in Ancient India, Use of copper, bronze and iron in Ancient India, The geography in literature of Ancient India. Influence of the Islamic world and Europe on developments in the fields of mathematics, chemistry, astronomy and medicine, innovations in the field of agriculture-new crop introduced new techniques ofirrigation.

Unit II: Indian Science in before and after Independence 7 Lectures

Introduction of different surveyors, botanists and doctors as early scientist in Colonial India, Indian perception and adoption for new scientific knowledge in Modern India, Establishment of premier research organizations like CSIR, DRDO and ICAR and ICMR, Establishment of Atomic Energy Commission, Launching of the space satellites, Botanical survey ofIndia.

Unit III: Prominent Indian scientists 8 Lectures

Eminent scholars in mathematics and astronomy: Baudhayana, Aryabhtatta, Brahmgupta, Bhaskaracharya, Varahamihira, and Nagarjuna, Medical science of Ancient India (Ayurveda and Yoga): Susruta, Charak. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha and Vikram Sarabhai.

Unit IV: Prominent research in Plant Sciences in Republic of India 7 Lectures

History of plant tissue culture from India, Green revolution in India: causes, details, and outcomes. First gene cloning in plants, First genome sequencing from India.Premier Plant Research institutes and scientists in India, GM Mustard. Allelopathy Plant research in India

Practical:

There is no experimental lab based Practical. However, the students are expected to prepare some term paper reports on the Life and works of some noted Indian Scientists especially the Botanists. Likewise, students need to prepare and organize some discussion on the ancient and medieval science in India and trace the reasons of inadequate visibility in the world. Prepare term papers on GM Crops, the controversies and procedure for approval. Prepare term papers on the significance of Allelopathic research fromIndia.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested Readings

1. Kuppuram G (1990) History of Science and Technology in India, South AsiaBooks.
2. Handa O. C. (2014) Reflections on the history of Indian Science and Technology, PentagonPress.
3. Basu A (2006) Chemical Science in Colonial India: The Science in Social History, K.P. Bagchi &Co.
4. Habib I, (2016.)A people's history of India 20: Technology in Medieval India, 5th Edition, Tulika Books.
5. A. Rahman et al (1982) Science and Technology in Medieval India – A Bibliography of Source Materials in Sanskrit, Arabic and Persian, New Delhi: Indian National Science Academy.
6. B. V. Subbarayappa & K. V. Sarma (1985), Indian Astronomy -– A Source Book, Bombay.
7. Srinivasan S, Ranganathan S (2013) Minerals and Metals heritage of India, National Institute of AdvancedStudies.
8. Srinivasiengar C N, (1967) The History of Ancient Indian Mathematics, World Press Private Ltd.Calcutta.
9. Bhardwaj H C (2000) Metallurgy in Indian Archaeology. Tara BookAgency

Semester	Course	Name of the course	Credits
I,II	AEC 4	Good Laboratory Practices	Theory:2

Learning Outcomes

On completion of this course, the students will be able to:

- Apply practical skills in science courses with the understanding of general laboratory practices
- Explore various research issues and theirsolutions
- Apply various techniques to study chemical compounds,salts
- Use various micro techniques used inchemistry

Keywords:

Laboratory calculations, calibration procedures, use of glassware, safety aspects inpreparation

Unit I: General Laboratory Practices 5 lectures

Common calculations in chemistry laboratories.Understanding the details on the label of reagent bottles.Preparation of solutions.Molarity and normality of common acids and bases.Dilutions.Percentage solutions.Molar, molal and normal solutions.Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit II: Instrument-Techniques and laboratory preparation procedure. 5 lectures

Use of micropipette, analytical balances, pH meter, conductivity meter, rotary evaporator, potentiometer.Use of purified water in lab experiments, Cleaning and drying of glassware, Preparation of crystals from given salt.Preparation of Dyes, Demonstration of preparation of material using Sol-gel procedure.

Suggested Readings

1. Seiler, J.P. (2005). Good Laboratory Practices: the why and how. Springer-Verlag Berlinand Heidelberg GmbH & Co. K; 2nded.
2. Garner, W.Y., Barge M.S., Ussary. P.J. (1992). Good Laboratory PracticeStandards: Application for field and Laboratory studies. WileyVCH.

Semester	Course	Name of the course	Credits
I,II	AEC 5	Introduction to Forensic Science and technology	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Understand the scope of forensic science
- Understand about various types of evidences
- Analyse various evidences
- Utilize various chemical analytical tools to analyze evidences.

Unit I **20 Lectures**

Scope of forensic science, Evidences in criminal law (act, case studies), Physical evidences (identification, collection and preservation of sample, physical properties of sample material, use of physical evidences in criminal proceedings), biological evidences (drugs, effects, identification, serology of blood, semen, saliva, DNA evidence, use of biological evidence in criminal proceedings), trace evidences (finger print, blood stream, hair, firearms, fibers, paints, etc),

Unit II **10 Lectures**

basic techniques of chemical analysis (FTIR, Mass spectroscopy, HPLC and GC with example of analysis). Admissible and non-admissible scientific evidence in legal system, Principle and limitation of DNA finger printing.

Recommended Books/references:

1. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001).
2. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi(2002).
3. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton(2005)
4. W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene Investigation, CRC Press, Boca Raton (2013).

Semester	Course	Name of the course	Credits
I,II	AEC 6	Renewable Energies (solar and biogas)	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Know about the renewable energy sources
- Utilize various renewable energy technologies to solve future energy consumption problems
- Identify biomass sources
- Estimate chemical composition of biomasses

Unit I: **10 Lectures**

Introduction to renewable energy sources – solar, wind, small hydro, biomass, geothermal and ocean energy, energy flow in ecosystem Solar Energy Resources Solar radiation: Spectrum of EM radiation, sun structure and characteristics, extraterrestrial radiation, solar constant, air mass, beam, diffused and total solar radiation, spectraldistribution

Unit II: **10 Lectures**

Measurement of solar radiation Instruments: sunshine recorder, Pyranometer, Pyrheliometer, Albedometer. Radiation measurement stations in India (NIWE, IMD etc.), solar radiation data, graphs, Meteonorm and NASA-SSE databases Hands-on measurement of beam, diffuse and total radiation

Unit III: **15 Lectures**

Solar mapping using satellite data, Typical Meteorological Year, Models and methods for estimating solar radiation, estimation of global radiation, estimation of diffused components

Basics Biomass resources: plant derived, residues, aquatic and marine biomass, various wastes, photosynthesis. Biomass resource assessment Estimation of woody biomass, non woody biomass and wastes, ASTM standards, Bulk chemical properties Moisture content, proximate and ultimate analyses, calorific value, waste water analysis for solids

Unit IV: **15 Lectures**

Chemical composition of biomass Cellulose, hemicelluloses and lignin content in common agricultural residues and their estimation, protein content in biomass, extractable, COD.Structural properties Physical structure, particle size and size distribution, permeability. Physical properties: Bulk density, angle of repose, thermal analysis (thermogravimetric, differential thermal and differential scanning calorimetry).Properties of microbial biomass: Protein estimation, flocculating ability, relative hydrophobicity of sludge, sludge volume index.

Semester	Course	Name of the course	Credits
I,II	AEC 7	Chemoinformatics	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Know about the history and prospects of chemo-informatics
- Represent molecules and chemical reaction using different notations, SMILES and Matrix representaion
- Search chemical structure and application of chemo-informatics in various fields

Unit I **5 Lectures**

Introduction to Chemo-informatics: History, Prospects of chemoinformatics, Molecular Modelling and Structure elucidation.

Unit II **10 Lectures**

Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Unit III **10 Lectures**

Searching chemical structures: Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit IV **15 Lectures**

Applications: Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modeling.Toxicity; Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design, Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand and structure based drug design; Applications in Drug Design.

Recommended Books/references:

1. Andrew R. Leach and Valerie, J. Gillet (2007) *An introduction toChemoinformatics.* Springer: The Netherlands.
2. Gasteiger, J. and Engel, T. (2003) *Chemoinformatics: A text-book.*Wiley-VCH.
3. Gupta, S. P. (2011) *QSAR & Molecular Modeling.* Anamaya Pub.: NewDelhi.

Semester	Course	Name of the course	Credits
I,II	AEC 8	Water remediation and conservation studies	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Know about the various sources of water pollution
- Know the normal standard of potable water as per WHO recommendation
- Understand water conservation and erosion of soil
- Develop various water remediation and conservation studies

Unit-I **10 Lectures**

Sources of water pollutants, pollutants, Industrial and human contribution, WHO recommendation about potable water, current scenario of drinking water quality, chemistry of toxicants like arsenic, fluoride, chromium, lead and mercury, cause and effects of water pollution, remediation, techniques involved such as adsorption, coagulation-filtration, Nalgonada techniques, reverse osmosis, activated charcoal detoxification, applications of non-toxic oxides and mixed oxides, regeneration and recycling, mechanisms of detoxification, bio-remediation, need of green chemistry, futurescope.

Unit-II **10 Lectures**

Introduction to water conservation and erosion of soil, forms of water erosion, factors affecting water erosion, types of water erosion, mechanics of water erosion control, agronomical measures of water erosion control, Terraces for water erosion control:

Modeling of watershed processes, Case study of water-shed modeling for water conservation and water quality.

Recommended Books/references:

1. Cittenden J. C. , Trussell J. R., Hand D. W., Howe K. J., Tchobanoglous G. , Water treatment: Principles and Design MWHpublication.
2. De A. K. Environmental Chemistry, WileyEastern
3. Clarson D., Dara S. S. A text book of Environmental chemistry and pollution control, S Chand Co. Soil and water analyticalmethod
4. Edzwald J., Water Quality & Treatment: A Handbook on Drinking Water (Water Resources and Environmental EngineeringSeries)

Semester	Course	Name of the course	Credits
I,II	AEC 9	Research Methodology	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Understand the concept of research and different types of research in the context of biology
- Develop laboratory experiment relatedskills.
- Develop competence on data collection and process of scientificdocumentation
- Analyze the ethical aspects ofresearch Evaluate the different methods of scientific writing andreporting

Keywords:

Qualitative, Quantitative, Reproducibility, Scientific methodology, Plagiarism, Scientific misconduct, Ethics in Science

Unit I: Basic ConceptsofResearch 12 lectures

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs. qualitative; conceptual vs empirical).Research methods vs methodology.Literature-review and its consolidation; Library research; field research; laboratoryresearch.

Unit II: Data Collection and DocumentationofObservations 12lectures

Maintaininga laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of fieldphotography.

Unit III: Overview of Application to Chemistryrelated problems 5 lectures

Key chemistry research areas, chemoinfomatics.

Unit IV: Ethics and Good Practical's and Art of Scientific Writing 11 lectures

Authors, acknowledgements, reproducibility, plagiarism, Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references.Power-point presentation.Poster presentation.Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

Practical

1. Experiments based on chemicalcalculations.
2. Lab computationalexperiments.
3. Poster presentation on definedtopics.
4. Technical writing on topicsassigned.
5. Identification of different type of research in day by daylife.
6. Curation of relevant scientific literature from GoogleScholar.
7. Demonstration for checking of plagiarism using recommendedsoftware.
8. Technical writing on topicsassigned.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested Readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, NewDelhi.

Semester	Course	Name of the course	Credits
I,II	AEC 10	Chemistry in Everyday life	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Understand the chemical processes involved in daily life
- Know the respiration process in terms of chemistry
- Understand chemicals hazardous for health
- Understand chemical structures of various vitamins
- Understand role of minerals in important biological processes.

Unit I: Respiration and energy production in human body 8 Lectures

Respiration, Respiratory enzymes, brief outline of hemoglobin and myoglobin, oxygen transport mechanism in body, co-operativity, Respiration in lower animals, hemocyanine, hemerythrine. Energy production in body, ATP; enzyme responsible for food digestion, mechanism of food digestion, active site of cytochrome c-oxidase.

Unit II: Chemical aspects of some common health hazards 5 Lectures

Anemia, sickle cell anemia, leukemia, blood pressure irregulation, blood sugar, arthritis, carbon monoxide poisoning in mines, cyanide poisoning, fluorosis etc.

Unit III: Vitamins and minerals 5 Lectures

Need for vitamin in body, types of vitamins, water soluble and fat-soluble vitamins, Vitamin B-12, vitamin C (Cyanocobalamine), D, Vitamin K. Role of minerals in body, iodine deficiency andremedy.

Unit IV: Significance of Radical chemistry in living system 10 Lectures

Radical production in environment, superoxide and peroxide, health impact, action of radicals, cell mutation, diseases caused by free radical, cancer, radical quencher, anti-oxidants, natural anti-oxidants like vegetables, beverages like tea and coffee, fruits.Radical destroying enzymes: superoxide dismutase, catalase, peroxidase, mechanism of action.

Unit V: Chemistry of Materials 10 Lectures

Soaps and Detergents – their action, Biofuels – production of biofuels and its utility as alternative fuel source, Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA; Examples of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers. Use of polymeric materials in dailylife.

Suggested Laboratory experiments:

1. Analysis of soaps anddetergents.
2. Analysis of Biofuels - flash point, pour point, cloudpoint
3. Preparation ofNylon6/6,6
4. Testing of adulterant in food, oil andvegetable

5. Vitamin-Cpreparation.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/references:

1. Kaim W, Bioinorganic Chemistry, Vol 4, Brigitte Scwederski, Wiley,1994.
2. Crichton R. H. Biological Inorganic Chemistry – An Introduction, Elsevier,2008.
3. Berg J. M., Tymoczeko J. L., Stryer l. Biochemistry, W. H. Freeman,2008.
4. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. (1994) *Bioinorganic Chemistry*. University Science Books(1994)
5. Lippard S., Berg J. M. Principles of Bioinorganic Chemistry; University Science Books 1994.
6. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International.

Semester	Course	Name of the course	Credits
I,II	AEC 11	Chemistry of food, nutrition, and preservation	Theory:2

Learning objective:

On completion of this course, the students will be able

1. To know about the basic of human physiological system
2. To learn about the nutrition and itsimportance
3. To learn about the foodscience
4. To learn about the food preservation and itsutility
5. To learn about the Quantitative estimation and nutritional assessment data

Key words: Food, nutrition, preservation.

Unit-I **10 Lectures**

Basic of human physiological system and food science:Digestive System: Structure and functions of G.I. tract, Process of digestion and absorption of food, Structure and functions of liver, gallbladder and pancreas.Basic concept on Food, Nutrition and Nutrients (Nutrition, Malnutrition and Health: Scope of Nutrition.), Classification of Food, Classification of Nutrients.

Unit-II **10 Lectures**

Nutrition: Dietary fibers (composition, properties and Minerals and trace elements(biochemical and physiological role, bioavailability and requirement with examples), Vitamines (examples, biochemical and physiological requirements, deficiency and excesses), Water (requirement, water balance), basic idea about community nutrition (objective, importance of various programmes).

Unit-III **10 Lectures**

Food preservation: definition, objectives and principles of food preservation. Different methods of food preservation. Preserved Products: Jam, Jelly, Marmalade, Sauces, Pickles, Squashes, Syrups-types, composition and manufacture, selection, cost, storage, uses and nutritional aspects, Food Standards: ISI, Agmark, FPO, MPO, PFA, FSSAI.

Practical:

Identification of Mono, Di and polysaccharides, Identification of Proteins, Identification of glycerol., Determination of moisture content in food, ash content and determination of calcium, iron, vitamin-C.

Comparison with norms and interpretation of the nutritional assessment data and its significance. Weight for age, height for age, weight for height, body Mass Index (BMI) Waist - Hip Ratio (WHR). Skin fold thickness.

Quantitative estimation of Sugars (Glucose, lactose, starch), Estimation of acid value, iodine value, Saponification value of fats, Estimation of blood Glucose, Estimation of serum cholesterol.

Note: Experiments may be added/deleted subject to availability of time and facilities

Reference/suggested books

1. Sri Lakshmi B(2017): Nutrition Science,6th Multicolour Ed. New Age International

(P)Ltd.
2. Roday S (2012): Food Science and Nutrition, 2nd Ed. Oxford UniversityPress.
3. Mann J and Truswell S(2017) : Essentials of Human Nutrition, 5th Ed. Oxford University Press.
4. Wilson K and Walker J(2000): Principles and Techniques of Practical Biochemistry, 5th Ed. Oxford UniversityPress.
5. Sadasivan S and Manikam K(2007): Biochemical Methods, 3rd Ed. New Age International (P) Ltd.
6. Oser B. L. (1965). Hawk's Physiological Chemistry, 14th Ed. McGraw-HillBook.
7. Gopalan C, Rama Sastri BV and Balasubramanian S.C. (2016): Nutritive value of Indian Foods, Indian Council of MedicalResearch.
8. Subalakshmi, G and Udipi, SA(2006):Food processing and preservation, 1st Ed. New Age International(P)Ltd.
9. Srilakshmi B(2018): Food Science, 7th Colour Ed. New Age International (P) Ltd.
10. Potter NN and Hotchkiss JH(1999): Food science,5th Ed ,Spinger.

SKILL ENHANCEMENT COURSES

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 1	Personality Development	Theory: 2

Learning outcomes:

After the completion of this course, the learner will be able to:

- Develop understanding of the concepts and principles of basic psychologicalskills
- Apply techniques and methods to enhance productivity and timemanagement
- Develop critical thinkingskills
- Organize human resources with improved leadershipqualities

Keywords:

Mental heuristics, Mental priming, Checklists, Stress management, Cognitive biases, Leadership qualities

Unit I: BasicPsychologySkills **8Lectures**

Mental Heuristics and Priming, Cialdini's six psychological principles, Charisma and charisma enhancements, facing interviews

Unit II: Productivity andTimeManagement **7 Lectures**

Eisenhower Matrix, Pomodoro Technique, Dealing with Procrastination, Journaling methods, Checklists, to-do lists and scheduling theevents

Unit III:DealingNegativity **7 Lectures**

Work-life balance, stress management, coping with failures anddepression

Unit IV: Critical Thinking andHumanresources **8 Lectures**

Logical fallacies, Cognitive biases, Mental Models, Critical Thinking. Evaluation and improvement; Leadershipqualities.

Suggested Readings

1. Bast, F. (2016). Crux of time management for students. Available at:https://www.ias.ac.in/article/fulltext/reso/021/01/0071-0088

2. Cialdini, R.B. (2001). Influence: The Psychology of Persuasion, Revised Edition. Harper Collius.

3. Green, C.J. (2015). Leadership and soft skills for students: Empowered to succeed in High School, College and beyond. Dog EarPublishing.

4. Velayudhan, A. and Amudhadevi, N. V. (2012). Personality Development for College Students. LAP Lambert AcademicPublishing.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 2	Computer Applications in Chemistry	Theory: 2

Learning outcomes:

After the completion of this course the learner will be able to:

- Apply the basic operations of spreadsheetapplications
- Recognize advanced resources for accessing scholarly literature frominternet
- Utilize bibliography management software while typing and downloadingcitations
- Operate various software resources with advanced functions and its open office substitutes

Keywords:

Spreadsheet, Google search, Subscription, Bibliography, MS office, Image processing

Unit I:SpreadsheetApplications **8 Lectures**

Introduction of spreadsheet (MS Excel), application, formulas and functions, performing basic statistics using spreadsheet applications, creating basic graphs using spreadsheet applications, logical (Boolean) operators.

Unit II:InternetResources **7Lectures**

Advanced Google search operators and Boolean functions, Introduction to Google Scholar and accessing scholarly literature from Internet, Fake News and spotting the fake news, multimedia resources and podcasts, RSS/XML Feeds and feed subscription using a feed reader.

Unit III:Bibliographymanagement **8 Lectures**

Introducing a bibliography management software (for e.g. Endnote), Styles and Templates, Changing the bibliography style as per journal format, Citing while typing in the office application, downloading citations from Google Scholar.

Unit IV: Othersoftwareresources **7 Lectures**

Introduction to advanced functions of MS Word and its Open Office substitutes including tracking changes, inserting page numbers and automatic table of contents, Google Docs and Forms, MS Power point, Microphotography and scale calibration with ImageJ, digital image processing (Paint.net or GIMP).

Suggested Readings

1. User manual and online user manual of respective soft wares for the most updated content
2. Published books are not recommended as versions keep on updating very frequently; therefore, it is not easy tofollow.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 3	Science Communication and Popularization	Theory:2

Learning outcomes:

After the completion of this course, the learner will be able to:

- Identify the need and role of science communication in humandevelopment
- utilize visual media science communication for creating scripts anddocumentaries
- Contribute in science popularization through internet communication and public sensitization

Keywords:

Print science, Visual media, Internet communication, Blogs, Outreach talks, Public sensitization

Unit I: PrintScienceCommunication **9 lectures**

Need for Science Journalism: Science has potential for breaking news, impact on Human life, impact on technology. Role of science and technology in human development.Framing policies at national and international levels. Writing and communicating popular articles effectively, case studies of celebrated works of science communicators including Cosmos by Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and Matt Riddley, importance for communication through regionallanguages.

Unit II: Visual MediaScienceCommunication **7 lectures**

Science outreach through visual media: Creating science documentaries, creating the outline and expanding, scripts, citing authentic sources, case study: Famous documentaries of Carl Sagan, David Attenborough and Prof. Yashpal

Unit III: InternetScienceCommunication **7 lectures**

Science outreach through internet: Social media, Websites, Blogs, Youtube, Podcast etc.

Unit IV: Science Outreach Talks and Public Sensitization **7lectures**

Tactics for providing a charismatic and effective public talk, use of metaphors, speaking in context, Science outreach for biodiversity conservation sensitization of public

Suggested Readings

1. Selected works of Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and MattRiddley.
2. Gigante, E. Marie (2018). Introducing Science Through Images: Cases of Visual Popularization (Studies in Rhetoric/Communication), University of South CarolinaPress.

Semester	Course	Name of the course	Credits
I,II,III,IV	SEC 4	Biofertilizers (Practical based course)	Theory: 2

Learning outcomes:

On the completion of this course, the students will be able to;

- Develop their understanding on the concept ofbio-fertilizer
- Identify the different forms of biofertilizers and theiruses
- Compose the Green manuring and organicfertilizers
- Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers

Keywords:

Useful microbes, Cyanobacteria, Mycorrhiza, Organic farming, Recycling, Vermicompost

UnitI **9 Lectures**

General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. *Azospirillum:* isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and massmultiplication.

Unit II **7 Lectures**

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

UnitIII **7 lectures**

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit IV **7 lectures**

Organic farming – Green manuring and organic fertilizers, Recycling of bio- degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.

Suggested Readings

1. Dubey, R.C. (2005). A Text book of Biotechnology S.Chand & Co, NewDelhi.
2. John Jothi Prakash, E. (2004). Outlines of PlantBiotechnology.Emka Publication, NewDelhi.
3. Kumaresan, V.(2005). Biotechnology, Saras Publications, NewDelhi.
4. NIIR Board. (2012). The complete Technology Book on Biofertilizer and organic farming. 2nd Edition. NIIR Project ConsultancyServices.
5. Sathe, T.V. (2004) Vermiculture and Organic Farming. Dayapublishers.
6. Subba Rao N.S. (2017). Biofertilizers in Agriculture and Forestry. Fourth Edition. Medtech.
7. Vayas,S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizersandorganicFarming Akta Prakashan,Nadiad.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 5	Herbal Science & Technology	Theory: 2

Learning outcomes:

On completion of this course the students will be able to;

- Develop their understanding on HerbalTechnology
- Define and describe the principle of cultivation of herbalproducts.
- List the major herbs, their botanical name and chemicalconstituents.
- Evaluate the drug adulteration through the biologicaltesting
- Formulate the value added processing / storage / quality control for the better use of herbalmedicine
- Develop the skills for cultivation of plants and their value added processing / storage / quality control

Keywords:

Herbal medicines, Plant products, Biopesticides, Pharmacognosy, Adulteration, Secondary metabolites

UnitI **7 lectures**

Herbal Technology: Definition and scope; Herbal medicines: history and scope; Traditional systems of medicine, and overview of AYUSH (Traditional Indian Systems of Medicine); Cultivation - harvesting - processing - storage of herbs and herbal products.

UnitII **7 lectures**

Value added plant products: Herbs and herbal products recognized in India; Major herbs used as herbal medicines, nutraceuticals, cosmeticals and biopesticides, their Botanical names, plant parts used, major chemicalconstituents.

UnitIII **8 lectures**

Pharmacognosy - Systematic position, botany of the plant part used and active principles of the following herbs: Tulsi, Ginger, Curcuma, Fenugreek, Indian Gooseberry, *Catharanthus roseus*, *Withania somnifera*, *Centella asiatica*, *Achyranthes aspera*, Kalmegh, Giloe (Tinospora), Saravar. Herbal foods, future of pharmacognosy.

UnitIV **8 lectures**

Analytical pharmacognosy: Morphological and microscopic examination of herbs, Evaluation of drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds). Plant gene banks, Cultivation of Plants and their value added processing / storage / quality control for use in herbal formulations, Introductory knowledge of Tissue culture and Micro propagation. of some medicinal plants (*Withania somnifera*, neem andtulsi),

Suggested Readings

1. Agarwal, P., Shashi, Alok., Fatima, A. and Verma, A. (2013). Current scenario ofHerbal Technology worldwide: An overview. *Int J Pharm Sci Res*; 4(11):4105-17.
2. Arber, Agnes. (1999). Herbal Plants and Drugs. Mangal Deep Publications,Jaipur.

3. Varzakas, T., Zakynthinos, G, and Francis Verpoort, F. (2016). Plant Food Residues as a Source of Nutraceuticals and Functional Foods. Foods 5 :88.
4. Aburjai, T. and Natsheh, F.M. (2003). Plants Used in Cosmetics. Phytotherapy Research 17:987-1000.
5. Patri, F. and Silano, V. (2002). Plants in cosmetics: Plants and plant preparations used as ingredients for cosmetic products - Volume 1. ISBN 978-92-871-8474-0, pp218.
6. AYUSH (www.indianmedicine.nic.in). *About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy*. New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government ofIndia.
7. Evans, W.C. (2009): Trease and Evans PHARMACOGNOSY. 16th Edition,SAUNDERS/ Elsevier.
8. Sivarajan,V.V.andIndia,B.(1994).AyurvedicDrugsandTheirPlantSources..*Oxford&IBH Publishing Company*, 1994 - Herbs - 570 pages.
9. Miller, L. and Miller, B. (2017). Ayurveda & Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. *Motilal Banarsidass,;Fourth edition.*
10. Kokate, C.K. (2003). Practical Pharmacognosy. Vallabh Prakashan,Pune.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 6	Fermentation Science and Technology	Theory: 2

Learning outcomes:

After completing this course, the learner will be able to:

- Employ the process for maintenance and preservation ofmicroorganisms
- Analyze the various aspects of the fermentation technology and apply for Fermentative production
- Demonstrate proficiency in the experimental techniques for microbial production of enzymes: amylase and protease, bio productrecover

UnitI **8 Lectures**

Preparation of microbial culture, Preparation and sterilization of fermentation media.Isolation and improvement of industrially important microorganisms.

UnitII **8Lectures**

Maintenance and preservation of microorganisms, Metabolic regulations and overproduction of metabolites. Kinetics of microbial growth and product formation.

UnitIII **8 Lectures**

Scope and opportunities of fermentation technology. Principles of fermentation: Submerged, solid state, batch, fed-batch and continuous culture. Fermentative production of vinegar, alcohol (ethanol, wine, beer), acids (citric acid and gluconic acid), amino acids (lysine and glutamic acid) and antibiotics (penicillin and streptomycin).

UnitIV **6Lectures**

Microbial production of enzymes: Amylase and Protease. Bioproduct recovery.

Suggested readings

1. Waites M.J. (2008). Industrial Microbiology: An Introduction, 7th Edition, Blackwell Science, London,UK.
2. Prescott S.C., Dunn C.G., Reed G. (1982). Prescott & Dunn's Industrial Microbiology, 4th Edition, AVI Pub. Co.,USA.
3. Reed G. (2004). Prescott & Dunn's industrial microbiology, 4th Edition, AVI Pub. Co., USA.
4. JR Casida L.E. (2015). Industrial Microbiology, 3rd Edition, New Age International (P) Limited Publishers, New Delhi,India.
5. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001) Industrial Microbiology: An Introduction. 1st Edition, Blackwell Science, London,UK.
6. Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003) Microbiology. 5th Edition, Tata McGraw-Hill Publishing Company Limited, NewDelhi.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 7	Environmental impact analysis (Practical based)	Theory: 2

Learning outcomes:

After completing this course, the learner will be able to;

- Have critical understanding of environmentalimpact
- Learn important steps of EIAprocess
- Interpret the environmental appraisal and procedures inIndia.

Unit I: OriginandDevelopment **8 Lectures**

Purpose and aim, core values and principles, History of EIA development, Environmental Management Plan, Environmental Impact Statement, Scope of EIA in Project planning and Implementation.

Unit II:EIAProcess **8 Lectures**

Components of EIA, EIA Methodology- Screening, Scoping, Baseline data, Impact Identification, Prediction, Evaluation and Mitigation, Appendices and Forms of Application, Techniques of Assessment-Cost-benefit Analysis, Matrices, Checklist, Overlays, Impact on Environmental component: air, noise, water, land, biological, social and environmental factors. EIA Document.

Unit III: Main participants inEIAProcess **7 Lectures**

Role of Project proponent, environmental consultant, PCBs, PCCs, public and IAA.Public participation.

Unit IV: Environmental Appraisal and Procedures in India and EIA **7 Lectures**

Methodology, indicators and mitigation, Environmental Audit of different environmental resources, Risk Analysis, Strategic environmental assessment, ecological impact assessment: legislation.

Practical

1. Prepare a Matrix of every environmental existing resource of your college or your hostel/mohalla or any defined area and evaluate each component using established methods and make auditanalysis.
2. Prepare a case report of Environmental impact of any area underdevelopment.

Suggested readings:

a. Kulkarni V and Ramachandra TV, (2006). Environmental Management, Capital Pub. Co. NewDelhi.

b. Petts, J. (2005) Handbook of Environmental Impact Assessment- Volume 1 and 2. Blackwell Publishers,UK.

c. Glasson, J. Therivel, R. and Chadwick, (2006) A. Introduction to Environmental Impact Assessment. Routledge,London.

d. Canter, W. L. (1995) Environmental Impact Assessment, McGraw-Hill Science/ Engineering/ Math, NewYork;

e. Morris, P. and Therivel, R. (1995) Methods of Environmental Impact Assessment, UCL

Press,London;

f. Petts, J. (1999) (ed) Handbook of Environmental Impact Assessment, volume 1 and 2, Blackwell Science,Oxford;

g. Therivel, R. and Partidario, M. R. (1996) (eds) The Practice of Strategic Environmental Assessment, Earthscan,London;

h. Vanclay, F. and Bronstein, D. A. (1995) (eds) Environmental and Social Impact Assessment, Wiley & Sons,Chichester.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 8	Skill Enhancement Course: IT skills for chemists	Theory: 2

Learning outcome

On completion of this course, the students will be able to:

- Have understanding of fundamental mathemarical functions
- Understand uncertainty in experimental techniques
- Develop computer programmes using various programs.

UNIT-I: IT Skills for Chemists

Fundamentals, mathematical functions, polynomial expressions, logarithms, the exponential function, units of a measurement, inter-conversion of units, constants and variables, equation of a straight line, plotting graphs.

Uncertainty in experimental techniques: Displaying uncertainties, measurements in chemistry, decimal places, significant figures, combining quantities. Uncertainty in measurement: types of uncertainties, combining uncertainties. Statistical treatment. Mean, standard deviation, relative error. Data reduction and the propagation of errors.Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression). Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation in different forms).Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary–bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).

Differential calculus: The tangent line and the derivative of a function, numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations). Numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).

UNIT-II: Computer programming:

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions.Elements of the BASIC language.BASIC keywords and commands.Logical and relative operators.Strings and graphics.Compiled versus interpreted languages.Debugging.Simple programs using these concepts.Matrix addition and multiplication.Statisticalanalysis. BASIC/FORTRAN programs for curve fitting, numerical differentiation and integration (Trapezoidal rule, Simpson's rule), finding roots (quadratic formula, iterative, Newton-Raphson method).

Recommended books/References:

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books(2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005). 3.Steiner, E. The Chemical Maths Book Oxford University Press (1996). 4.Yates, P. Chemical calculations. 2nd Ed. CRC Press(2007).
5. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters3-5.
6. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487pages.

7. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co.(1985).
8. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi(1996).

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 9	Intellectual property right (IPR) and business skills forchemists	Theory: 2

Learning outcome

On completion of this course, the students will be able to:

- Know History, types and important of intellectual property.
- Have understanding about different types of trademarks.
- Know about Patent and copyright transfer system
- Learn about registration, Industial design and trade secrets and different international agreements about IPR

Introduction to Intellectual Property:

Historical Perspective, Different Types of IP, Importance of protecting IP.

Copyrights

Introduction, How to obtain, Differences from Patents.

Trade Marks

Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc. Differences from Designs.

Patents Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.

Geographical Indications

Definition, rules for registration, prevention of illegal exploitation, importance to India.

Industrial Designs

Definition, How to obtain, features, International design registration.

Layout design of integrated circuits

Circuit Boards, Integrated Chips, Importance for electronic industry.

Trade Secrets

Introduction, Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

Different International agreements

(a) World Trade Organization(WTO):

(i) General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii) General Agreement on Trade related Services (GATS) (iii) Madrid Protocol (iv) Berne Convention (v) Budapest Treaty.

(b) ParisConvention

WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity

IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcement agencies

– Police, Customs etc. Economic Value of Intellectual Property – Intangible assets and their valuation, Intellectual Property in the Indian Context – Various laws in India Licensing and

technology transfer.

Business Basics

Key business concepts: Business plans, market need, project management and routes to market.

Chemistry in Industry

Current challenges and opportunities for the chemistry-using industries, role of chemistry in India and globaleconomies.

Financial aspects

Financial aspects of business with case studies.

Recommended Books/References:

1. Acharya, N.K. Textbook on intellectual property rights, Asia Law House(2001).
2. Guru, M. & Rao, M.B. Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications(2003).
3. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw- Hill(2001).
4. Miller, A.R. & Davis, M.H. Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers(2000).
5. Watal, J. Intellectual property rights in the WTO and developing countries, Oxford University Press, NewDelhi.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 10	Analytical Clinical Biochemistry	Theory: 2

Learning outcome

On completion of this course, the students will be able to:

- Identify among various biological molecules
- Understand primary, secondary and tertiary structures of proteins.
- Indentify structures of DNA, RNA, Lipids etc.
- Know about nomenclature, Classification of Enzymes

Structure, properties and functions of carbohydrates, lipids and proteins:

Carbohydrates:Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. Isolation and characterization of polysachharides.

Proteins:Classification, biological importance; Primary and secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Isolation, characterization, denaturation of proteins.

Enzymes:Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

Lipids:Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins: Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones.

Structure of DNA(Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.

***Enzymes*:** Nomenclature, classification, effect of pH, temperature on enzyme activity, enzyme inhibition.

A diagnostic approach to biochemistry:

Blood:Composition and functions of blood, blood coagulation. Blood collection and preservation of samples.Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol andbilirubin.

Urine:Collection and preservation of samples. 6. Formation of urine. Composition and estimation of constituents of normal and pathological urine.

Recommended books/references:

1. Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell(1977).
2. Wilson, K. & Walker, J. *Practical Biochemistry.* Cambridge University Press(2009).
3. Varley, H., Gowenlock, A.H & Bell, M.: *Practical Clinical Biochemistry,* Heinemann, London (1980).
4. Devlin, T.M., *Textbook of Biochemistry with Clinical Correlations*, John Wiley & Sons,2010.

5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman,2002.
6. Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed. PHI Learning.
7. Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*, W.H. Freeman,2013.
8. O. Mikes, R.A. Chalmers: *Laboratory Handbook of Chromatographic Methods*, D. Van Nostrand & Co.,1961.

Analytical Clinical Biochemistry Practical

Identification and estimation of the following:

1. Carbohydrates – qualitative andquantitative.
2. Lipids –qualitative.
5. Determination of cholesterol using Liebermann- Burchardreaction.
6. Proteins –qualitative.
7. Isolation of protein.
8. Determination of protein by the Biuretreaction.
9. Determination of nucleicacids.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell(1977).
2. Wilson, K. & Walker, J. *Practical Biochemistry.* Cambridge University Press(2009).
3. Varley, H., Gowenlock, A.H & Bell, M.: *Practical Clinical Biochemistry,* Heinemann, London (1980).
4. Devlin, T.M., *Textbook of Biochemistry with Clinical Correlations*, John Wiley & Sons,2010.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman,2002.
6. Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed. PHI Learning.
7. Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*, W.H. Freeman,2013.
8. O. Mikes, R.A. Chalmers: *Laboratory Handbook of Chromatographic Methods*, D. Van Nostrand & Co.,1961.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 11	Mushroom Culture Technology	Theory: 2

Learning outcomes:

On completion of this course, the students will be able to:

- Recall various types and categories ofmushrooms.
- Demonstrate various types of mushroom cultivatingtechnologies.
- Examine various types of food technologies associated with mushroomindustry.
- Value the economic factors associated with mushroomcultivation
- Device new methods and strategies to contribute to mushroomproduction.

Keywords:

Edible mushrooms, Poisonous mushrooms, Cutivation technology, Mushroom bed, Mushroom unit, Storage and Nutrition

UnitI **7Lectures**

Introduction, History. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus*.

UnitII **9 Lectures**

Cultivation Technology: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low-cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparations of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation- Low-cost technology, Composting technology in mushroomproduction.

UnitIII **7 Lectures**

Storage and nutrition: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.

UnitIV **7 Lectures**

Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and regional level. Cost benefit ratio - Marketing in India and abroad, ExportValue.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore -560018.
3. Tewari, Pankaj and Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol.II.

CERTIFICATE COURSEs/VALUE ADDED COURSES

Semester	Course	Name of the course	Credits=02
I-VI	VAC-3	Fuel Chemistry	Theory+ Practical

1. **Department** Chemistry
2. **Name of the Course:** Certificate Course in Fuel Chemistry
   Nature of Course(Certificate/ Value Added): Certificate
3. **Mode of Course:** Hybrid Mode (Online + Offline)
   Online / Offline / Physical
4. **Number of Seats:** 20
5. **Eligibility Criteria for Admission:** 12th Pass, Ongoing B Sc in any discipline with Chemistry as a paper.
6. **Introduction and relevance of Course**:

In the present scenario energy are first and foremost requirement for the socio-economic development of the society and nation as well which is also recognized by United Nations (UN) as one of the very important and inevitable common goals for the sustainable development goals (SDGs). This course will enable the scientific knowledge, skill and hands-on experience about the most non-renewable energy sources fossil fuels (coal, petroleum, and natural gas) to meet out the energy demand of the country. This will assist them to be industry ready to contribute effectively in the field of coal, petroleum chemistry and technology. In the Bilaspur city the regional research centre of CSIR-Central Institute of Mining and Fuel Research (CIMFR) is located where they recruit the project assistant and project fellow having the knowledge and experience on fuel chemistry, therefore, this course will provide job opportunities too.

7. **Objectives of the course**: The course will have the following objectives
   - To know about the sources of energies.
   - To study the fuel as the main source of energy particularly fossil fuels.
   - To know the chemical compositions of different fuels
   - To study Domestic and industrial applications of coal.
   - To understand about petroleum and petrochemical industry.
   - Various prospects of lubricants
8. **Learning outcome of the course**:
   - Understand both conventional based fuels, and alternative & renewable fuels.

- Understand the chemistry that underpins coal and petroleum fuel science and technology.
- They will understand the refining processes used to produce fuels and lubricants and will know how differences in chemical composition affect properties of fuels and their usage in different applications.
- Understand the fuel product specifications, various test methods used to qualifydifferent types of fuels as well characterization methods.
- They will get experimental experience on fossil fuels like coal, petroleum, and natural gas)
- Students can get job opportunities in various projects of of CSIR-Central Institute of Mining and Fuel Research (CIMFR).

9. Number of lectures: 2 hour per week (02 Credit)

10. Number of practical's (if any): 2 hour per week (01 Credit)

11. List of experiments (If any)-

- Determination of flash point & fire point of given fuel sample.
- Determination of viscosity index, cloud point, pour point of given fuel sample.
- Determination of calorific value of given fuel sample/coal sample using bomb calorimeter. Proximate analysis of given coal sample.
- Determination of the iodine number of oil.
- Determination of the saponification number of oil.

12. Syllabus:

Credits: 02 **30 Lectures**

Unit 1

Review of energy sources (renewable and non-renewable). Energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission.Classification of fuels and their calorific value. Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel

Unit II

Coal as Fuel: Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point. Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit III

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining anddifferent types

of petroleum products and their applications Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit IV

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (flash point, fire point, viscosity index, cloud point, pore point) and their determination.

13. Suggestive Readings:

- Industrial Chemistr by Stocchi, E. Vol-I, Ellis Horwood Ltd. UK (1990).
- Engineering Chemistry by Jain, P.C. & Jain, M. Dhanpat Rai & Sons, Delhi.
- A Text Book of Engineering Chemistry S. S. Dara S Chand & Company
- Industrial Chemistry by Sharma, B.K. & Gaur, H. Goel Publishing House, Meerut (1996).
- Chemistry of Fossil Fuels and Biofuels by Harold Schobert , Cambridge University Press 2013.
- The Chemistry and Technology of Coal by James G. Speight, CRC Press Boca Raton (2012)
- Water for Energy and Fuel Production, Yatish T. Shah, CRC Press Boca Raton (2014)
- Process Chemistry of Coal Utilization: Impacts of Coal Quality and Operating Conditions by Stephen Niksa, Elsevier 2019
- Chemistry of Coal Conversion by Richard H. Schlosberg Springer (1985).
- The Chemistry and Technology of Petroleum by James G. Speight CRC, Boca Raton (2014).
- Lubricants and Lubrication by Wilfried Dresel, Wiley (2017).

14. Course Coordinator (Name & Designation)

Dr S S Thakur, Assistant Professor

Prof G, K Patra, Professor

15. Evaluation Criteria:

Components	Class Test	Hands on Experiment	End Semester	Total
Weightage (%)	**20**	**20**	**60**	**100**

16. Infra Structure requirements (if any): Basic laboratory with small instrument like flash and fire point apparatus, Bomb Calorimeter, viscometer, consumables chemicals etc.

17. Financial Requirement (if any): Rs. 50,000/- for instrument and chemicals

18. Proposed fee for the Course (if any): 5000/- (or as per direction of the university)

19. Budgetary provisions : 50, 000/-

Semester	Course	Name of the course	Credits=02
I-VI	VAC-5	POLYMER CHEMISTRY	Theory+ Practical

1. **Department:** Chemistry
2. **Name of the Course:** Certificate Course in Polymer Chemistry
3. **Nature of Course:** Certificate or Value Added Course: Certificate
4. **Mode of Course:** Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
5. **Number of Seats:** 20
6. **Eligibility Criteria for Admission:** Intermediate/ B Sc in any discipline with Chemistry as a paper
7. **Introduction and relevance of Course**: Polymer is a natural or artificial chemical compound consisting of large molecules which are made up of smaller, joined-together molecules called monomers. Due to their broad spectrum of properties, both synthetic and natural polymers play essential and versatile roles in everyday life.Polymers range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function. Polymers, both natural and synthetic, are created via polymerization of many small molecules, known as monomers. This course will provide the opportunity to the learner to get job in polymer industries. Learner can start own small level work based on polymer Processing that are one of the part of Syllabus
8. **Objectives of the course:**
    - To study the methods for preparation of variety of Polymers
    - To study the utilization of polymer in the preparation of different industrial articles along with other important compounds.
9. **Learning outcome of the course:** This course will educate the students on the subject of polymers that constitute one of the most important materials used presently. The course will include fundamentals of synthesis, characterization, properties and also include discussion on the applications of polymers, as well as challenges pertaining to contemporary polymer research.
10. **Number of lectures (I hour =1 credit per week):**2 (02 hour)
11. **Number of practical's (if any)(2 hours = 1 Credit per week):** 1(2 Hour)
12. **List of experiments (If any)-** attached with annexure I
13. **Syllabus:** See annexure 1
14. **Suggestive Readings:** See annexure 1
15. **Course Coordinator (Name & Designation):** Dr Arti Srivastava, Assistant Professor

16. **Evaluation Criteria** (to be decided by HOD and Course Teacher) by Written examination of theory and practical.
17. **Infra Structure requirements (if any):** Available in the department, 01 instrument required
18. **Financial Requirement (if any):**
19. **Proposed fee for the Course (if any):** 5000/-
20. **Budgetary provisions –** See annexure II

Syllabus on Polymer Chemistry (Certificate Course)

Credits: 02 **30 Lectures**

Unit 1

Introduction: Background, Nomenclature, Classifications, Examples and Applications, Principles of Polymerization

Unit II

Synthesis of Polymers: Step-Growth Polymerization, Radical Chain Polymerization, Controlled Radical Polymerization, Copolymerization Ionic Chain Polymerization, Coordination Polymerization, Ring-Opening Polymerization, Polymerization techniques.

Unit III

Characterization of Polymers: Determination of Molecular Weight, Frictional Properties of Polymers in Solution, Hydrodynamic Size, DSC, TGA and SEM.

Unit IV

Polymer Properties: Crystallinity in polymers, Glass transition temperature, Rheological properties, Mechanical, Optical, Electrical, Surface and Other Industrially Relevant Properties Degradation of polymers.

Unit V

Some industrially important Polymer reactions, Polymer Processing: Polymer additives, compounding and processing techniques

21. **Books recommended**:

1. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey-Interscience, New York.

2. G. Odian, P. W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, New York.

3. G. Odian, Principles of Polymerization, 3rd edition (1991) John Wiley, Singapore

4. P.Bahadur and N.V. Sastry, Principle of Polymer Sciences , Narosa Publishing House, New Delhi (2002)

5. V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar , Polymer Sciences, Wiley Eastern, New Delhi

(1986).

A Visit to Polymer Industry

Suggested list of Experiments (based on availability of the resources)

1. Purification of monomer
2. Radical polymerization vinyl monomers.
3. Determination of molecular weight of polymer by viscometric method.
4. Determination of molecular weight of polymer by GPC method
5. Synthesis of Nylon.
6. Synthesis of Hydrogel and its application

Annexure II

Amount of Minimum Proposed Budget: Rs 50,000/-

Amount required for Chemical: Rs 40,0000/-

Miscellaneous budget: Rs 10,000/-

Semester	Course	Name of the course	Credits=02
I-VI	VAC-4	COSMETIC FORMULATION	Theory+ Practical

Total Credit: 02 **Total hours: 30**

Course Objective:

This course is intended to provide a comprehensive survey of ingredients fundamental to the cosmetic industry. The course will emphasize current trends in the selection of cosmetic ingredients. The chemistry and technology of cosmetic raw materials will be related to their behavioral properties as utilized in the construction of stable functional systems. In this way, it is intended to generate a better understanding of the contributions of ingredients to the performance of finished product formulations. Emphasis will be placed on recognizing and dealing with problem areas associated with the use of various ingredients. Safety considerations and other pertinent matters which can influence ingredient selection will be included in these discussions.

Course Content:

UNIT - I: Classification of raw materials and raw materials used in the cosmetic industry for the manufacture of finished products. Method of sampling, Indian Standard specification laid down for sampling and testing of various cosmetics in finished form by the bureau of Indian standards. Factors affecting stability of a formulation, ICH guidelines, Methods of stabilizations and Methods of stability testing.Concept of development of stability indicating analytical methods.

UNIT - II: Determination of physical and chemical constants such as extractive values, moisture content, alcohol content, volatile oil content, ash values, bitterness values, foreign matters, and physical constants applicable to the lipid containing drugs.

UNIT III: Brief introduction of the following cosmetic preparation and a detailed study on their quality control: Shampoo, Tooth paste, skin powder, skin creams, hair creams, nail polish, after shave lotion, bath and toiletries, lipstick and hair dyes, perfumes, depilatories.

UNIT- IV: Packaging of cosmetics –Filling of solids, semisolids & liquids. Materials used for cosmetic packaging Rules & regulations and legal provisions for packaging & labeling.

UNIT-V: Experiments: Nano-Formulation of Gels, Shampoos, Hair-conditioners; Color cosmetics

Examination Scheme:

Components	**Class Test**	**Hands on Experiment**	**End Semester**	**Total**
Weightage (%)	**20**	**20**	**60**	**100**

Text & References:

1. Comprehensive Pharmacy Review 5th Edition by Leon Shargel, Alan H. Mutnick, Paul F. Souney, Larry N. Sawnson – 2004.
2. Applied Biopharmaceutics and Pharmacokinetics, 4th Edition by Leon Shargel / Andrew B.C., Yu – 1999.
3. A. H. Beckett and J. B. Stenlake Practical Pharmaceutical Chemistry, Part I and Part II, 4th Edition.
4. G. H. Jeffery, J. Basset, J. Mendham, R. C. Denny (Rev. by) Vogels Text Book of Quantitative Chemical Analysis, 5th Edition 1989, ELBS.
5. The Controller of Publications; New Delhi, Govt. of India, Indian Pharmacopoeia, Vol. I and Vol. II - 1996.
6. J. B. Wilkinson and R. J. Moore: Herry's Cosmeticology; Longman Scientific and Technical Publishers, Singapore.
7. P.D. Sethi; Quantitative Analysis of Drugs in Pharmaceutical Formulations, 3rd Edition - 1997,
8. ICH guideline for impurity determination and stability studies.
9. Practical HPLC method development by Lloyd R. Snyder, Joseph J. Kirkland, Joseph I. Glajch, John Wiley and Sons 2nd Edition – 1997
10. Chang. W.N "Nanofibres fabrication, performance and applications", Nova Science Publishers Inc, 2009.
11. Carbon Nanotubes: Synthesis, Structure, Properties, and Applications, Edited by M. S. Dresselhaus,G. Dresselhaus, P. Avouris, Springer-Verlag, 2000.
12. Textbook of Nanoscience and Nanotechnology, B.S. Muty, P. Shankar, Baldev Raj, B.B Rath and James Murday, University Press, IIM (ISBN-978 81 7371 738 3).
13. Introduction to Nanotechnology by Charles P. Poole Jr and. Frank J. Owens, Wiley-Inter science, 2003.

14. Nanoscale Materials in Chemistry Edited by Kenneth J. Klabunde, John Wiley & Sons, Inc., ISBNs: 0-471-38395-3 (Hardback); 0-471-22062-0.

How is Cosmetic Formulation Course Beneficial?

- They can also work in hospitals by training patients how to take care of their skin after surgery.
- They can also have jobs related to manicure and pedicure such as to beautify the hands and nails by cleaning and shaping the nails; decorate nails with paintings or designs or even with imitation jewels.

Cosmetic Technology Employment Areas

- Advertisement Industries
- Beauty Clinics
- Beauty parlour
- Food & Cosmetic Industries
- Resorts
- Skin Clinics
- Spa Centers
- Star Hotels

Semester	Course	Name of the course	Credits=02
I-VI	VAC-1	**EFFICIENT TECHNOLOGIES FOR FOOD PROCESSING AND SHELF LIFE EXTENSION**	Theory+ Practical

1. Department: Chemistry
2 Name of the Course: Certificate Course in
3 Nature of Course: Certificate or Value Added Course: Certificate
4 Mode of Course: Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
5 Number of Seats: 20
6 Eligibility Criteria for Admission: B Sc in any discipline with Chemistry as a paper
7. **Introduction and relevance of Course**: Food processing which includes both fresh and packaged food involves handling of foods, preparation and storage through the subsequent stages so that the pathogens and toxic components present in food are destroyed and deactivated making the food safer and hygienic. Food preservation techniques combines science-based knowledge with technologies, to prevent spoilage and extend shelf-life and ensure consumers free of pathogenic microorganism food. Deterioration of food leads to loss of quality including color, texture, taste as well as nutritive value.By preserving food, food waste can be reduced, which is an important way to decrease production costs and increase the efficiency of food systems, improve food security and nutrition and contribute towards environmental sustainability.For instance, it can reduce the environmental impact of food production

8. **Objectives of the course:**

- ✓ To impart knowledge in the area of food science and technology
- ✓ To aware with the recent technologies used in food preservation and processing
- ✓ To understand the quality control of different food items
- ✓ To understand the importance of food safety and food management

1. **Learning outcome of the course:**

After completing this certificate course the learner will be able to:

- ✓ understand the food processing and technology, its history,development and present status
- ✓ explain the significance and basic concepts of the subject
- ✓ aware of the skills required to be a professional food technologist
- ✓ aware of the career opportunities available and educational
- ✓ qualifications required for specific careers in the industry
- ✓ know the scope for self employment as small, medium or large scaleentrepreneurs.

10. Number of lectures (I hour =1 credit per week): 1 (01 hour)
11. Number of practical's (if any) (2 hours = 1 Credit per week) 1(2 Hour)
12. List of experiments (If any)- attached with annexure I
13 Syllabus:

Credits: 02 **30 Lectures**

Unit I

Introduction: Food Constituents & Functions, Quality and Safety Aspects of Food, Factors Affecting Quality during Processing and Storage, Role of Water in Food and its Shelf Life, Browning Reactions

Unit II

Technologies in Food Preservation: Principles of Food Preservation, Traditional Food Preservation Technologies, High Pressure Processing of Food, Membrane Technology, Food Irradiation, Hurdle Technology.

Unit III

Nanotechnology in Food Packing: Nano encapsulation,Nanoemulsions, Nanoparticles/active packagingNanoclays in packaging, Nanocomposites in packaging, Nanosensors at the packaging and processing plant, Nanosensors in plastic film packages/ Electronic tongue/ Intelligent packaging, NanosensorsNanofibresColor changing labels: Nanocochelates/ nanodroplets, Nanofilms/ Nanolaminates

Unit IV

Food Quality enhancement and analysis: Rancidity, Natural Antioxidants,High Energy RTE Food Paste, Ozonation of Food Grains, Food Fortification: Iron Fortified Rice (IFR), Nutri Dal and Fortified Noodles, Hyper Spectral Imaging for Quality Analysis of Food Grains, Non-Destructive Methods for Analysis of Grain Quality, Detection of Spoilage in Grains using Biosensors.

Practical

- To study the effect of enzymatic browning in fruits and vegetables.
- To study different types of blanching of fruits and vegetables.
- Preservation of food by canning.
- To perform cut out analysis of caned product.
- Preservation of food by high concentration of sugar i.e. jam.
- Preservation of food by high concentration of salt/acid i.e. pickle.
- Preservation of food by addition of chemicals i.e. tomato ketchup.
- Preservation of food by drying in a cabinet drier.
- Preservation of fruits & vegetables by freezing.

- Preservation of milk by pasteurization and sterilization.

14. Suggested readings/ Text and Reference Books:

- Food Processing Technology by P.J.Fellows, Woodhead publishing ltd.
- Food Science by N.N. Potter, CBS publishing.
- Physical principles of Food Preservation. Vol. II by M. Karel, O.R. Fenema and D.B. Lurd, Maroel, Dekker Inc. New York.
- The technology of food preservation by N.W. Desrosier and J.N. Desrosier, CBS publishing

15. Course Coordinator:

a. Dr NirajKumari, Assistant Professor in Chemistry, Department of Chemistry, Guru GhasidasVishwavidyalaBilaspur CG, India

b. Dr Arti Srivastava, Assistant Professor in Chemistry, Department of Chemistry, Guru GhasidasVishwavidyalaBilaspur CG, India

16. Evaluation Criteria (to be decided by HOD and Course Teacher):

Components	Class-Test	Experiment	End Semester	Total Marks
Weightage (%)	**20**	**20**	**60**	**100**

17. Infrastructure requirements (if any): Basic laboratory system with pH meter, magnetic stirrer, characterization and small testing equipments.

18. Financial Requirement (if any): Approx. Rs 50,000

19. Proposed fee for the Course (if any): Rs.5000.00 (As per the University's norms).

20. Budgetary provisions: Rs.50,000.00

Semester	Course	Name of the course	Credits=02
I-VI	VAC-6	Eco-Friendly Lubricants – Chemistry And Application	Theory+ Practical

1. **Department:** Chemistry
2. **Nameof the Course:** **Eco-friendly Lubricants – Chemistry and Application**
3. **Natureof the Course:** Certificate
4. **Modeof the Course:** Online/Offline/Physical
5. **NumberofSeats:** 20
6. **EligibilityCriteriaforAdmission:** 10+2 (OngoingUGstudents)

7. IntroductionandRelevanceof the Course: The automotive industry in India is the fifth-largest in the world as per the last year statistics. Lubricants are the soul of the automotive industry. A lubricant is a substance that helps to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces. The property of reducing friction is known as lubricity.

The certificate course in *Eco-friendly Lubricants - Chemistry and Application* is designed for undergraduate students looking for career in automotive industry as well as lubricants industry. This course emphases on chemistry involves in the formulating process, quality assessment, characterization and disposal techniques of lubricants. Through this course, students must improve their skills concerning theoretical and practical approaches towards all kinds of lubricants.

8. Objectives of the Course:

- The main objective of the course is to deal fundamentals of friction, viscosity and lubrication.
- The course is useful in understanding the nature and characteristic of lubricants raw materials.
- The basic objective of the course is to learn about types of lubricants.
- The course is convenient to understand the various industrial applications of lubricants.
- The basic objective of the course is to get knowledge about role of lubricants in engineering chemistry.
- The course is helpful in comprehension the various properties of lubricants such as iodine number, aniline point, emulsion number, flash and fire point, drop point, cloud and pour point, corrosion stability, saponification number etc.
- The course is fruitful in appreciation the importance of eco-friendly lubricants.

9. LearningOutcomeof the Course:

Upon completing the course, student will be able to:

- Describe the chemistry of lubricants.
- Understand and importance of composition of lubricants.
- Optimize the iodine number, aniline point, emulsion number, flash and fire point, corrosion stability, saponification number etc.
- Understand the lubrication mechanism.
- Determine the application of lubricants.
- Analyze the disposal techniques of lubricants.

10. Number of Lectures: 02hrs perweek(2Credit)

11. NumberofPractical: 02 hrs perweek (1Credit)

12. ListofExperiments:

- Viscosity measurement of various lubricants.
- Determining flash and fire point of lubricants.
- Analyzing drop point and aniline point of lubricants.
- Chemical analysis of corrosion stability in lubricants.
- Laboratory analysis various automotive engine oils.
- On site industrial visit.

13. Syllabus:

UNIT I: Definition of Lubricants and Lubrication: Definition,Brief history and progress of Lubricants. Composition of Lubricants. Additives used in Lubricants. Functions and various characteristic features of Lubricants.Role of Lubricants in Engineering Chemistry.

UNIT II:Classification of Lubricants: Solid, liquid, semi-solid and synthetic Lubricants. Properties of Lubricants: viscosity, iodine number, aniline point, emulsion number, flash and fire point, drop point, cloud and pour point, corrosion stability, saponification number etc.

UNIT III: Various Lubrication Methods: Grease Lubrication, Oil Lubrication, etc. Mechanism of Lubrication: thick film, thin film and extreme pressure lubrication. Essential requirements of a good lubricant. Application of Lubricants: Automotive engine oils, tractor, other motors, industrial, aviation, marine etc.

UNIT IV: Eco-friendly Lubricants and Disposal Techniques: Eco-friendly Lubricants, Lanolin: composition, modern developments, production and applications, Guidelines for the proper disposal, Biodegradability of Lubricants, Stabilization and reuse, Degradation through tillage or composting, Dumping, Storage of waste.

14. SuggestiveReadings:

- Don, M. P.; Webster, M.; Daschner, E. (2016). *Lubrication Fundamentals* (Third Edition, Revised and Expanded ed.). CRC Press.
- Donnet, C.; Erdemir, A. (2004). "Historical developments and new trends in tribological and solid lubricant coatings". *Surface and Coatings Technology*. 76–84.
- Jumat, S.; Nadia, S.; Emad, Y. (2010). "Biolubricants: raw materials, chemical modifications and environmental benefits". *European Journal of Lipid Science and Technology*. 112: 519–530.
- Khopkar, S. M. (2007). Environmental Pollution, Monitoring and Control. New Age International Publishers.
- Chawla, S.; Rai, D. & Sons (2017). A Text Book of Engineering Chemistry.
- Sahoo, P. (2005). Engineering Tribology. Prentice-Hall of India. New Delhi.
- Lansdown, A. R. (1982). Lubrication, A practical Guide to Lubricant selection. Pergamon Press.
- Majumdar, B. C. (1999). Introduction to Tribology of Bearings. Wheeler Publishing. New Delhi.

15. CourseCoordinator(Name&Designation):

(a) Dr. Bharat Lal Sahu (Assistant Professor)

(b) Dr. Bijnaneswar Mondal (Assistant Professor)

16. EvaluationCriteria:

Components	**ClassTest**	**Hands on Experiment**	**EndSemester**	**Total**
Weightage (%)	**20**	**20**	**60**	**100**

17. InfraStructureRequirements: Basiclaboratorywithsmallequipment likeheating mantle, magnetic stirrer, melting point checker and viscometer for characterization and testingpurpose.

18. Financial Requirement: Approximate Rs. 50,000.

19. ProposedfeefortheCourse: Rs.5000(As per the University's norms).

20. BudgetaryProvisions: Rs.50,000.

(Existing staff will handle all the classes, No separate/additional Faculty will be provided for the conduct of the course, however guest faculty may be called on demand basis, payment of which may be made as per budgetary provisions of the course)

CHOICE-BASED CREDIT SYSTEM(CBCS)

Course Structure & Syllabus

for

M. Sc. Chemistry

(To be implemented from Session 2021-2022)

Department of Chemistry

School of Physical Sciences
Guru Ghasidas Vishwavidyalaya
Bilaspur-495 009

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CBCS- Course structure for M. Sc. (Chemistry)

(To be implemented from Session 2021-2022)

SEMESTER -I								
Course Structure	**Course Code**	**Title**	**T/L**	**CCA**	**ESE**	**Total Marks**	**Credit**	**Final credit**
CC-1	CYPATT1	Analytical Chemistry I	T-3	40	60	100	3	5
	CYPALT1	Analytical Chemistry Practical I	L-4	40	60	100	2	
CC-2	CYPATT2	Inorganic Chemistry I	T-3	40	60	100	3	5
	CYPALT2	Inorganic Chemistry Practical I	L-4	40	60	100	2	
CC-3	CYPATT3	Organic Chemistry I	T-3	40	60	100	3	5
	CYPALT3	Organic Chemistry Practical I	L-4	40	60	100	2	
CC-4	CYPATT4	Physical Chemistry I	T-3	40	60	100	3	5
	CYPALT4	Physical Chemistry Practical I	L-4	40	60	100	2	
OE	CYPATO1	Polymer Chemistry	T-3	40	60	100	3	5
	CYPALO1	Polymer Chemistry- Practical I	L-4	40	60	100	2	
VAC/ Certificate Course/ Optional	CYPATC1	Refer the List of Value-Added Course (p. 5)	T-2	40	60	100	2	Additional Credit Course
	CYPALC1		L-2	40	60	100	1	
						Total Credit		**25**
Semester-II								
CC-5	CYPBTT1	Analytical Chemistry II	T-3	40	60	100	3	5
	CYPBLT1	Analytical Chemistry Practical-II	L-4	40	60	100	2	
CC-6	CYPBTT2	Inorganic Chemistry II	T-3	40	60	100	3	5
	CYPBLT2	Inorganic Chemistry Practical-II	L-4	40	60	100	2	
CC-7	CYPBTT3	Organic Chemistry II	T-3	40	60	100	3	5
	CYPBLT3	Organic Chemistry Practical-II	L-4	40	60	100	2	
CC-8	CYPBTT4	Physical Chemistry II	T-3	40	60	100	3	5
	CYPBLT4	Physical Chemistry Practical-II	L-4	40	60	100	2	
CC-9	CYPBTT5	Molecular Spectroscopy	T – 4+1*	40	60	100	5	5
DSE-1	CYPBTD1	Instrumental Analytical Techniques	T – 4+1*	40	60	100	5	5
	CYPBTD2	Bio-inorganic Chemistry	T – 4+1*	40	60	100	5	
	CYPBTD3	Chemistry of Heterocycles	T – 4+1*	40	60	100	5	
	CYPBTD4	Solid State Chemistry	T – 4+1*	40	60	100	5	
	Remarks*:* *Any one course from DSE-1 will be offered to each student by the Department.*							
VAC/ Certificate Course/ Optional	CYPATC1	Refer the List of Value-Added Course (p. 5)	T-2	40	60	100	2	Additional Credit Course
	CYPALC1		L-2	40	60	100	1	
						Total Credit		**30**
Semester-III								
CC-10	CYPCTT1	Computer Applications in Chemistry	T – 4+1*	40	60	100	5	5
RM	CYPCTA1	Research Methodology	T-2	40	60	100	2	2

OE-2	CYPCTO2	Medicinal Chemistry	T-3	40	60	100	3	5
	CYPCLO2	Medicinal Chemistry Practical	L-4	40	60	100	2	
	CYPDTO3	Industrial Chemistry	T-3	40	60	100	3	
	CYPDLO3	Industrial Chemistry Practical	L-4	40	60	100	2	
	Remarks:*Any one course each from OE will be offered by the Department*.							
DSE-2	CYPCTD1	Principles of Analytical Chemistry	T-3	40	60	100	3	5
	CYPCLD1	Analytical Chemistry Practical III	L-4	40	60	100	2	
	CYPCTD2	Organometallic Chemistry of Transition Metals	T-3	40	60	100	3	
	CYPCLD2	Inorganic Chemistry Practical III	L-4	40	60	100	2	
	CYPCTD3	Stereochemistry, Reactions and Rearrangements	T-3	40	60	100	3	
	CYPCLD3	Organic Chemistry Practical III	L-4	40	60	100	2	
	CYPCTD4	Electrochemistry	T-3	40	60	100	3	
	CYPCLD4	Physical Chemistry Practical III	L-4	40	60	100	2	
	Remarks*: Any one course from DSE-2 will be offered to each student by the Department.*							
DSE-3	CYPCTD5	Chemical Analysis	T-3	40	60	100	3	5
	CYPCLD5	Analytical Chemistry Practical IV	L-4	40	60	100	2	
	CYPCTD6	Inorganic Rings, Chains, and Clusters	T-3	40	60	100	3	
	CYPCLD6	Inorganic Chemistry Practical IV	L-4	40	60	100	2	
	CYPCTD7	Chemistry of Natural Products	T-3	40	60	100	3	
	CYPCLD7	Organic Chemistry Practical IV	L-4	40	60	100	2	
	CYPCTD8	Quantum Chemistry	T-3	40	60	100	3	
	CYPCLD8	Physical Chemistry Practical IV	L-4	40	60	100	2	
	Remarks*: Any one course from DSE-3 will be offered to each student by the Department*							
VAC/ Certificate Course/ Optional	CYPCTC1	Refer the List of Value-Added Course (p.5)	T-2	40	60	100	2	Additional Credit Course
	CYPCLC1		L-2	40	60	100	1	
						Total Credit		**22**
Semester-IV								
CC-11	CYPDTT6	Biological Chemistry	T-3	40	60	100	3	5
	CYPDTL6	Biological Chemistry Practical	L-4	20	30	50	2	
	Remarks*: Any one course each from OE-2 will be offered by the Department.*							
DSE-4	CYPDTD1	Advanced Separation Techniques	T – 4+1*	40	60	100	5	5
	CYPDTD2	Structural Methods in Inorganic Chemistry	T – 4+1*	40	60	100	5	
	CYPDTD3	Organic Spectroscopy for Structural Elucidation	T – 4+1*	40	60	100	5	
	CYPDTD4	Statistical Mechanics	T – 4+1*	40	60	100	5	
	Remarks*: Any one course from DSE-4 will be offered to each student by the Department*							
	CYPDTD5	Electroanalytical Methods	T – 4+1*	40	60	100	5	
	CYPDTD6	Special Topics in Inorganic Chemistry	T – 4+1*	40	60	100	5	

DSE-5	CYPDTD7	Reagents and Reactions in Organic Synthesis	T – 4+1*	40	60	100	5	5
	CYPDTD8	Chemical Kinetics	T – 4+1*	40	60	100	5	
	Remarks: *Any one course from DSE-5 will be offered to each student by the Department*							
DSE-6	CYPDTD9	Environmental Chemistry	T – 4+1*	40	60	100	5	5
D	CYPDDD1	Dissertation/field work/ internship/project/ Industry visit	D-12	40	60	100	6	6
VAC/ Certificate Course/ Optional	CYPATC1	Refer the List of Value-Added Course (p. 5)	T-2	40	60	100	2	Additional Credit Course
	CYPALC1		L-2	40	60	100	1	
Total								**26**
MOOC's#								
Total Credit								**Credit: 103**

CC = Core courseDSE = Discipline specific Elective OE = Open Elective T= Theory L=Lab
Course Structure:

List of Value-Added Course (Certificate Course)	
1	Lab Safety Management (Prof. G. K. Patra)
2	Green Water Technology (Dr. S. K. Singh & Dr. U. P. Azad)
3	Agrochemicals Formulation (Dr. Charu Arora)
4	Cement Chemistry (Dr. S. S. Thakur & Prof. G. K. Patra)
5	Chemistry of Smart Materials and Technology (Dr. Arti Srivastava & Dr. Neeraj Kumari)
6	Food Adulteration and Testing (Dr. V. K. Rai and Dr. Manorama Singh)

#MOOC's courses may be offered at least one time during entire PG programme for the any of Core Course, Generic elective, Discipline specific elective, AEC course, Skill enhancement course available on MOOC's platform time to time. If any such course related to your subject is not available on MOOC's platform, department may continue with regular courses.

T – 4+1*refer to 4 hours Lecture and 1 hour Tutorial

SEMESTER–I

CC-1: CYPATT1-Analytical Chemistry-I (Credit-3)

OBJECTIVES AND LEARNING: *Introduction, scope and objectives of analytical chemistry, selection of methods, tools of analytical chemistry, different analytical chemometrics as t-test, F-test, Q-test etc, general treatment of equilibria in aqueous medium, theory of redox indicators, principles of chromatography, classification, GC, HPLC.*

1. **Introduction:** Scope & objectives, Analytical chemistry and chemical analysis, Classification of analytical methods, Method selection, Sample processing, Steps in a quantitative analysis, Quantitative range (bispartite classification), Data organization, Analytical validations, Limit of detection and limit of quantitation, The tools of analytical chemistry and good lab practices.

2. **Analytical chemometrics:** Useful statistical test: test of significance, the F test, the student 't' test, the chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, significant figures, regression analysis (least square method for linear and non-linear plots), statistics of sampling and detection limit evaluation. Chemometrics for optimization, modeling and parameter estimation, factor analysis, resolution and pattern recognition.

3. **Treatment of Equilibria:** Solvents and solutions, leveling of aqueous and non- aqueous solvent effects, general treatment of equilibria in aqueous medium involving monoprotic weak acid and weak base, and salts of weak acids and weak bases. Activity and concentration, Effect of electrolytes on chemical equilibria, Calculation of pH, Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of pH indicators, Complexation equilibria and complexometric titrations, Redox equilibria and redox titration, Theory of redox indicators, precipitation titrations.

4. **Chromatographic Separation:** Principle of chromatography, classification of chromatography, planar chromatography (paper and thin layer chromatography) and column chromatography (Gas chromatography, High-performance liquid chromatography).

OUTCOMES: *Students will learn how to do statistical analysis in analytical chemistry for different data analysis, solving problems related to pH and theory of redox indicators, Theoretical approach towards different types of chromatographic separations.*

Books Recommended:

1. R. L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
2. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, New York.
3. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
4. J. H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), Saunders Holt, London.

CC-1: CYPALT1-Analytical Chemistry Practical-I (Credit-2)

OBJECTIVES AND LEARNING: *Understanding of term standard solution, titration, back titration, equivalence point, end point, primary and secondary standard, solves volumetric calculations based on performing different types of experiments.*

1. Determination of accuracy, precision, standard deviation, coefficient of variation, and least square fitting of certain set of experimental data in an analysis
2. Composition of two sets of results in terms of significance (Precision and accuracy) by (i) student's t-test, (ii) F-test
3. Quantitative determination of iron in soil samples by Redox titration method
4. Determination of hardness by EDTA titrations method using Eriochrome Black T
5. Determination of chloride by Argentometric method
6. Determination of composition of the metal complexes by Jobs continuous variation and mole ratio method
7. Spectrophotometric determination of iron using thiocyanate method
8. Determination of buffer capacity by pH metry.

Note: *Experiments may be added/deleted subject to availability of time and facilities***.**

OUTCOMES: On successful completion of these semesters, students will be able to know:

- The principles and applications of instrumental methods of analysis, including chemical separation methods etc.
- formulating and solving problems in the laboratory
- how to communicate scientific information clearly and accurately, both in oral and in written forms
- the composition of written laboratory reports that summarize experimental procedures and the accurately present and interpret data
- statistical methods of data analysis including error distributions, hypothesis testing, confidence intervals, the method of maximum likelihood or least-squares analysis.

CC-2: CYPATT2-Inorganic Chemistry-I (Credit-3)

OBJECTIVES AND LEARNING:

1. The students should be able to describe boding in coordination complexes.
2. The students should be able to explain electronic spectra of Transition Metal Complexes.
3. The students should be able to explain coordination, spectral and magnetic properties of lanthanides and actinides.
4. The students should be able to explain the use of terms Hard and Soft in relation to metal ions and ligands and discuss the stability of complexes in terms of hard and soft interactions.

1. **Metal-Ligand Bonding in Transition Metal Complexes**: Crystal field splitting diagrams in complexes of low symmetry; Spectrochemical and Nephelauxetic series; thermodynamic and structural effects; site selection in spinels, Jahn-Teller distortions; experimental evidence for metal-ligand orbital overlap; ligand field theory, molecular orbital theory of octahedral complexes.

2. **Electronic spectra of Transition Metal Complexes**: Spectroscopic ground states; Orgel energy level and Tanabe-Sugano diagrams for transition metal complexes; Charge transfer spectra; electronic spectra of octahedral and tetrahedral Co(II) and Ni(II) complexes and calculation of ligand-field parameters.

3. **Lanthanides and Actinides**: contraction, coordination, optical spectra and magnetic properties.

4. **HSAB Theory:** Classification of acids and bases as hard and soft; HSAB principle, theoretical basis of hardness and softness; Lewis-acid base reactivity approximation; donor and acceptor numbers, E and C equation; applications of HSAB concept.

5. **Uses of Organic reagents in Inorganic Analysis:**Cupferron, DMG, dithiozone, aluminon, oxine, dithiooxamide, α-benzoinoxime, αnitro-(3-naphthol, α-nitroso-3-naphthol, diphenyl carbazone, diphenyl carbazide, anthranilic acid, tannin, pyragallol, benzidine. salicylaldoxime, o-phenanthroline.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Boding in coordination complexes.
2. Spectral and magnetic properties of coordination compounds.
3. Coordination, spectral and magnetic properties of lanthanides and actinides.
4. Stability of complexes in terms of hard and soft interactions.

Books Recommended:

1. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn. (1999), John Wiley & Sons, New York.
2. James E. Huheey, Inorganic Chemistry, 4th Edn. (1993), Addison-Wesley Pub. Co., New York.
3. R. S. Drago, Physical Methods in Inorganic Chemistry, International Edn. (1971), Affiliated East-West Press, New Delhi.
4. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, (2006).
5. Vogel's Text book of Quantitative Inorganic Analysis, ELBS Press.

CC-2: CYPALT2-Inorganic Chemistry Practical-I (Credit-2)

OBJECTIVES AND LEARNING:The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Quantitative separation and determination of the following pairs of metal ions using gravimetric and volumetric methods:
   (i) Ag+ (gravimetrically) and Cu^{2+}(Volumetrically)
   (ii) Cu^{2+} (gravimetrically) and Zn^{2+}(Volumetrically)
   (iii) Fe^{3+} (gravimetrically) and Ca^{2+}(Volumetrically)
   (iv) Mg^{2+} (gravimetrically) and Ca^{2+}(Volumetrically)
   (v) Cu-EDTA (Volumetrically) and Cu-KCNS(Gravimetrically).
   (vi) Ni- EDTA (Volumetrically) Ni- DMG (Gravimetrically.)

2. Separation of a mixture of cations/anions by paper chromatographic technique using aqueous/non-aqueous media.
   (i) Pb^{2+} and Ag^{+} (aqueous and non-aqueous media)
   (ii) Co^{2+} and Cu^{2+} (non-aqueous medium)
   (iii) Cl^{-} and I^{-} (aqueous-acetone medium)
   (iv) Br– and I^{-} (aqueous-acetone medium)

Note:*Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES:On successful completion of these semesters, students will be able to know:

- The principles and applications of qualitative and quantitative analysis.
- Learning paper chromatographic techniques for the identification and separations of inorganic cations/anions.
- Collection, analysis and representation of data in a scientific manner.

CC-3: CYPATT3-Organic Chemistry-I (Credit-3)

OBJECTIVES AND LEARNING: Students will learn aromaticity, Effects of Structure on Reactivity, Mechanism and Stereochemistry of S_N1, S_N2, S_Ni and S_N2' reactions, The E1, E2 and E1cB mechanisms, Orientation of the double bond, Electrophilic, free-radical and nucleophilic mechanisms-Mechanistic and Stereochemical aspects. Orientation and reactivity.

1. **Aromaticity & Effects of Structure on Reactivity:** Benzenoid and non-benzenoid systems, anti-aromaticity, Homoaromaticity and NMR based concept of aromaticity; Linear free energy relationships (LFER), the Hammett equation - Substituent and reaction constants; the Taft treatment of polar and Steric effects in aliphatic compounds.

2. **Nucleophilic Substitution at Saturated Carbon:** Mechanism and Stereochemistry of SN1, SN2, SNi and SN2′ reactions. The reactivity effects of substrate structure, solvent effects, competition between SN1 and SN2 mechanisms.

3. **Neighboring Group Participation:**Evidences of N.G.P.; the Phenonium ion, participation by π and σ bonds, Anchimeric assistance. Classical vs. non-classical carbonium ions–the present status.

4. **Elimination reactions:** The E1, E2 and E1cB mechanisms, Orientation of the double bond. Hofmann versus Saytzeff elimination, Pyrolytic syn-elimination, Competition between substitution and elimination reactions.

5. **Addition to Carbon–Carbon Multiple Bonds:** Electrophilic, free-radical and nucleophilic mechanisms-Mechanistic and Stereochemical aspects. Orientation and reactivity. Hydroboration and Michael reaction.

OUTCOMES: After successful completion of the course, students will be enriched in knowledge to apply in their future endeavors. Students will be much familiar and acquainted with concept of aromaticity and its effect on structure, stability and reactivity. Students will gain the knowledge of Linear free energy relationships, polar and Steric effects in aliphatic compounds. Students will be well-versed with the basic as well as advanced concept of Organic reaction. Understand the basic concept of organic chemistry at advance level to apply in practical knowledge. Aromaticity of molecules and its effect on reactivity and stability. Relation between structure, reactivity and energy of

molecule as well as reaction dynamics. Basic as well as advanced knowledge of different mechanisms of addition reaction, substitution reaction and elimination reaction. Reactivity effects of substrate structure and solvent effects in SN1, SN2, E1 and E2 mechanism to unlock the basic problems of organic chemistry. To apply these basic concepts in solving the complex organic problems based on fundamentals.

Books recommended:

1. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
2. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi.
3. S.M. Mukherjee and S.P. Singh, Reaction Mechanism in Organic Chemistry, Ist Edition (1990), Macmillan India Ltd., New Delhi.
4. T.H. Lowry and K.S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition)
5. R.T. Morrison and R.N. Boyd, Organic Chemistry, 6th Edition (2003), Prentice- Hall of India, New Delhi.
6. P.S. Kalsi, Organic Reactions and Their Mechanisms, Ist Edition (1996), New Age International Pub., New Delhi.

CC-3: CYPALT3-Organic Chemistry Practical-I (Credit-2)

OBJECTIVES AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

Separation of binary mixtures (Solid-Solid) of organic compounds and identification of individual components (physical characterization, elemental analysis, functional group (s) detection, derivative preparation and melting point determination.

OUTCOMES:On completion of this module, the learner will be able to independently identify the presence of different components/molecules in the unknown organic mixture, detection of elements, functional groups, prepare derivatives of organic molecules

CC-4: CYPATT4-Physical Chemistry-I (Credit-3)

OBJECTIVES AND LEARNING:To understand the ion–ion interaction and different ionic atmosphere, kinetics of complex and explosion reactions, the phenomena of chemical equilibrium in a microscopic world of a chemical reaction, to understand the consequences of Nernst heat theorem, the need of third law of thermodynamics and its applications, the kinetics of adsorption of particles on solid surfaces.

Electrochemistry: Activity Coefficient and Ionic Migration in Electrolyte Solutions: Quantitative treatment of Debye-Hückel theory of ion-ion interaction and activity coefficient, applicability and limitations of Debye-Hückel limiting law, its modification for finite-sized ions, effect of ion-solvent interaction on activity coefficient. Debye-Hückel-Onsagar (D-H-O) theory of conductance of electrolyte solution, its applicability and limitations, Pair-wise association of ions (Bjerrum and Fuoss treatment), Modification of D-H-O theory to account for ion-pair formation, Determination of association constant (KA) from conductance data.

Chemical Kinetics: Mechanism of Composite Reactions - types of composite mechanisms, rate equations for composite mechanisms, simultaneous and consecutive reactions, steady state

treatment, rate-determining steps, microscopic reversibility and detailed balance, dynamic chain (H_2-Br_2 reaction, decomposition of ethane and acetaldehyde) and oscillatory reactions (Belousov-Zhabotinskii reaction), branching chain: Hydrogen oxygen reaction (H_2O_2) reaction.

Surface Chemistry and Catalysis: Bimolecular surface reactions - reaction between a gas molecule and an adsorbed molecule, reaction between two adsorbed molecules, inhibition and activation energy of such reactions, BET and Langmuir adsorption isotherm.

Catalytic activity at surfaces (volcano curve), transition state theory of surface reactions: rates of chemisorption and desorption, unimolecular and bimolecular surface reaction, comparison of homogeneous and heterogeneous reaction rates, surface heterogeneity, lateral interaction.

Thermodynamics: Properties of non-ideal solutions-deviations (negative and positive) from ideal behaviour, excess functions for non-ideal solutions, calculations of partial molar quantities, determination of partial molar volume and partial molar enthalpy.

Third Law of thermodynamics: Nernst heat theorem, variation of entropy with temperature, determination of absolute entropy of liquids and gases, residual entropy.

OUTCOMES:

- Upon course completion, the student will be able to define central parts of electrochemical cells and electrochemical environment around the electrode and they can apply the famous Debye Huckel and Onsager equation for calculation of strength of electrochemical atmosphere with the change of variables.
- Students will be able to interpret the behavior of interfaces, the phenomena of physisorption and chemisorptions, kinetic applications of different theories and their main industrial applications.
- Students will be able to apply thermodynamics and kinetics knowledge to equilibrium systems in the solution of practical cases, proposing different strategies, evaluating possible options and providing a reasoned analysis of the results, working both individually and cooperatively.

Books Recommended:

1. Modern Electrochemistry, Vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy, Second Edition, Plenum Press, New York (1998).
2. Chemical Kinetics, K. J. Laidler,Third Edition (1987), Harper & Row, New York.
3. Physical Chemistry, P. W. Atkins, 7th Edition, Oxford University Press, New York (2002)
4. Physical Chemistry, P. W. Atkins, 7th Edition, Oxford University Press, New York (2002).
5. Physical Chemistry, I.N. Levine, 5th Edition (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.
6. Kinetics and Mechanism of Chemical Transformations, J. Raja Ram and J.C. Kuriacose, MacMillan Indian Ltd., New Delhi (1993).

CC-4: CYPALT4-Physical Chemistry Practical-I (Credit-2)

OBJECTIVES AND LEARNING:The learners should be able to validate the conceptual understanding acquired from the theory classes:

1. Saponification of ethyl acetate with sodium hydroxide by chemical method.
2. Comparison of acid strengths through acid catalyzed methyl acetate hydrolysis.
3. Energy of activation of acid catalyzed hydrolysis of methyl acetate.
4. Distribution coefficient of I_2 between two immiscible solvents.
5. Conductometric titration of a weak acid with strong base.

6. Conductometric titration of a mixture of weak and strong acids.
7. Potentiometric titration of a strong acid with strong base using quinhydrone electrode.
8. Conductometric titration of KCl with AgNO3.
9. Molecular weight of a non-electrolyte by cryoscopy method.
10. Determination of Molecular weight of a non-volatile substance (non-electrolyte) by Landberger method.

Note:*Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES:

- Upon course completion, the student will be able to apply all these experiment in relevant industry and further in higher studies for the outcome.
- To interpret the experimental results obtained by conductometer and potentiometer.
- Students will be able to conduct the Chemical kinetics experiment on various important reactions.
- Students will be able to describe the principles behind the experiment performed in the laboratory.

1: CYPATO2-Polymer Chemistry (Credit-3)

OBJECTIVE AND LEARNING:

- Learning scientific Mechanism of step-growth and chain growth polymerization.
- To understand the nature and properties of polymers.
- To predict Glass transition temperature and Degradation of polymers.
- Defining The Flory-Huggins Theory of Polymer solutions.

1. **Introduction:**Introduction, Classification of Polymers, Intermolecular forces in Polymers.

2. **Mechanism and kinetics of step-growth and chain growth polymerization:** radical, cationic, anionic and condensation polymerization. Copolymerization, Reactivity Ratios, Thermodynamic Aspects of Polymerization. Mechanism of Living Radical Polymerizations: Nitroxide mediated polymerization (NMP), Metal-catalyzed Living Radical Polymerization, Coordination polymerization, Ring opening polymerization.

3. **Polymer solutions:** Thermodynamics of polymer dissolution, The Flory-Huggins Theory of Polymer solutions, Nature of polymer macromolecules in solution, Size and shape of macromolecules in solution.

4. **Polymer structure and Physical properties:** Microstructure of polymer chains, crystallinity in polymers, Glass transition temperature, rheological properties. Degradation of polymers. Polymer reactions. Polymer Processing.

5. **Experimental methods:** polymer fractionation, molecular weight determination: Molecular mass – number and mass average molecular mass, determination of molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography.

OUTCOMES: After studying this course, you should be able to:

- Summarize historical evolution of the polymers.

- Identify the repeat units of particular polymers and specify the isomeric structures which can exist for those repeat units.
- Evaluate the Polymer structure and Physical properties.
- Determine the molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography.
- Recognize monomers and polymers.

Books Recommended:

1. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey-Interscience, New York.
2. G. Odian, P. W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, New York.
3. G. Odian, Principles of Polymerization, 3rd edition (1991) John Wiley, Singapore
4. P.Bahadur and N.V. Sastry, Principle of Polymer Sciences, Narosa Publishing House, New Delhi (2002)
5. V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar, Polymer Sciences, Wiley Eastern, New Delhi (1986).

OE-1: CYPALO2-Polymer Chemistry Practical (Credit-2)

OBJECTIVE AND LEARNING:

- Learning scientific Mechanism of step-growth and chain growth polymerization.
- To understand the nature and properties of polymers.
- To predict Glass transition temperature and Degradation of polymers.
- Defining The Flory-Huggins Theory of Polymer solutions.

1. Purification of monomer
2. Polymer synthesis:
   A. Synthesis of homopolymer and their copolymers by Free radical polymerizationin aqueous solution.
   B. Polymerization of vinyl monomer in nonaqueous media.
   C. Preparation of urea-formaldehyde resin
   D. Preparation of hydrogel
   E. Preparation of Nylon 6,6
3. Polymer molecular weightDetermination:
   A. Determination of molecular weight by viscometry:
   B. Determination ofthe viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
4. CharacterizationTechniques:
   A. FTlR studies of Polymers
   B. XRD analysis
   C. Polymerization kinetics by UV analysis

OUTCOMES: After studying this course, you should be able to:

- Summarize historical evolution of the polymers.
- Identify the repeat units of particular polymers and specify the isomeric structures which can exist for those repeat units.
- Evaluate the Polymer structure and Physical properties.
- Determine the molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography.
- Recognize monomers and polymers.

Reference Books:

1. Harry R. All.cock, Frederick W. Lampe and James E. MarhContemChemistry, 3ro ed. Prentice-Hall (2003)
3. Fred W. Billmeyer, Textbook of Polymer Science,-3rd edition, WileyJnterscience (1984).
4. Joel R. Fried, Polymer Science and Technology' 2nded' Prentice-Hall (2003).
5. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
6. Seymour/Carraher's Polymer Chemistry, 9th ed. by Charles E, Carraher, Jr. (2013).

SEMESTER–II

CC-5: CYPBTT1-Analytical Chemistry – II (Credit-3)

OBJECTIVES AND LEARNING:Theory, instrumentation and applications of X-rays (emission, absorption, diffraction and fluorescence), Atomic absorption spectroscopy, Atomic emission spectrometry, UV-visible molecular absorption spectrometry, Jobs method of continuous variation, mole ratio, and slope ratio analysis, Molecular luminescence (fluorescence, phosphorescence, chemiluminescence).

1. **Basics of Polarography:** Origin of polarography, Current-voltage relationship, Theory of polarographic waves (DC and sampled DC (tast) polarograms), Instrumentation, interpretation of polarographic curve, Limiting current, residual and charging current, diffusion current, migration current. Supporting electrolytes. Effect of supporting electrolyte on the limiting current, Half wave potential and its significance, Qualitative and quantitative applications.

2. **Spectroscopic Techniques:** Theory, Instrumentation and applications of X-rays (emission, absorption, diffraction and fluorescence methods), Atomic absorption Spectroscopy, Atomic fluorescence spectrometry, Atomic emission spectrometry.

3. **Spectrophotometry:** UV-visible molecular absorption spectrometry, Principle and applications, determination of stoichiometry of complexes (Job's method of continuous variation, mole ratio and slope ratio analysis). Molecular luminescence spectrometry (fluorescence, phosphorescence, chemiluminescence).

4. **Thermal Analysis:** Theory, methodology and applications of thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), and Differential scanning calorimetry (DSC). Principles, techniques and applications of thermometric titration methods.

5. **Automation in the Laboratory:** Principles of automation, Process control through automated instruments, Autoanalyzers (single channel and multi-channel), Basic sequences of multi-fold operational analyzers in segmented and non-segmented flows.

OUTCOMES:

- Having successfully completed this module, you will be able to:
- understand the underlying theoretical basis of analytical techniques including titration and gravimetric analysis, spectroscopic methods including UV-visible, Fluorescence, and atomic absorption, chromatography, and electroanalysis;
- be able to select the appropriate analytical methods to evaluate a sample;
- critically evaluate data from a variety of analytical chemistry techniques and apply knowledge of the statistical analysis of data;
- have developed the skills required to work as a member of a group;
- be aware of current developments in the field of analytical chemistry.

Books Recommended:

1. Willard, Merrit, Dean, Settle, Instrumental Methods of Analysis, 7th Ediion, CBS Publishers & Distributors PVT Ltd.
2. D.A. Skoog, Principles of Instrumental Analysis, 5th Edition (1998), Saunders College Publishing, Philadelphia, London.
3. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
4. J.H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), Saunders Holt, London.

5. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, New York.

CC-5: CYPBLT1- Analytical Chemistry Practical-II (Credit-2)

OBJECTIVE AND LEARNING: Understanding of term standard solution, titration, back titration, equivalence point, end point, primary and secondary standard, solves volumetric calculations based on performing different types of experiments.

1. Determination of biological oxygen demand (BOD) and dissolved oxygen (DO) in water samples
2. Determination of chemical oxygen demand (COD) in waste water samples
3. Determination of total phosphorous and total dissolved solid in drinking water
4. Gas chromatography: Quantitative determination of organic compounds
5. Thin layer chromatography: Separation of amino acids
6. Iodometric titration: Determination unsaturation (iodine number)
7. Potentiometric titration: Determination of concentration of halide ion(s) in given solution
8. Determination of trace metal impurities present in water sample by voltammetric method

Note:*Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES: On successful completion of these semesters, students will be able to know:
(a) The principles and applications of instrumental methods of analysis, including chemical separation methods etc. (b) formulating and solving problems in the laboratory (c) how to communicate scientific information clearly and accurately, both in oral and in written forms (d) the composition of written laboratory reports that summarize experimental procedures and the accurately present and interpret data (e) statistical methods of data analysis including error distributions, hypothesis testing, confidence intervals, the method of maximum likelihood or least-squares analysis.

CC-6: CYPBTT2-Inorganic Chemistry – II (Credit-3)

OBJECTIVES AND LEARNING:

1. The students should be able to describe reactivity, electron transfer and mechanism in coordination and organometallic compounds.
2. The students should be able to explain bonding, synthesis and reactivity of transition metal complexes with pi donor ligands.
3. The students should be able to explain Wade's rule and the capping rule.
4. The students should be able to describe supramolecular interactions.
5. The students should know basic principle of Optical Rotatory Dispersion and Circular Dichroism.

1. **Kinetics and Mechanism of Substitution Reactions:** Nature of substitution reactions; prediction of reactivity of octahedral, tetrahedral and square-planar complexes in terms of VBT and CFT; rates of reactions; acid hydrolysis, base hydrolysis and anation reactions.

2. **Electron Transfer Reactions:** Mechanism and rate laws; various types of electron transfer reactions, Marcus-Husch theory, correlation between thermal and optical electron transfer reactions.

3. **Supramolecular Chemistry:** Definition, supramolecular host-guest compounds, macrocyclic effect, nature of suparmolecular interactions, molecular machine, biomodelling.

4. **Optical Rotatory Dispersion and Circular Dichroism:** Basic Principles of ORD and CD techniques. ORD and Cotton effect, Faraday and Kerr effects; Applications in determining absolute configuration of metal complexes.

5. **Symmetry Point groups:** determination of point group of a molecule. Representations. The great orthogonality theorem. Character table. Construction of character tables for c2v and c3v groups.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Reactivity, electron transfer and mechanism in coordination and organometallic compounds.
2. Boding ad reactivity of transition metal complexes with CO, NO and hydrides.
3. Supramolecular interaction and their application in host guest interaction and molecular machine.
4. Basic principle of optical rotatory dispersion and circular dichroism.

Books Recommended:

1. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn (1967), Wiley Eastern Ltd., New Delhi.
2. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd Edn. (1999), ELBS, London.
3. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn., John Wiley & Sons, New York (1999).
4. D.N. Sathyanarayana, Electronic Absorption Spectroscopy and Related Techniques, University Press (India) Ltd., Hyderabad (2001).
5. J.-M. Lehn; Supramolecular Chemistry-Concepts and Perspectives, Wiley-VCH, (1995).
6. P. D. Beer, P. A. Gale, D. K. Smith; Supramolecular Chemistry, Oxford University Press, (1999).
7. J. W. Steed and J. L. Atwood; Supramolecular Chemistry, Wiley, (2000).
8. Introductory Quantum Chemistry, A.K. Chandra, 4th Edition (1994), Tata Mcgraw Hill, New Delhi.
9. Atomic & Molecular Symmetry Groups and Chemistry, S.C. Rakshit, Aug 2021, CRC Press
10. Chemical Applications of Group Theory, 3ed, F. A. Cotton, Willey

CC-6: CYPBLT2- Inorganic Chemistry Practical-II (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

- Inorganic preparation of Mono Nuclear Metal Complexes.
- Preparation of coordination complexes and their characterization by magnetic susceptibilitymeasurements and IR, UV / Vis, ^{1}H NMR spectroscopic techniques.

a)Tetrammine cupric sulphate $[Cu(NH_3)_4]SO_4 \cdot H_2O$.
b) *tris* (thiourea) cuprous sulphate $[Cu(NH_2CSNH_2)_3]_2\ SO_4 \cdot H_2O$
c) *tris* (thiourea) cuprous chloride $[Cu(NH_2CSNH_2)_3]Cl$.
d) Hexa ammine nickel(II) chloride $[Ni(NH_3)_6]\ Cl_2$.
e) Hexathiourea–plumbus nitrate $[Pb(NH_2CSNH_2)_6]\ (NO_3)_2$.
f) Potassium trioxalato chromate $K_3\ [Cr(C_2O_4)_3]$.

g) Potassium trioxalato aluminate K_3 $[Al(C_2O_4)_3]$.
h) sodium trioxalateferrrate(III) Na_3 $[Fe(C_2O_4)_3]$ $9H_2O$.
i) Hexamminecobalt(III) chloride $[Co(NH_3)_6]$ Cl_3.
j) Pentathioureadicuprous nitrate $[Cu(NH_2CSNH_2)_5]$ $(NO_3)_2$.

Note:*Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES:

- Knowing about IR, electronic spectra and magnetic susceptibility of various transition metal complexes.
- Calculation of ligand field parameters based on electronic spectra of various transition metal complexes.
- Student will have idea about instrumentation methods of structural determination.

CC-7: CYPBTT3-Organic Chemistry – II (Credit-3)

OBJECTIVES AND LEARNING:To make student aware the advance level of basic organic chemistry to apply in different reaction mechanisms and organic transformations.

1. **Electrophilic Aromatic Substitution & Nucleophilic Substitution:** The Arenium ion mechanism, orientation and reactivity in monosubstituted benzene rings. Ipso substitution. Electrophilic aromatic substitution of naphthalene, phenanthrene and antharcene.

2. **Aromatic Nucleophilic Substitution:** The Aromatic SN1, SN2 and Benzyne mechanisms. Reactivity – effect of substrate structure, leaving group, and attacking nucleophile. Nucleophilic aromatic substitution of naphthalene, phenanthrene and antharcene.

3. **PericyclicReactions:** Orbital symmetry and correlation diagram, Woodward-Hoffmann rules; cycloaddition [2+2] and [4+2], and electrocylic reactions. Prototropic and Sigmatropic rearrangements, Cope, Claisen and Ene reactions, Cheletropic reactions; 1,3-Dipolar cycloaddition.

4. **Photochemistry–I:** Introduction and Basic Principles of Photochemistry, Photochemical energy, Jablonski diagram, photo-sensitization and quenching.

5. **Photochemistry–II:** Photochemistry of olefins Isomerization, Di-□-methane rearrangement and cycloadditions; Photochemistry of aromatic compounds; Photochemistry of carbonyl compounds: Norrish type-I and Norrish type-II cleavage; Intramolecular and intermolecular hydrogen abstraction; Photocyclo-addition of ketones with unsaturated compounds: Paterno-Buchi reaction, photodimerisation of α,β-unsaturated ketones, rearrangement of enones and dienones, Photo-Fries.

OUTCOMES: After successful completion of the course, students will learn the advanced organic chemistry concepts that will be applied in solving their future chemistry problems. They will learn about Arenium ion mechanism, orientation and reactivity. participation by π and σ bonds, Anchimeric assistance. Classical versus non-classical carbonium ions. Woodward-Hoffmann rules; cycloaddition [2+2] and [4+2], and electrocylic reactions. Prototropic and Sigmatropic rearrangements, Ene reactions and Cheletropic reactions; 1,3-Dipolar cycloaddition. Photochemical energy, Jablonski diagram, photosensitisation and quenching, Isomerization, Di-π-methane rearrangement and cycloadditions; Norrish type-I and Norrish type-II cleavage; Paterno-Buchi reaction, photodimerisation of α,β-unsaturated ketones, rearrangement of enones and dienones, Photo-Fries rearrangement.

Books recommended:

1. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
2. Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi.
3. S.M. Mukherjee and S.P. Singh, Reaction Mechanism in Organic Chemistry, Ist Edition (1990), Macmillan India Ltd., New Delhi.
4. T.H. Lowry and K.S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition).
5. R.T. Morrison and R.N.Boyd, Organic Chemistry, 6th Edition (2003), Prentice- Hall of India, New Delhi.
6. P. S. Kalsi, Organic Reactions and Their Mechanisms, Ist Edition (1996), New Age International Pub., New Delhi.
7. S. M. Mukherjee and S. P. Singh, Pericyclic Reactions, MacMillan India, New Delhi.
8. I. Fleming, Pericyclic Reactions (1999), Oxford University Press, Oxford.
9. I. Fleming, Frontier Orbitals and Organic Chemical Reactions (1976), Wiley, New York.
10. T. L. Gilchrist and R. C. Storr, Organic Reactions and Orbital Symmetry, 2nd Edn., Cambridge University Press, 1979.
11. R.B. Woodward and R. Hoffman, The Conservation of Orbital Symmetry, Verlag Chemie GmbH, 1970.
12. T.H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, 1998.
13. J. Singh and J. Singh, Photochemistry and Pericyclic Reactions, 2nd Edn., New Age International (P) Ltd., 2005
14. John D. Coyle, Introduction to Organic Photochemistry, John Wiley and Sons, New York (1986).
15. C. H. Depuy and O. L. Chapman, Molecular Reactions and Photochemistry, 2nd Edition (1988), Prentice-Hall of India (P) Ltd., New Delhi.
16. F. A. Carey and R. J. Sundberg, Photochemistry in Advanced Organic Chemistry, Chapter 13, Part A, 3rd Edition (1990), Plenum Press, New York.
17. N. J. Turro, Modern Molecular Photochemistry, University Science Books, Sausalito (1991).

CC-7: CYPBLT3-Organic Chemistry Practical-II (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Synthesis of organic compounds involving important chemical reactions such as aldol condensation, nitration, bromination, diazotization, coupling reactions, molecular rearrangements etc.
2. Isolation of some natural products (Caesin from milk, lycopene from tomatoes, Nicotine from tobacco leaves etc.).

Note:*Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES: On completion of this module, the learner will be able to:

- Independently synthesize important organic molecules
- Purify synthesized molecules
- Calculate the percentage of yield of the products
- Able to identify the outcome of products by spectroscopic techniques.

CC-8: CYPBTT4-Physical Chemistry – II (Credit-3)

OBJECTIVES AND LEARNING:To learn the basic concept of Corrosion and micelles and their uses, radio chemistry and transport phenomenon like viscosity, diffusion etc in gaseous state, learn the micelles.

1. **Corrosion:** Scope and economics of corrosion, causes and types of corrosion, electrochemical theories of corrosion, kinetics of corrosion (corrosion current and corrosion potential). Corrosion measurements (weight loss, OCP measurement, and polarization methods), units of corrosion rate, passivity and its breakdown. Corrosion prevention (electrochemical, inhibitor, and coating methods).

2. **Transport Phenomena:** General transport equation: Thermal condutivity, Viscosity and Diffusion. Intermolecular Forces: Long range forces. Lennard Jones potential.
   Physical transformation of Pure substances: stability of Phases, Phase boundaries, three typical phase diagram, thermodynamic criteria of equilibrium, the dependence of the stability on the conditions, location of phase boundaries, the Ehrenfest classification of phase transition.

3. **Chemical thermodynamics:** Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; thermodynamics of ideal and non-ideal gases, and solutions.

4. **Micelles Surface-active agents and their classification, Hydrophile-Lipophile Balance:** HLB parameter, Shape and Structure of micelles, micro-emulsions, reverse micelles, micellization, Critical miceller concentration (cmc), phase separation and mass action models, factors affecting cmc of surfactants, thermodynamics of micellization, micelle temperature range: MTR or Krafft Point.

5. **Radiochemistry:** Radiation detection & measurements--Proportional, Geiger-Muller and Scintillation counters, semiconductor detectors. Radiochemical principles in the use of tracers. Applications of radioisotopes as tracers: activation analysis, isotope dilution technique, age determination, medical applications.Radiation Chemistry: Elements of radiation chemistry, units for measuring radiation absorbed.

OUTCOMES:

- The course contains background for understanding various corrosion processes, protection methods and materials selection with practical examples. Based on physical chemical theory, the student shall be able to evaluate if corrosion can occur under specific operating conditions in a given equipment or construction. In cases where corrosion can occur, the student shall be able to determine the probable corrosion type, estimate the corrosion rate and propose the most reasonable protection method with regard to safety, price and environmental considerations.
- Students will be able to understand the physicochemical fundamentals that allow for the interpretation of transport phenomena in physical and chemical processes, phase equilibria and interface behaviour and adsorption phenomena.
- Students will be able to restate definition of system, surrounding, closed and open system, extensive and intensive properties. Student will be able to determine the reversibility or irreversibility of a thermodynamic process.
- Students will be able to Introduce about the Micelle, Critical Micelle Concentration and Micellization and its thermodynamics. Students will be able to Determination of CMC of any Surfactant.
- Students will be able to explain the concepts of Radiation Chemistry. Applications of Radioisotopes in different field is very useful for the students.

Books Recommended:

1. Modern Electrochemistry, Vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy, Second Edition, Plenum Press, New York (1998).
2. Electrochemical Methods: Fundamentals and Applications; A.J. Bard and L.R. Faulkner, 2nd edition (2001), John Wiley & Sons, New York.
3. Physical Chemistry, P. W. Atkins, 7th Edition, Oxford University Press, New York (2002).
4. Physical Chemistry, N. Levine, 5th Edition (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.
5. "Physical Chemistry", K. J. Laidler and J. M. Meiser, 3rd Edition (International Ed.) Houghton Mifflin Co., New York.
6. "Physical Chemistry", R. S. Berry, S. A. Rice and J. Ross, 2nd Edition, Oxford University Press, Oxford (2000).
7. Y. Moroi, Micelles: Theoretical and Applied Aspects, Plenum Press, New York (1992).
8. F.W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Wiley-Interscience, New York.
9. B. G. Harvey, Introduction to Nuclear Physics and Chemistry, Prentice Hall, Inc. (1969).
10. H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition (1995), Wiley-Eastern Ltd., New Delhi.
11. G. Fridlander, J.W. Kennedy, E. S. Macias, and J. M. Miller, Nuclear & Radiochemistry, 3rd Edition (1981), John Wiley, New York.

CC-8: CYPBLT4-Physical Chemistry Practical – II (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Rate constant of acid catalyzed hydrolysis of sucrose by polarimetric method.
2. Rate constant of acid catalyzed hydrolysis of sucrose by chemical method.
3. Rate constant of $FeCl_3$-catalyzed H_2O_2 decomposition by gasometric method.
4. Degree of hydrolysis of urea hydrochloride by kinetics method.
5. Equilibrium constant of $KI + I_2 \rightleftharpoons KI_3$ by distribution method.
6. Phase diagram of a binary organic system (Naphthalene and Diphenyl).
7. Determination of solubility and solubility product of sparingly soluble salt conductometrically.
8. Potentiometric titration of a redox system (ferrous ammonium sulfate with $K_2Cr_2O_7$).
9. Adsorption of acetic acid on charcoal to verify Freundlich adsorption isotherm.
10. Determination of the velocity constant of hydrolysis of an ester/ionic reaction in miceller media.

OUTCOMES:

- Upon course completion, the student will be able to apply the experiment based on adsorption, phase diagram and molecular weight in relevant industry and further in higher studies for the outcome.
- To interpret the experimental results obtained by conductometer and Polarimeter.
- Students will be able to conduct the Chemical kinetics experiment on various important reactions.
- Students will be able to describe the principles behind the experiment performed in the laboratory.

CC-9: CYPBTT5-Molecular Spectroscopy (Credit-5; Theory 04 + Tutorial 01)

OBJECTIVES AND LEARNING: This module will provide theory, instrumentation and applications of different spectroscopic techniques.

1. **Unifying Principles:** Electromagnetic radiation, interaction of electromagnetic radiation with matter, absorption, emission, transmission, reflection, refraction, dispersion, polarization, and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, result of the time-dependent perturbation theory, transition moment selection rules, intensity of spectral line. Born-Oppenheimer approximation, rotational, vibrational, and electronic energy levels. Fourier Transform Spectroscopy.

2. **Rotation and Vibration of Diatomic Molecules:** Vibration-rotational spectra of diatomics; P,Q,R branches, normal modes of vibration, overtones, hot bands Raman spectroscopy: Origin; rotational and vibrational Raman spectra of diatomics, Anharmonicity, Selection Vibration of polyatomic molecules–normal coordinates. Polarization of Raman lines. Fingerprint region and applications.

3. **Electronic Spectroscopy:** Electronic spectra of diatomic molecules, Franck-Condon principle, Vibronic transitions, $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$ transition. Dissociation and pre-dissociation. Rotational fine structure.

4. **Nuclear Magnetic Resonance:** Review of angular momentum. Basic principles and relaxation times. Magnetic resonance spectrum of hydrogen. First-order hyperfine energies. NMR in liquids: Chemical shifts and spin-spin couplings First order Spectra: A3X, AX and AMX systems. Solid state NMR spectroscopy, Introduction of 2D NMR spectroscopy, Basic principle and Applications of COSY, NOE and HMBC.

5. **Photoelectron Spectroscopy (PES):** Photo excitation and photo ionization, core level photo ionization (XPS, ESCA.) and valence level (UPS) experiments, detection of atoms in molecules, chemical shift.

OUTCOMES: Student will get the knowledge of principles and different spectral techniques and how to do apply using these spectroscopic analyses in their experimental work.

Book Recommended:

1. J. M. Hollas, Modern Spectroscopy, 4th edition (2004) John Wiley & Sons, Ltd., Chichester.
2. C. N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.
3. A Carrington and A. D. Mc Lachlan, Introduction to Magnetic Resonance, Chapman and Hall, London (1979).
4. R. K. Harris, Nuclear Magnetic Resonance Spectroscopy, Addison Wesley, Longman Ltd, London (1986).

DSE-1: CYPBTD1-Instrumental Analytical Techniques (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: This module will provide theory, instrumentation and applications of different analytical instrumental techniques of Fourier Transform Infra-Red (FTIR), Raman, Nuclear Magnetic Resonance (NMR), Electron Spin Resonance (ESR), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Inductively coupled plasma emission spectroscopy (ICPE).

1. **Infrared Spectroscopy:** Infrared instruments, typical applications of infrared spectroscopy (qualitative and quantitative).

2. **Raman Spectroscopy:** Raman spectroscopy, Instrumentation, Analytical applications of Raman spectroscopy.

3. **Nuclear Magnetic Resonance Spectroscopy:** Theory of nuclear magnetic resonance, Environmental effects on NMR spectrometers, Applications of proton NMR, C13 NMR, Two dimensional Fourier-transform NMR, Magnetic resonance imaging (MRI), Quantitative applications of NMR: Drug Analysis, Molecular Weight determination.

4. **Electron Spin Resonance Spectroscopy:** Theory, Instrumentation and Important analytical applications.

5. **Electron Spectroscopy:** Theory, Instrumentation and applications of Electron spectroscopy (ESCA and Auger), Scanning electron microscopy (SEM), Scanning tunnelling microscopy (STM) and Atomic force microscopy (AFM).

6. **Plasma Emission Spectroscopy:** Theory, Instrumentation and Analytical applications of inductively coupled plasma emission spectroscopy (ICPE).

7. **Applications in analysis of special materials:** Analysis of dairy products, food additives, petrochemicals (including liquid and gaseous fuels), drugs and pharmaceuticals and fertilizers.

OUTCOMES: Student will get the knowledge of principles and instrumentation of different analytical techniques and how to do the analysis using FTIR, Raman, NMR, ESR, SEM, TEM and ICPE.

Books Recommended:

1. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, 5th Edition (1998), Harcourt Brace & Company, Florida.
2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
3. J.M. Hollas, Modern Spectroscopy, 3rd Edition (1996), John Wiley, New York.
4. H.A. Strobel, Chemical Instrumentation – A Systematic Approach, 2nd Edition (1973), Addison Wesley, Mass.
5. D.C. Garratt, the Quantitative Analysis of Drugs, 2nd Edition (1992), Chapman and Hall Ltd., London.
6. W. Horwitz (Editor), Official Methods of Analysis, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC.

DSE-1: CYPBTD2- Bio-inorganic Chemistry (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: Objective of this course is

1. The students should be able to describe role of alkaline earth metal ions in biological systems.
2. The students should know structure and function of iron, copper and molybdenum in biological systems.
3. The students should be able to explain structure and reactivity of Urease, Hydrogenase, and Cyanocobalamine.
4. The students should be able to know interaction of metal with DNA and chemotherapeutic agents.
5. The students should be able to knowStructure and role ofIron storage and transport proteins.

1. **Role of alkaline earth metal ions in biological systems:** (i) Catalysis of phosphate transfer by Mg2+ ion, (ii) Ubiquitous regulatory role of Ca2+ -muscle contraction.

2. **Iron, copper and molybdenum proteins with reference to their oxygenation and oxidase activity:** (i) Anti-oxidative functions: cytochrome P-450, catalases and peroxidases, (ii) Nitrate and nitrite reduction: NO3 and NO2 reductase, (iii) Electron transfer: cytochromes; blue copper proteins and iron-sulfur proteins and their Synthetic models, (iv) Nitrogen fixation through metal complexation, nitrogenase, (v) Photosynthesis (PS-I and PS-II).

3. **Metalloenzymes:** Urease, Hydrogenase, and Cyanocobalamine. Superoxide Dismutase, Carbonic anhydrase, Carboxypeptidase.

4. **DNA and its interaction with metal complexes:** Protein structure, Ramachandran - plot, protein folding: DNA/RNA structures, various forms (a, b, c, z) of DNA, and DNA binding protein-zinc-finger protein, DNA probe and chemotherapeutic agents.

5. **Iron storage and transport proteins:**Hemoglobin, Myoglobin, Hemerythrin and hemocyanin, Ferritin, Siderophores, Transferritin and Hemosiderin

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Role of alkaline earth metal ions in biological systems.
2. Structure and function of iron, copper and molybdenum in biological systems.
3. Structure and reactivity of Urease, Hydrogenase, and Cyanocobalamine.
4. Interaction of metal with DNA and chemotherapeutic agents.
5. Structure and role of iron storage and transport proteins.

Books recommended:

1. M. N. Hughes, Inorganic Chemistry of Biological Processes, 2nd Ed. (1981), John-Wiley & Sons, New York.
2. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide, Wiley, New York (1995).
3. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Books, (1994).
4. I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, Bioinorganic Chemistry, Viva Books Pvt. Ltd., New Delhi (1998).

DSE-1: CYPBTD3-Chemistry of Heterocycles (Credit-4 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: Student will learn the synthesis and application of heterocycles as half of the drugs and natural products saving life contains heterocycles.

1. **Introduction:** Definition of heteroatom, Aromatic and non-aromatic heterocyclic compounds, Classification and nomenclature of heterocyclic compounds, important reactions with heterocyclic compounds i.e., oxidation, reduction and tertiary effect of Nitrogen in heterocyclic compound.

2. **Non-Aromatic Small Ring (Three/Four-Membered) Heterocycles:** Different types of strains, interactions and conformational aspects of non-aromatic heterocycles. Synthesis, reactivity and importance of the following ring systems: Aziridines, Oxiranes, Thiiranes, Oxaziridines, Azetidines, Oxetanes and Thietanes.

3. **Five Membered Heterocyclics with Two Hetero Atoms**: Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyrazole, Imidazole, Oxazole, Thiazole, Isoxazole, Isothiazole,

4. **Six Membered Heterocyclics with Two Hetero Atoms**: Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyridazine, Pyrimidine. Pyrazine, Oxazine, thiazine: Fused heterocycle: Benzimidazole, benzoxazole and benzthiazole.

5. **Use of Heterocycles in Life:** Structure determination, synthesis and applications of Thiamine (B1), Pyridoxine, Ascorbic acid and Biotin (H).

OUTCOMES: After learning the course, students will be able to design, synthesis and apply the studies about heterocycles in their future academic industry career.

Book Recommended:

1. I.L. Finar, Organic Chemistry, Vol. II, 5th Edition (1975 Longman Ltd., New Delhi.
2. T.L. Gilchrist, Heterocyclic Chemistry, 3rd Edition (1997) Addison-Wesley Longman Ltd., England
3. R.K. Bansal, Heterocyclic Chemistry: Syntheses,Reactions and Mechanisms, 3rd Edition (1999), New Age International, Publisher, New Delhi.
4. A.R. Katritzky and A.F. Pozharskii, Handbook of Heterocyclic Chemistry, 2nd Edition (2000), Pergamon Press, Oxford.
5. Advances in Heterocyclic Chemistry, A.R. Katritzky (Editor), Academic Press, New York.
6. Heterocyclic Compounds, A. Weissberger (Editor), Interscience, New York.
7. T. Gilchrist: Heterocyclic Chemistry R. M. Acheson: An Introduction to the Chemistry of Heterocyclic Compounds
8. J. A. Joule & K. Mills: Heterocyclic Chemistry
9. A. Paquette: Principles of Modern Heterocyclic Chemistry
10. J, A. Joule & Smith: Heterocyclic Chemistry.

DSE-1: CYPBTD4-Solid State Chemistry (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: To identify and apply the concepts involved in the syntheses, structure and physical properties of crystalline inorganic solid, XRD of Solids, band theory and magnetic properties of solids.

1. **Solid State Reactions:** General Principles, Experimental procedure, Co-precipitation as precursor to solid-state reactions, Kinetics of solid-state reactions, Crystallization of solutions, melts, glasses and gels. Growth of single crystals: Czochralski, Bridgman and Stockbarger methods. Zone Melting.

2. **X-ray Diffraction & Crystal Structure:** Diffraction of X-rays by crystals: Bragg's law, Definitions related to crystal structure, crystallographic direction and crystallographic phases. X-ray diffraction experiments: The powder method and the single crystal method. Reciprocal lattice. Structure factor and its relation to intensity and Electron density. The phase problem. Description of procedure for an X-ray structure analysis.

3. **Phase Transitions:** Thermodynamic and Burger's classification of phase transition, Kinetics of phase transition- nucleation and growth, T-T-T diagrams, Factors influencing kinetics of phase transition, Martensitic and order-disorder transitions.

4. **Electronic Properties and Band Theory:** Electronic structure of solids- band theory, Refinement of simple band theory- k-space and Brillouin Zones, Band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, Doped semiconductors, p-n junctions. Superconductors Meissner effects.

5. **Magnetic Properties:** Behavior of substances in a magnetic field, effect of temperature: Curie and Curie-Weiss law, origin of magnetic moment, ferromagnetic, antiferromagnetic and ferromagnetic ordering, super exchange, magnetic domains, hysteresis.

OUTCOMES: After finishing this course the students will be able to
Grasp the basis of ensemble approach in statistical mechanics to a range of situations.Explain the fundamentals of thermodynamics, carnot cycle, statistics and distributions.Explain the fundamental differences between classical and quantum statistics and learn about quantum statistical xlaws.Analyze important examples of ideal Bose systems and Fermi systems.

Books Recommended:

1. A.R. West, Solid State Chemistry and its Applications, John Wiley and Sons, Singapore (1984).
2. L.V. Azaroff, Introduction to Solids, Tata McGraw-Hill, New Delhi (1977).
3. L. Smart and E Moore, Solid State Chemistry, Chapman & Hall, Madras (1992).
4. H. V. Keer, Principles of Solid State, Wiley Eastern (1993)

SEMESTER–III

CC-10: CYPCTT1-Computer Applications in Chemistry (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVES AND LEARNING:To get a brief knowledge of FORTRAN 77 and other numerical methods.

FORTRAN 77: Types of Constants and Variables in Fortran, Dimension, Data, Type, COMMON and EQUIVALENCE statements, Arithmetic and Logical IF, IF-THEN-ELSE Constructs, DO statement, Various types of I/O statements, Library functions, Statement functions, Function Subprograms and subroutine subprograms with suitable examples.

Numerical Methods: Roots of Polynomials, Solution of Linear simultaneous equations, matrix multiplication and inversion. Numerical integration. Statistical treatment of data, variance and correlations, Least square curve fitting.

OUTCOMES: Students will learn different programming languages which are required for helping in different molecular simulations.

Books Recommended

1. V. Rajaraman, Fortran 77, Prentice Hall (India), New Delhi.
2. K. V. Raman, Computers in Chemistry, Tata McGraw Hill (1993).
3. C. Xavier, Fortran 77 and Numerical Methods, New Age International Pvt. Ltd. Publishers, New Delhi
4. S. Lipschutz and A. Poe, Schaum's Outline Series – Theory and Problems of Programming with Fortran including structured Fortran, Mc Graw Hill Book Company, Singapore.

RM: CYPCTA1- Research Methodology (Credit-2)

OBJECTIVE AND LEARNING: To make the student aware about design and perform the research based-on their theoretical background in their PG study.

1. **Use of Information Technology resources:** The Internet and World Wide Web, Internet resources for Chemistry, Internet search engines, use of spreadsheets, word processors, data bases and other packages, finding and citing information. End-note software for references.

2. **Basic concept of Research Methodology:** Definition, objective and design of a research problem in Chemical sciences. Need and sources of Literature survey: journals, journal abbreviations, abstracts, reviews, monographs, text books, chemical abstracts and online source of literature search. Types of scientific communication: research papers, review.

3. **Concepts of Chemical safety:** Chemical safety and ethical handling of chemicals, safe working procedure and protective environment, emergency procedure and first aid, safe storage and use of hazardous chemicals, identification and procedure for working with substances that pose hazards, flammable or explosive hazards, identification and procedures for working with gases at pressures above or below atmosphere, and information about different symbols in chemistry and industry research laboratories.

4. **Advanced Spectral Techniques**: Applications of UV-Visible, IR, NMR and Mass spectroscopy for the structural elucidation of compounds in chemical research.

OUTCOMES: After completing this study, student will about the research methodology how to design their research work.

Reference Books:

1. Dr. C.R. Kothari, Research Methodology: Methods and Techniques, New Age International Publishers, 2nd Ed., New Delhi (2014.)
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, Pearson Education; 2nd Ed., (2005).
3. M.D. Barbara Gastel and Robert A. Day, How to Write and Publish a Scientific Paper, Greenwood Publishing Group Inc, 8th Ed., 2016.
4. Tanmoy Chakraborty and Lalita Ledwani, Research Methodology in Chemical Sciences: Experimental and Theoretical Approach, Apple Academic Press; 1st Ed., 2016.

OE-2: CYPCTO1- Medicinal Chemistry (Credit-3)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Various chemical and structural aspects of medical drugs
2. Several Biological activity parameters and Drug metabolism
3. Conventional and modern methods for drugs synthesis

1. **Structure and activity:** Relationship between chemical structure and biological activity (SAR). Receptor Site Theory. Approaches to drug design. Introduction to combinatorial synthesis in drug discovery.

2. **Few Important Drugs:**
   - (a) Antibiotics and antibacterials:
     - (i) Introduction
     - (ii) Antibiotic β-Lactam type - Penicillins, Cephalosporins
     - (iii) Anticancer - Dactinomycin (Actinomycin D), Methoxytrexate
     - (iv) Antibacterial – Ciprofloxacin, Norfloxacin
     - (v) Antiviral – Acyclovir
   - (a) Antimalarials: Chemotherapy of malaria. SAR. Chloroquine, Chloroguanide and Mefloquine
   - (b) Non-steroidal and Anti-inflammatory Drugs: Diclofenac Sodium, Ibuprofen and Netopam.
   - (c) Antihistaminic and antiasthmatic agents: Terfenadine, Cinnarizine, Salbutamol and Beclomethasone dipropionate.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. The basics of medicinal chemistry and biophysical properties of various drugs.
2. Concept of rational drug design and their related applications

Books Recommended:

1. Burger, Medicinal Chemistry, Vol. I-III, (1995) Wiley Interscience Publications, New York.
2. W. O. Foye, Principles of Medicinal Chemistry, 3rd Edition (1989), Lea &Febiger/ Varghese Publishing House, Bombay.
3. D. Lednicer and L. A. Mitscher, The Organic Chemistry of Drug Synthesis, Vol. I-III, Wiley Interscience.

4. A. Kar, Medicinal Chemistry, (1993) Wiley Eastern Ltd., New Delhi.
5. N. K. Terrett, Combinatorial Chemistry, (1998) Oxford Univ. Press, Oxford

OE-2: CYPCLO1- Medicinal Chemistry Practical (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the practical classes about conventional and modern methods for drugs synthesis

1. Preparation and characterization of following drugs and intermediates
   (a) Sulphanilamide, (b) 7-Hydroxy, 4-methyl coumarin
   (c) Chlorobutanol, (d)Triphenyl imidazole
   (e)Tolbutamide, (f) Hexamine, (g) Aspirin,
   (h) Ibuprofen,(i) Atropine,(j) Chlorpromazine.

2. Resolution of racemic drug to single enantiomer by chemical methods

OUTCOMES: After completion of the course, the learner can be able to understand:
1. Independently synthesize important organic drug molecules
2. Separate and purify synthesized drug molecules.

OE-2: CYPCTO2-Industrial Chemistry (Credit-3)

OBJECTIVE AND LEARNING: To get the detailed knowledge about different process used for the purification of contaminated and hard water. To know the basic constituents of glass, and its types, classification of fertilizers, different types of solid and liquid fuels, dyes and fibers.

1 **Water and Its Treatment:** Sources of water, chlorinated and nonchlorinated water, chemical method of sterilization: precipitation method, Aeration, ozonisation, chlorination, chloramines process, potassium permanganate method, Physical method of sterilization: Boiling, exposure to sunlight, hard and soft water, Types of hardness, temporary and permanent hardness, water softening, cold and hot lime soda process, zeolite process, ion exchange process, removal of iron, silica, and dissolved oxygen from water for industrial purposes, water for boiler uses, water analysis.

2 **Glass and Rubbers:** Glass: physical and chemical properties of glass, constituents in glasses, raw materials, manufacturing of glasses, optical glass, borosilicate glass, lead glass, colored glass, opal glass, safety glass, fiber glass.Natural and Synthetic Rubber: classification of rubber, natural and synthetic rubber.

3. **Chemical Fertilizers:** Classification of fertilization, nitrogeneous fertilizers, method of production and its action- ammonium nitrate, ammonium sulphate, urea, calcium cyanamide, ammonium chloride, phosphate rock, normal super phosphate, triple super phosphate.

4. **Solid and liquid fuels:** Definition and Classification of coal, Proximate and ultimate analysis, Determination of calorific value of solid fuel, Flue gas analysis, Classification of

petroleum, composition of petroleum, mining of petroleum, refining of petroleum, octane rating, octane number and antiknock compound, cetane number, production of gases, crude naptha, benzene, kerosene oil, fuel oil, lubricating oil, paraffin wax and black tarry after refining. Cracking: thermal cracking, hydrocracking, and fluid catalytic cracking.

5 **Fibers and Dyes:** Synthetic Fibers: Preparation of fibers- Nylons, Nylon-66, Nylon-6, Nylon-11, Nylon-610, Nylon-8, polyethylene terephthalate, orlon, saran, vinyon, taflon.Synthetic Dyes and Dyeing: Requisites of true dyes, sensation of color, witt's theory, chromophores, auxochromes: batho-, hypso-, hyper-, and hypochromic shifts; classification of dyes: acid dyes, basic dyes, adjective dyes, vat dyes, ingrain dyes, sulfur dyes, pigment.

OUTCOMES: At the end of the course student will be able to

1. Get fully industry-based knowledge.
2. Apply the knowledge for the analysis and purification of water.
3. Understand different types of glass and its production by using the raw material.
4. Understand composition of different types of fertilizers.
5. Understand various types of liquid and solid fuels and their analysis, different types of fibers and dyes and their synthesis.

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.

OE-2: CYPCLO2-Industrial Chemistry Practical (Credit-2)

OBJECTIVE AND LEARNING: To get the detailed knowledge about the removal of hardness of water by complexometric titration, estimation of the chemical and biological oxygen demands, estimation of nitrogen in fertilizers, determination of calorific value of solid fuel, estimation of chloride contents in a given water sample.

1. Determination of hardness of water by complexometry titration
2. Determination of BOD and COD of water sample
3. Determination of calorific value of solid fuel by Bomb Calorimeter.
4. Estimation of nitrogen in Urea
5. Synthesis of Dyes
6. Determination of flash and fire point of liquid fuel/ lubricant
7. Determination of Chloride content of water sample by Mohr's method
8. Estimation of iron from soap-bar (colorimetrically)

OUTCOMES: At the end of the course student will be able to

1. Remove the hardness of any given water sample.
2. Estimate the COD and BOD of given water sample.
3. Estimate the nitrogen contents in a given fertilizer sample.
4. Find the calorific value of the given solid fuel.
5. Calorimetrically estimate iron from soap bar.
6. Synthesize dyes using starting materials.

DSE-2: CYPCTD1- Principles of Analytical Chemistry (Credit-3)

OBJECTIVE AND LEARNING: The course will provide an:

- Introduction into the fundamentals of chemical analysis, including an understanding of some of the most important analytical techniques today (titration and gravimetric analysis, spectroscopic methods, separation techniques, electroanalysis etc.)
- Introduction into fundamentals of polarography, instrumentation and their application in qualitative and quantitative analysis.
- Different types of sensors and their applications.
- Determines systematic method for solving the multiple-equilibrium problems, pH calculation and their application in different systems, solves the problems related to pH calculation.

1. **Acid-Base Equilibria:** General concept of acid-base equilibria in water and in non-aqueous solvent, Definition of pH and pH scale (Sorenson and operational definitions), and its significance, Hammett acidity function, pH calculation for aqueous solutions of very weak acid and very weak base, salts of weak acid and weak bases, mixture of weak acid and its salts, mixture of weak base and its salts.

2. **Buffer Solutions:** Theory of buffer solution, dilution and salts effects on the pH of a buffer, Buffer index, Criteria and expression of maximum buffer capacity, Application of pH buffers, Preparation of buffer solutions of known ionic strength (Typical examples). Practical limitations in use of buffers, Metal ion buffers and their applications, Biological buffers and their applications.

3. **Photometric Titrations:** Basic principles, comparison with other titrimetric procedures, types of photometric titration curves, Instrumentation (Titration cell, Detectors, choice of analytical wavelength). Quantitative applications, Typical examples of one component and multicomponent analyses.

4. **Chemical Sensors:** Principles, types of chemical sensors based on the modes of transductions, Types of chemical sensor based on the chemically sensitive materials (solid electrolyte, gas, semiconductor), Humidity sensors, Biosensors, Electrochemical sensors (Potentiometric sensors, Ion-selective electrodes, Membrane electrodes, Amperometric sensors, Clark and Enzyme electrodes).

OUTCOMES: Student will learn theoretical approach to acid-base equilibria treatments in aqueous medium and calculation of pH, buffer system, construction and applications of different types of electrochemical, optical, mass sensor etc.

Books Recommended:

1. D.A. Skoog and D.M. West, Fundamental of Analytical Chemistry, International Edition, 7thEdition (1996), Saunders College Publishing, Philadelphia, Holt, London.
2. R.L. Pecsok, L.D. Shields, T. Cairns and L.C. McWilliam, Modern Methods of Chemical Analysis, 2nd (1976), John Wiley & Sons, New York.

3. D.A. Skoog, Principles of Instrumental Analysis, 5th Edition (1998), Saunders College of Publishing, Philadelphia, London.
4. H.A. Strobel, Chemical Instrumentation: A Schematic Approach, 2nd Edition (1973), Addison Wesley, Reading, Mass.

References:

1. H.A. Laittnen and W.E. Harris, Chemical Analysis, 2nd International Student Edition (1960), McGraw Hill, New York.
2. R.G. Bates, Electrometric pH Determinations: Theory and Practice, 3rd Edition (1973), John Wiley & Sons, New York.
3. G.D. Moody and J.D.R. Thomas, Ion-selective Electrodes, London.
4. G.W. Ewing, Instrumental Methods of Chemical Analysis, 5th Edition (1978), McGraw Hill Book Co., New York.

DSE-2: CYPCLD1- Analytical Chemistry Practical-III (Credit-2)

OBJECTIVE AND LEARNING: Experiments of solvent extraction separation, estimation of biomolecules and metal ions in various real samples and packaged food samples.

1. Solvent Extraction: Determination of Fe (III) by chloride extraction in ether
2. Determination of Cd^{2+} ions concentration in given solution by voltammetrically (i) calibration (ii) standard addition
3. Determination of Na_2CO_3 content (%) of washing soda using a pH meter
4. Estimation of carbohydrate using Anthrone method
5. Estimation of acid values and iodine number in given oils/fats
6. Determination of buffer capacity of given acidic buffer.

Note: *Experiments may be added/deleted subject to availability of time and facilities*

OUTCOMES: The module will provide the hands-on different types of separation methods and analytical instruments to prepare, separate and quantify samples from various matrices.Apply the scientific process, including statistical analysis of data, conducting and presenting the data of chemical analysis.Able to develop methods for tracing and measuring new substances.

DSE-2: CYPCTD2- Organometallic Chemistry of Transition Metals (Credit – 3)

OBJECTIVE AND LEARNING: The objective of this course is

1. The students should be able to describe structure, synthesis and reactivity of organometallic compounds of O_2, N_2, CO, NO, Phosphine and carbenes.
2. The students should be able to explain catalytic reaction by transition metal compounds.
3. The students should be able to explain structure and characterization of metal hydrides.
4. The students should be able to know structure, synthesis and functionalization of porous materials.

1. **Metal Carbonyls:** Bonding, synthesis and reactivity of transition metal complexes with CO, NO, metal carbonyl hydrides and metal carbonyl clusters, Semibridging carbonyls; metal nitrosyl carbonyls; tertiary phosphines and arsines as ligands; carbenes and carbynes,

Dioxygen and Dinitrogen complexes of Transition metal, Fluxional organometallic compounds.

2. **Transition Metal Compounds in Catalysis:** Homogeneous and Heterogeneous catalysis, Types of catalysts, Catalysis by organometallic compounds: Hydrogenation of olefins, Wilkinson's catalyst, Tolman catalytic loop; synthesis gas, water-gas shift reaction; Hydroformylation (oxo process), Monsanto acetic acid process, Wacker process; synthetic gasoline: Fischer-Tropsch process and Mobile process, polymerization, oligomerization and metathesis reactions of alkenes and alkynes, Zieglar-Natta catalysis, photo dehydrogenation catalyst (platinum POP). Asymmetric Catalysis by organometallic complexes.

3. **Transition Metal Compounds with M-H bonds:** Metal hydrides (classical and non-classical). Agnostic interaction. Application of NMR in studying hydrido complexes.

4. **Porous materials Organic-inorganic hybrid materials:** Zeolites, AlPO, mesoporous materials, soft chemistry-based processes, functionalization of porous materials, MOF compounds, H_2/CO_2 gas storage and catalytic application, covalent organic Framework.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Structure, synthesis and reactivity of organometallic compounds of O_2, N_2, CO, NO, Phosphine and carbenes.
2. Catalysis by transition metal compounds.
3. Structure and characterization of metal hydrides.
4. Structure, synthesis and applications of porous materials.

Books Recommended:

1. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn., (1999), John-Wiley & Sons, New York.
2. James E. Huheey, Inorganic Chemistry, 4th Edn., (1993), Addison Wesley Pub. Co., New York.
3. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 1st Edn.(1988), John-Wiley & Sons, New York.
4. J. P. Collman, L. S. Hegedus, J. R. Norton and Richard G. Finke, Principles and Applications of Organotransition Metal Chemistry, 1st Edn.(1987), University Science Books, Mill Valley.
5. Ch. Elschenbroich and A. Salzer, Organometallics, VCH.
6. C. N. R. Rao, J. Gopalakrishnan, New Directions in Solid State Chemistry; Cambridge University Press: Cambridge (1997).
7. A. K. Cheetham, Solid State Chemistry:Compounds; Oxford University Press: Oxford, (1992).
8. J. N. Lalena and D. A. Cleary, Principles of Inorganic Materials Design; Wiley: New York, (2010).
9. Inorganic Chemistry, 5th Edition, Gary L. Miessler, St. Paul J. Fischer, Donald A. Tarr, Pearson publication.

DSE-2: CYPCLD2-Inorganic Chemistry Practical – III (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

I. Synthesis of inorganic complexes/compounds and their characterization by various physicochemical methods, viz. IR, UV, Visible, NMR spectroscopy, magnetic susceptibility etc. Selection can be made from the following or any other from the existing literature.

(i) *Cis* and *trans*isomers of $[Co(en)_2Cl_2]Cl$.

(ii) Ion-exchange separation of oxidation states of vanadium.
(iii)Synthesis, purification by sublimation and structural characterization of ferrocene.
(iv)Preparation of triphenyl phosphene PPh_3, and its transition metal complexes.
(v) Snnhesis of (*N*,*N*')-bis(salicyldehyde)ethylenediamine Salen; and its cobalt complex [Co(Salen)].
(vi) Synthesis of metal acetylacetonates like Vanadyl / Alumunium acetylacetonate.
(vii) Synthesis and structural characterization of $[Ni(py)_4(NCS)_2]$.
(v)Single Crystal Growth of ligand and metal –complexes by various methods.

Note*: Experiments may be added/deleted subject to availability of time and facilities*

OUTCOMES: After completion of the course, the learner can be able to understand:

- About IR, electronic spectra and magnetic susceptibility of various transitionmetal complexes.
- Calculation of ligand field parameters based on electronic spectra of various transitionmetal complexes.
- Instrumentation methods of structural determination.

DSE-2: CYPCTD3- Stereochemistry, Reactions and Rearrangements (Credit – 3)

OBJECTIVE AND LEARNING:A detailed study of stereochemistry and conformations in organic molecules, asymmetric synthesis, various name reactions and rearrangements.

1. **Stereochemistry:** Molecular symmetry and chirality; Stereoisomerism; configuration and conformation; relative and absolute configuration; determination of relative configuration: Prelog's rule, Cram's rule (Felkin modification); Chiral auxiliaries, Optical Activity in absence of chiral carbon: biphenyls and Allenes and Atropisomerism.

2. **Asymmetric Synthesis:**Enantioselcetive synthesis with chiral non racemic reagents and catalysts: Hydroboration with chiral boranes (IpcBH2), (Ipc)2BH, Carbonyl group reduction with chiral complex hydride (BINAL-H, Chiral oxazaborolidines), Chiral organometal complex–(-)DAIB; 3-exo-dimethylamino isoborneol. Enantioselective hydrogenation with [Rh(DIPAMP)]+. Diastereoselective synthesis: Aldol reactions.

3. **Conformation:** Conformations of acyclic and cyclic system (5 and 6 member rings), fused (6/6); stability, reactivity and mechanism; reactions of 5/6-membered ring. Conformations of fused ring and bridged ring compounds

4. **Advanced Name Reactions:**Mukaiyama reaction, Julia olefination, McMurry reaction, Chichibabin reaction, Shapiro reaction, Baylis-Hillman reaction and Olefin metathesis

5. **Rearrangement Reactions:**Sommelet-Hauser rearrangement, Stevens rearrangement, Neber Rearrangement, Favorskii, rearrangements, Hofmann-Loffler-Freytag reaction, Barton reaction, Grob fragmentation reactions.

OUTCOMES: On Completion of this module, the learner will be able to calculate optical purity and enantiomeric excess. discuss the relative stability of conformational isomers of cyclohexanes and related compounds. draw all the

stereoisomers of organic compounds, and recognise diastereomers, enantiomers, meso compounds and centers of symmetry. recognize and discuss the stereoisomers of chiral compounds that do not contain a stereogenic carbon centre and assign the configuration of the stereoisomers. explain and predict the stereochemical outcome of asymmetric organic reactions for examples, hydroboration by chiral boranes, reduction of ketones by chiral boron-based reagents, asymmetric hydrogenation by using chiral catalyst etc. and their mechanism.

Books Recommended:

1. M.B. Smith and J. March, March's Advanced Organic Chemistry-Reactions, Mechanisms and Structure, 5th Edition (2001), John Wiley & Sons, New York.
2. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edition (1994), Wiley Eastern Ltd., New Delhi.
3. J. Aube and R. E. Gawley, Principles of Asymmetric Synthesis.
4. E.L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, Wiley Interscience, New York (2004).
5. Paul de Mayo, Molecular Rearrangements, Vol.I& II, Interscience Publishers, New York (1963).
6. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic chemistry, Oxford University press INC, New York, 2001.

DSE-2: CYPCLD3-Organic Chemistry Practical-III (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes

1. Organic Synthesis involving 2-3 steps (Synthesis, % Yield Calculation)
2. Characterization of synthesized organic compounds by melting point determination, and FT-IR, UV-Vis spectroscopic studies.

OUTCOMES: On Completion of this module, the learner will be able toidentify the presence of different components/molecules in the unknown mixture, design a particular organic synthesis purify the reaction products by various techniques such as recrystallization, TLC, column chromatography etc.

DSE-2: CYPCTD4- Electrochemistry (Credit-3)

OBJECTIVE AND LEARNING: To understand the electrical double layer as Metal electrolyte interfaces and differential capacitance, concept of electro capillary phenomenon, and thermodynamic aspects of metal electrolyte interfaces, the concept of over potential, exchange current density, Tafel equations and Tafel plot, the Butler Volmer multielectron electrodic kinetics.

1. **Introduction and overview of electrochemical Processes:** Electrochemical Cell and reactions, Faradiac and Non-Faradiac processes, electrochemical experiments and variables in electrochemical cells, Basic Electrochemical thermodynamics, free energy and cell EMF.

2. **Electrical Double Layer at Metal/Electrolyte Interface:** OHP and IHP, Structure of the double layer: Helmholtz-Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium conditions, overpotential, exchange current density, Tafel plot. Polarizable and non-polarizable interfaces.

3. **Metal/Electrolyteinterfaces:** Semiconductor (SC)/electrolyte interface: Structure of Semiconductor interfaces, Creation of space charge region (Garrett-Brattain Space charge), Capacity of space-charge. Metal/ water interaction- Contact adsorption, its influence on capacity of interface, Complete capacity- potential curve, Constant capacity region hump.

4. **Electrified Interface properties:** Determination of interfacial tension of mercury as a function of potential across the interface, Thermodynamics of double layer (Lippmann equation), Electrocapillary equation, Determination of surface excess and other electrical parameters- electrical capacitance of the interface and relative surface excesses.

5. **Electrode Kinetics:** Essentials of Electrode Reaction, Multistep reactions- a near equilibrium relation between current density and over potential, Concept of rate determining step. Determination of reaction order. stoichiometric number, and transfer coefficient.

OUTCOMES:

- The learner should be able to apply theories in electrochemistry to analyze electrode kinetics
- To understand representing electrochemical cell
- The learner will be able to explain various over potential involved during the operation the cell using tafel equations
- The students will be able to apply the knowledge to calculate electrochemical cell parameters, over potential, active surface areas, charge on electrode and their surface excess.
- The students will be able to apply the Butler Volmer multielectron electrodic kinetics to the particular electrolysis process.

Books Recommended:

1. Modern Electrochemistry, Vol. 1 & 2A and 2 B, J.O'M. Bockris and A.K.N. Reddy,Plenum Press, New York (1998).
2. Electrochemical Methods: Fundamentals and Applications; A.J. Bard and L.R. Faulkner, 2nd edition (2001), John Wiley & Sons, New York.

DSE-2: CYPCLD4-Physical Chemistry Practical-III (Credit-2)

OBJECTIVE AND LEARNING: Teaching and learning: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Conductometric study of the kinetics of saponification of ethyl acetate.
2. Conductometric titration of a polybasic acid.
3. Conductometric titration of triple mixture (HCl+NH4Cl+KCl) with NaOH.
4. Ternary phase diagram of water, benzene, and acetic acid.
5. Determination of molecular weight of a macromolecule by viscometry.
6. Synthesis of Metal Nanoparticles by Chemical method.
7. UV analysis of synthesized metal Nanoparticles
8. To Study the kinetics of Iodination of acetone

OUTCOMES: Upon course completion, the student will be able to apply the experiment based on adsorption, phase diagram and molecular weight in relevant industry and further in higher studies for the outcome.

- To interpret the experimental results obtained by conductometer and Polarimeter.
- Students will be able to conduct the Chemical kinetics experiment on various important reactions.
- Students will be able to describe the principles behind the experiment performed in the laboratory.

DSE-3: CYPCTD5-Chemical Analysis (Credit-3)

OBJECTIVE AND LEARNING: The primary objective of this course is to acquire basic concepts, principles, and techniques of modern analytical chemistry that would empower students with an analytical mind set and the abilities to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results.

1. **Sampling, Standardization & Calibration:** Analytical samples and methods, sampling and sample handling of minerals, ores, metals, liquid, gaseous, solids and biological samples, obtaining a representative sample, sampling uncertainties, the gross sample, preparing a laboratory sample, standardization and calibration, comparison with standards, external standard calibration, minimizing errors in analytical procedures.

2. **Molecular recognition and applications:** Definition and principle of recognition process, host guest interaction, receptor in separation of cation and anions, crown ethers, cryptands, calixarenes.

3. **Biochemical analysis:** Estimation of carbohydrates, amino acids and ascorbic acid in biological systems, purification of proteins (spectrophotometric and ELISA), estimation of protein in egg albumin, estimation of free fatty acid, Iodine value and saponification value of fats/oils, estimation of blood cholesterol, DNA and RNA.

4. **Soil and water analysis:** Determination of nitrogen, phosphorus (spectrophotometric),potassium, calcium, sodium (flame photometric) in soil samples; determination of metals, iron, copper, nickel and zinc (spectrophotometric) arsenic, lead, mercury, chromium, selenium (AAS) in soil and water samples.

5. **Organic group analysis:** Determination of hydroxyl, carbonyl, amides and ester groups, Determination of molecular weight and percentage purity of carboxylic acid, Estimation of sugars, Estimation of unsaturation.

OUTCOMES: The student learns the skill to prepare standard solution, samples and analysis of the samples through using accurate methods. The course makes the student to learn how to prepare solutions quantitatively and analysis the analyte with high accuracy.Therefore, students will be able:

1. To develop an understanding of the range and uses of analytical methods in chemistry.
2. To establish an appreciation of the role of chemistry in quantitative analysis
3. To develop an understanding of the broad role of the chemist in measurement and problem solving for analytical tasks.
4. To provide an understanding of chemical methods employed for elemental and compound analysis.
5. To provide experience in some scientific methods employed in analytical chemistry.
6. To develop some understanding of the professional and safety responsibilities residing inworking on chemical analysis.

Books Recommended:

1. P.L. Kirk, Quantitative Ultramicroanalysis, John Wiley.
2. C.L. Wilson and D.L. Wilson, Comprehensive Analytical Chemistry", Vol. I (A) and I(B), Elsevier.
3. G.D. Christian, Analytical Chemistry, John Wiley & Sons, New York (2001).
4. S.M. Khopkar, Analytical Chemistry of Macrocyclic and Supramolecular Compounds, Narosa Publishing House, New Delhi (2002).
5. Jag Mohan, Organic Analytical Chemistry - Theory and Practice, Narosa Publishing House, New Delhi (2003).

DSE-3: CYPCLD5- Analytical Chemistry Practical-IV (Credit-2)

OBJECTIVE AND LEARNING: Experiments of estimation of different elements in soil, water quality parameters, and other biomolecules' determination

1. Determination of nitrogen and phosphorus in soil samples
2. Determination of ascorbic acid by titration method
3. Estimation of cholesterol in blood sample
4. Estimation of water quality parameters of given water samples
5. Determination of Ni2+ concentration by EDTA back titration method
6. Determination of purity of oxalic acid sample by (1) Potentiometric method (2) Volumetric method.

Note*: Experiments may be added/deleted subject to availability of time and facilities*

OUTCOMES: The module will provide the hands-on analysis of different elements in soil samples, analytical instruments to prepare, separate and quantify samples from various matrices.Apply the scientific process, including statistical analysis of data, conducting and presenting the data of chemical analysis.Able to develop methods for tracing and measuring some compounds, such as cholesterol etc.

DSE-3: CYPCTD6-Inorganic - Rings, Chains, Clusters and Photochemistry (Credit-3)

OBJECTIVE AND LEARNING: Objective of this course is

- The students should be able to Know Synthesis and structural principles Isopoly and Heteropoly Acids and Salts.
- The students should able to explain Metal Clusters and Metal-Metal Bonds.
- The students should be able to explain Structure and Bonding in Boranes.
- The students should be able to know main group and organometallic chemistry.
- The students should be able to knowClassification of Inorganic Polymers.
- The students should be able to know basic principle of inorganic photochemistry and its application.

1. **Isopoly and Heteropoly Acid and Metal clusters:** Synthesis and structural principles with reference to those of V, Nb, Ta, Cr, Mo and W. Metal clusters and metal-metal

bonds, compounds with metal-metal multiple bonds, metal carbonyl, halide and chalcogenide clusters.

2. **Inorganic Photochemistry:** Basic Principles, Basic photochemical processes, photosubstitution, photoredox, photoisomerisation and photo rearrangementreactions in inorganic complexes. Photovoltaic and photogalvanic cells- photoelectrochemical cells, photoassisted electrolysis of water – aspects of solar energy conversion. Application of metal complexes in solar energy conversion.

3. **Polyhedral Boranes:** Lipscomb's Topological concept,Higher boranes, carboranes, metallo-boranes and metallo-carboranes –Structure and Bonding in the light of Wade's Rules, Wade- Mingo's Rule, Jemmismno rule, Polyatomic Zintl cations and anions

4. **Parallels between main group and Organometallic Chemistry:**Isolobal, Isoelectronic concept (Hoffman) in organometallic and metal-cluster chemistry, Chevrel Phases. infinite metal chains, multidecker molecules, cluster-surface analogy

5. **Inorganic Polymers:** Classification, Types of Inorganic Polymerization, Comparison with organic polymers, Boron-oxygen and boron-nitrogen polymers, silicones, coordination polymers, sulfur-nitrogen, sulfur-nitrogen-fluorine compounds, – binary and multi-component systems, hemolytic inorganic systems.

OUTCOMES: After completion of the course, the learner can be able to understand:

- Synthesis and structural principles Isopoly and Heteropoly Acids and Salts.
- Metal Clusters and Metal-Metal Bonds.
- Structure and Bonding in Boranes.
- Main group and organometallic chemistry.
- Types of Inorganic Polymers.
- The basic principle of photochemistry.
- Photomaterial for a specific application particularly metal complexes in solar energy conversion.

Books Recommended:

1. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn. (1999), John-Wiley & Sons, New York.
2. James E. Huheey, Inorganic Chemistry, 4th Edn. (1993), Addison Wesley Pub. Co., New York.
3. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn. (1997), Butterworth Heinemann, London.
4. Charles H. De Puy, Orville L. Chapman Molecular Reactions and Photochemistry, , Prentice Hall of India Private Limited, New Delhi, 1988
5. K.K.Rohatgi Mukherjee, Fundamentals of Photochemistry, Wiley Eastern Ltd., 1978
6. N.J.Turro, Modern molecular Photochemistry Benjamin / cummings,Menlo park, California (1978).

DSE-3: CYPCLD6- Inorganic Chemistry Practical – IV (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

Any three/four techniques covered in the semester out of the following syllabus:

(i) Instrumental methods of analysis utilizing flame photometer, UV-Vis Spectrophotometer, pH-meter, potentiometer, Fluorometer, turbidimeter, electrochemical methods, separation of mixtures of metal ions by ion exchange chromatography.
(ii) Study of electronic spectra of various transition metal complexes using UV-Vis spectrophotometer for determination of Racah Parameter.
(iii) Quantum chemical calculation of structure and IR Spectra of H_2O molecule by using Gaussian Program.
(iv) Quantum Yield Calculation of fluorescent molecule using spectrofluorometer.
(v) Determination of redox potential of some redox active molecule

Any other experiments done in the class during the current academic semester.

Note*: Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES: After completion of the course, the learner can be able to understand:

- Hands- on experience about IR, flame photometer, UV-Vis Spectrophotometer , pH-meter, potentiometer, Fluorometer, turbidimeter, electrochemical methods .
- And Calculate ligand field parameters and quantum yield based on electronic spectra of various transition metal complexes.

DSE-3: CYPCTD7- Chemistry of Natural Products (Credit-3)

OBJECTIVE AND LEARNING: The concerned students manifest their capability of imagination and understanding by learning a specified course. They develop their ability to understand complex situations and improve their vision for taking decision.

1. **Alkaloids:** Structure elucidation of alkaloids – A general account; Structural and, Retrosynthetic analysis, synthesis and stereochemistry of Quinine, Reserpine and Morphine.

2. **Terpenoids:** Definition and examples; terpenes – isoprene rule; mono terpenes: Structure elucidation, Retrosynthetic analysis and synthesis of Geraneol, Camphor, longfolene and Abietic acid.

3. **Steroids**: Introduction, nomenclature of steroids, absolute configuration of steroid. Structure elucidation and Synthesis of Cholesterol; Synthesis of Progesterone and Aldosterone

4. **Prostaglandins**: Introduction, nomenclature of prostaglandins; approaches to prostaglandin synthesis; cyclohexane precurors (Woodward synthesis of PGF2α), bicycloheptane precursors (Corey's synthesis of prostaglandins E and F)

5. **Carbohydrates**: Conformational analysis of monosaccharides (e.g. pentoses and hexoses); Anomeric and reverse anomeric effect; Mutarotation and abnormal mutarotation; Use of complexing agents: Borates and Phosphates; synthesis of glycosides; general treatment of polysaccharide chemistry: Hydrolysis, methylation and periodic oxidation, Smith degradation.

OUTCOMES: A student having studied a subject like 'NATURAL PRODUCT' will be capable of understanding the chemical sciences which are involved in the flora and the fauna. This will impart the students' knowledge regarding biologically active molecules which represent a major class of pharmaceuticals and drugs.

Books Recommended:

1. Nitya Anand, J.S. Bindra and S. Ranganathan, Art in Organic Synthesis, 2nd Edition (1970), Holden Day, San Francisco.
2. S.W. Pelletier, Chemistry of the Alkaloids, (1970) Van Nostrand Reinhold Co., New York.
3. K.W. Bentley, The Alkaloids, Vol. I., (1957) Interscience Publishers, New York.
4. I. L. Finar, Organic Chemistry, Vol. II, 5th Edition (1975) Longman Ltd, New Delhi.
5. J.W. Apsimon, Total Synthesis of Natural Products, Vol. 1-6, Wiley-Interscience Publications, New York.
6. J.S. Bindra and R. Bindra, Creativity in Organic Synthesis.
7. J.S. Bindra and R. Bindra, Prostaglandins Synthesis.
8. S. Warren, Organic Synthesis: Disconnection Approach, (1982) Wiley, New York.
9. K. C. Nicolaou, Classics in Total Synthesis of Natural Products, Vol. I & II.
10. J. Clayden, N. Greeves, S. Warren, and P. Wothers, Organic Chemistry, Chapter 30, (2001) Oxford University Press, Oxford.
11. E. A. Davidson, Carbohydrate Chemistry, Holt, Rinehart and Winston, New York1967.
12. R. D. Guthrie and J. Honeyman, An Introduction of Chemistry of Carbohydrate, 3rd Edn., Clarendon Press, Oxford, 1988.
13. J. Kennedy, Carbohydrate Chemistry, Clarendon Press, Oxford, 1988.

DSE-3: CYPCLD7- Organic Chemistry Practical – IV (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Some important techniques related to organic separation: Paper Chromatography, Thin layer Chromatography, Column chromatography.
2. Green synthesis and structural analysis of organic compounds by FT-IR, UV-Vis spectroscopy.

OUTCOMES: On Completion of this module, the learner will be able to:identify the presence of different components/molecules in the unknown mixture, design a particular organic synthesis, purify the reaction products by various techniques such as recrystallization, TLC, column chromatography etc.

DSE-3: CYPCTD8- Quantum Chemistry (Credit-3)

OBJECTIVE AND LEARNING: To understand the deviation of classical mechanics and evolution of quantum mechanics, the Schodinger equation for some model systems (wave function and energy state determination), the approximation method to solve the Schodinger wave equation for some higher order system., the quantum mechanical treatment of molecular systems using Ab-initio or first principle calculation.

1. **Concepts of Quantum Chemistry**: General formulation of Quantum Mechanics: Eigen functions and Eigen values and quantum mechanical operators. Expectation value of a physical quantity. Orthogonalization and normalization of wave functions. Postulates and theorem of quantum mechanics,

2. **Solutions to Schrodinger Equation**: Schrodinger wave equation solution of Schrodinger wave equation to some model systems viz. particle in a box, rigid rotor, harmonic oscillator, H atom problems.

3. **Approximation Methods in Quantum Chemistry**: Variation method, Stationary perturbation theory for non-degenerate and degenerate. Ground state of He atom. Time-dependent perturbation theory. Radiative transition, Einstein coefficients.

4. **Angular momentum and many electron system**: ordinary Angular momentum, generalized angular momentum, eigen functions for angular momentum, eigen values of Angular momentum, Operator algebra: use of ladder operator, Addition of angular momenta,Antisymmetry and pauli exclusion principle.

5. **Molecular structure:** Born-Oppenheimer approximation, Molecular orbital treatment for H2+ moleule. Huckel theory of conjugated system, bond order and charge density calculation, Hückel MO treatment of simple and conjugated polyenes: ethene, 1,3 - butadiene, Cyclo Butadiene. Alternant hydrocarbons: Benzene. Introduction to Extended Huckel Molecular Orbital Theory.

OUTCOMES: After finishing the course, the student will be able to –
account for theory of angular momentum, theory for orbitals and electrons, and describe both coupled and uncoupled representation - account for the Born-Oppenheimer approximation – account for approximation methods such as variational theory and perturbation theory.

Books Recommended:

1. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics, 3rd edition (1997), Oxford University Press. Oxford.
2. H. Eyring, J. Walter and G.E. Kimball, Quantum Chemistry, John Wiley, New York (1944)
3. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ., Inc., New Delhi.
4. G. M. Barrow, Physical Chemistry, Fifth edition, Tata MacGraw Hill, New delhi (1994).
5. J. N. Gurtu and A. Gurtu, Advanced Physical Chemistry, Pragati Edition, Meerut (2009).

DSE-3: CYPCLD8- Physical Chemistry Practical-IV (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Cyclic Voltammetry of the [Fe(CN)6]3-/[Fe(CN)6]4- system.
2. Corrosion study of Iron in an acid and basic solution.
3. Synthesis and FTIR analysis of synthesized metal Nanoparticle oxides.
4. Determination of molar mass of non-volatile substances by Lansberger method.
5. Determination of molar mass of naphthalene and acetanilide by Rast's method.
6. Determination of intrinsic viscosity of polyacrylamide and poly vinyl alcohol by viscometric method.
7. To investigate the effect of ionic strength on the reaction between potassium iodide and potassium peroxodisulphate.
8. Conductometric titration of triple mixture (HCl+NH4Cl+KCl) with NaOH.

OUTCOMES: Upon course completion, the student will be able to apply the experiment based on adsorption, phase diagram and molecular weight in relevant industry and further in higher studies for the outcome.To interpret the experimental results obtained by conductometer and Polarimeter. Students will be able to conduct the Chemical kinetics experiment on various important reactions. Students will be able to describe the principles behind the experiment performed in the laboratory.

SEMESTER–IV

CC-11: CYPDTT6- Biological Chemistry (Credit-3)

OBJECTIVE AND LEARNING:

The learners should be able to validate the conceptual understanding acquired from the theory classes

1. Learn about various biological entities such enzymes, lipids, carbohydrates, cell-membranes etc.
2. Various chemical and structural aspects of proteins, amino acids, nucleic acids etc.

Important roles of biological processes and further effects.

1. **Molecules of life:** Amino acids and proteins, Carbohydrates-polysaccharides, lipids, cell-membranes and nucleic acids.

2. **Structure and function:** Protein structure, Ramachandran - plot, protein folding: DNA/RNA structures, various forms (*a*, *b*, *c*, *z*) of DNA, *t*-RNA structure, transcription and translation, gene expression and DNA binding protein-zinc-finger protein.
3. **Metabolism and Energetics:** Glycolysis, citric acid cycle, oxidative phosphorylation and transport through membranes.

4. **Enzymes:** Introduction, classification, formation and function of enzymes, co-enzymes, cofactors (elementary idea); Enzyme kinetics, TON and TOF, Enzyme inhibitors.

5. **Metalloenzymes:** Hydrolytic and redox enzymes: Carbonic anhydrase and superoxide dismutase.

6. **Oxygen uptake proteins:** Hemerythrin and hemocyanin.

7. **Molecular recognition:** Molecular organization, Chiral recognition and role of sugar in biological recognition.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. The basics properties and functions of various elements such as DNA/RNA, enzymes, protein structures etc.
2. Aspects of several metabolic cycles and oxygen uptake process
3. Concept of biological recognition and molecular organization

Books Recommended:

1. L. Stryer, Biochemistry, 5th Edition, (2002) Freeman &Co. New York
2. D.L. Nelson and M.M. Cox, Lehninger Principles of Biochemistry 3rd Edition ((2002) McMillan North Publication
3. D. Voet, J. G. Voet, Biochemistry 3rd Edition (2004), Wiley International Publication.
4. I. Bertini, H. B. Gray, S. J. Lippard, J.S. Valentine, 1st South Asian Edn., (1998) Viva Books Pvt. Limited, New Delhi
5. M. B. Smith, Organic Synthesis, (1998) Mc Graw Hill Inc, New York.

OE-2: CYPDTL6-Biological Chemistry Practical (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the practical classes

1. Several separation techniques for biological compounds from a mixture
2. Basic techniques and analytical methods for biological compounds handling.

1. Paper chromatography: Separation of amino acids and carbohydrates in a mixture
2. Carbohydrates: Qualitative analysis, quantitation of glucose and ribose.
3. Amino acids and proteins: Qualitative analysis, quantitation of proteins and amino acids.
4. Fats: Acid number, saponification and iodine values.
5. Effect of pH and temperature on the rate of enzyme reaction.
6. Agarose Gel Electrophoresis and separation of DNA.

OUTCOMES: After completion of the course, the learner can be able to understand:
Qualitative and Qualitative analysis of several natural components such as proteins and amino acids.
Vital roles of internal and external reaction parameters in biological processes.

DSE-4: CYPDTD1- Advanced Separation Techniques (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: The module will provide detail study of solvent extraction, chromatographic separations [Gas chromatography, high performance liquid chromatography, Ion-exchange chromatography, Reverse phase chromatography & Bonded phase chromatography (BPC), Size exclusion chromatography, Super critical fluid chromatography (SFC)], separation techniques based on rate processes [(a) Barrier-separation methods: Membrane separation-Ultrafiltration, dialysis, electrodialysis, electro-osmosis, reverse osmosis (b) Field separation methods: Electrophoresis, Ultracentrifugation], mass spectrometry and hyphenated mass spectrometric techniques such as GC-MS, LC-MS, CE-MS, ICP-MS.

1. **Separation Techniques Based on Phase Equilibria:** Solvent Extraction: Liquid-Liquid and super critical fluid extraction, Quantitative treatment of various solvent, extraction equilibria.

2. **Separation Techniques Based on Rate Processes:** (a) Barrier-separation methods: Membrane Separation-Ultrafiltration, dialysis, electrodialysis, electro-osmosis, reverse osmosis (b) Field separation methods: Electrophoresis, Ultracentrifugation.

3. **Chromatographic Separation:** Gas chromatography, high performance liquid chromatography, Ion-exchange chromatography, Reverse phase chromatography & Bonded phase chromatography (BPC), Size exclusion chromatography, Super critical fluid chromatography (SFC).

4. **Mass Spectrometry:** Principle, classification (EI, CI, FD and FAB, MALDI, SIMS and ESI) and applications in characterization of organic compounds, mass analyzers, mass spectral fragmentation of organic compounds, molecular ion peak, metastable peak and nitrogen rule.

5. **Hyphenated mass spectrometric techniques:** GC-MS, LC-MS, CE-MS, ICP-MS, tandem mass spectrometers, principle and applications.

OUTCOMES: Student will get the knowledge (principles and instrumentation and applications) about different types of separation techniques such as solvent extraction, chromatographic separation, hyphenated mass spectrometric techniques and analysis of different samples using these techniques.

Books Recommended:

1. Skoog, West, Holler & Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Cengage Learning PVT. Ltd.
2. J.D. Seader and E.J. Henley, Separation Process Principles, 1st Edition (1998), John Wiley & Sons. Inc., New York.
3. Willard, Merrit, Dean, Settle, Instrumental Methods of Analysis, 7th Edition, CBS Publishers & Distributors PVT Ltd.
4. G.D. Christian, Analytical Chemistry, John Wiley & Sons, New York (2001).
5. J. H. Gross, Mass Spectrometry: A Textbook, Springer, Verlag, Berlin, (2011).

DSE-4: CYPDTD2- Structural Methods in Inorganic Chemistry (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: Objective of this course is:

1. The students should be able to explain basic theory of NMR Spectroscopy and analyse NMR Spectra of compounds.
2. The students should know basic principle of ESR Spectroscopy and analyse Hyperfine Splitting and the g-value.
3. The students should be able to explain Basic principle, conditions for Mossbauer spectroscopy and Spectral parameters.
4. The students should be able to know theory of Infrared and Raman Spectroscopy ad spectral analysis.
5. The students should be able to knowtheory of Mass Spectrometry, Fragmentation pattern and recognition of the molecular ion peak.

1. **NMR Spectroscopy:** (i) Use of Chemical shifts and spin-spin couplings for structural determination, (ii) Double resonance, and Dynamic processes in NMR, (iii) Decoupling phenomenon, Nuclear Overhauser Effect, DEPT spectra and structural applications in 13C NMR, (iv) Use of Chemicals as NMR auxillary reagents (shift reagents and relaxation reagents (v) 1H NMR of paramagnetic substances. (VI) NMR of Metal nuclei

2. **Electron Spin Resonance Spectroscopy:** Basic principle, Hyperfine Splitting (isotropic systems); the g-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); Electron-electron interactions, Anisotropic effects (the g-value and the hyperfine couplings); Structural applications to transition metal complexes.

3. **Mössbauer Spectroscopy:** Basic principle, conditions for Mossbauer spectroscopy, Spectral parameters (Isomer shift, electric quadrupole interactions, magnetic interactions), temperature dependent effects, structural deductions for iron and tin complexes, miscellaneous applications.

4. **Infrared and Raman Spectroscopy:** Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factor affecting the band positions and intensities, far IR region, metal-ligand vibrations, normal co-ordinate analysis. Applications of vibrational

spectroscopy in investigating (i) symmetry and shapes of simple AB_2, AB_3 and AB_4 molecules on the basis of spectral data, (ii) mode of bonding of ambidentate ligands (thiocyanate, nitrate, sulphate and urea). Classical and quantum theories of Raman Effect, pure rotational, vibrational, and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle. Resonance Raman spectroscopy, coherent anti-stokes Raman spectroscopy (CARS).

5. **Mass Spectrometry:** Fragmentation pattern and Fingerprint applications in the interpretation of Mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak; Ionization techniques (EI and FAB).

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Theory of NMR Spectroscopy and analyse NMR Spectra.
2. Basic principle of ESR Spectroscopy and analyse Hyperfine Splitting and the g-value.
3. Basic principle, conditions for Mossbauer spectroscopy and Spectral parameters.
4. Theory of Mass Spectrometry, Fragmentation pattern and recognition of the molecular ion peak.
5. Theory of Mass Spectrometry, Fragmentation pattern and recognition of the molecular ion peak.

Books Recommended:

1. E. A. V. Ebsworth, D. W. H. Rankin and S. Cradock, Structural Methods in Inorganic Chemistry, 1st Edn. (1987), Blackwell Scientific Publications, Oxford, London.
2. R. S. Drago, Physical Methods in Chemistry, International Edition (1992), Affiliated East-West Press, New Delhi.
3. K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 4th Edn. (1986), John Wiley & Sons, New York.
4. W. Kemp, Organic Spectroscopy, 3rd Edn. (1991), Macmillan, London.
5. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India Pvt. Ltd., New Delhi (2001).
6. R. L. Dutta and A. Syamal, "Elements of Magneto Chemistry," 2nd Edition, Affiliated East West Press, New Delhi.

DSE-4: CYPDTD3-Organic Spectroscopy for Structural Elucidation (Credit - 5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: Structure elucidation of the different organic compounds using UV, IR, PMR, CMR and Mass spectroscopy will be discussed to make students able to interpret and analyse the spectra of organic compounds.

1 **Infrared-Ultra-Violet Spectroscopy:** UV: Absorption of dienes, polyenes,carbonyl compounds and α,β-unsaturated carbonyl compounds. Woodward rule and its application. Aromatic compounds. IR: Vibration modes and bond stretching. Absorption of common functional groups, electrical and Steric effects, effects of Hydrogen bonding. Fingerprint region and interpretation of IR spectra.

2 **PMR Spectroscopy:** Interpretation of spectra, chemical shift, shielding mechanism and anisotropic effects, chemical exchange. Spin-spin interactions, naming spin systems, magnitude of coupling constant: geminal, vicinal and long-range couplings. Second order spectrum and analysis of AB, AMX and ABX systems. Simplification of Complicated

Spectra: Aromatic induced shifts, spin decoupling, deuterium exchange, spectra at higher fields. Hindered rotation and rate processes.

3 **CMR Spectroscopy:** General considerations, chemical shift, coupling constants. Nuclear Overhauser effect. Spin-spin, spin-lattice relexations. Off resonance decoupling. DEPT. Interpretation of simple CMR spectra.

4 **2D NMR Spectroscopy:** COSY, NOESY and HETCOR.

5 **Mass Spectrometry:** Introduction, ion production, fragmentation, factors influencing ion abundance, single and multiple bond cleavage, rearrangements, cleavage associated with common functional groups, molecular ion peak, metastable ion peak, Nitrogen rule and interpretation of mass spectra.

OUTCOMES: To learn about the principle and applications of ultraviolet and Woodward Fisher Rule and understand the infra-red spectroscopy in organic structure determination. To know about the Nuclear magnetic resonance spectroscopy, proton chemical shift, spin-spin coupling, coupling constants and applications to organic structures ^{13}C resonance spectroscopy. To learn the Mass spectrometry and its applications including the optical rotatory dispersion and its applications. To study the concepts of Cotton effect, axial halo-ketone rule and octant rule. Student investigates the various chemical process by using a series of spectroscopic techniques. The various corner of synthetic chemistry related problem will be explained by these techniques.

Book Recommended:

1. J.R. Dyer, Application of Absorption Spectroscopy of Organic Compounds, Prentice Hall, New Delhi (1978).
2. R.M. Silverstein and F.X. Webster, Spectroscopic Identification of Organic Compounds, 6th Edition (2003) John Wiley, New York.
3. D.H. Williams and I.F. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Edition (1988), Tata-McGraw Hill, New Delhi.
4. P.Y Bruice, Organic Chemistry, 2nd Edition (1998) Prentice – Hall, New Delhi.

DSE-4: CYPDTD4-Statistical Mechanics (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: To learn the laws of Thermodynamics, To learn Ensembles: Phase Chemistry: Proposed Syllabi (effective from session 2012-13) Page 41 of 47 space. Canonical and grand canonical ensembles. Ideal gas in canonical and grand canonical ensembles. Partition Function, Bose Einstein statistics, Fermi Dirac Statistics.

1. **Review of Thermodynamics:** Laws of Thermodynamics, free energy, chemical potential and entropy, partial molar properties: free energy, volume and heat content, and their significances. Concept of fugacity and determination of fugacity.

2. **Basic Statistical Mechanics Ensembles:** Phase space. Ensemble. Equal a priori probability. Microcanonical ensemble. Entropy. Gibb's paradox. Entropy of a two-level system. Canonical and grand canonical ensembles. Ideal gas in canonical and grand canonical ensembles.

3. **Partition Function:**Canonical partition function, molecular partition function, Review of rotational, vibrational and translational partition functions. Application of partition functions to specific heat of solids and chemical equilibrium, relationship between partition function and enthalpy, entropy and other thermodynamic quantities.

4. **Ideal Bose-Einstein Gas:** Bosons: General introduction and characteristics, Bose Einstein statistics, Bose-Einstein distribution, Bose- Einstein condensation. Thermodynamic properties of ideal BE gas.

5. **Ideal Fermi-Dirac Gas:** Fermions: General introduction and characteristics, Fermi-Dirac statistics,Fermi- Dirac Fermi-Dirac distribution, Degenerate Fermi gas. Electron in metals. Magnetic susceptibility, Superconductivity.

OUTCOMES:

After finishing this course the students will be able to:

Grasp the basis of ensemble approach in statistical mechanics to a range of situations.Explain the fundamentals of thermodynamics, carnot cycle, statistics and distributions.Explain the fundamental differences between classical and quantum statistics and learn about quantum statistical distribution laws.Analyze important examples of ideal Bose systems and Fermi systems.

Books Recommended:

1. Statistical Mechanics, B.K. Agarwal and M. Eisner, Wiley Eastern, New Delhi (1988).
2. Statistical Mechanics, D.A. Mcquarrie, Harper and Row Publishers, New York (1976).

DSE-5: CYPDTD5- Electroanalytical Methods
(Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: The module will provide an introduction into the fundamentals of chemical analysis, including an understanding of some of the most important analytical techniques, theoretical idea to different types of electroanalytical techniques cyclic voltammetry, polarography, amperometry, choranoamperometryetc.Thorough theoretical and practical understanding of advanced analytical instruments, for example for measuring metals, proteins, medicinal and non-medicinal drugs.Able to assess the different modified electrodes and role of cyclic voltammetry in sensing.

1. **General Introduction:** Overviews of electrode processes, polarization and overvoltage, reference electrodes (Ag/AgCl, hydrogen, mercury pool) working electrodes (Pt, GCE, DME, SME, HMDE, rotating platinum electrode), Three-electrode system, factors affecting electrode reaction rate and current, Modes of mass transfer (diffusion, migration, convection).

2. **Polarography:**Illkovic equation and its derivation, Criteria of polarographic reversibility, Interpretation of catalytic, kinetic, adsorption and capacitive currents. Polarographic maxima and maximum suppressors.

3. **Modern electroanalytical techniques:** Necessity and development of new voltammetric techniques, Oscilliography, Differential pulse voltammetry, Normal pulse voltammtery,

Derivative voltammetry, Cyclic voltammetry (Reversible, irreversible, quasireversible), Linear sweep volatammetry, Alternating current voltammetry.

4. **Other related techniques:** Chronoamperometry, Chronopotentiometry. Controlled-potential and constant current coulometry, Stripping voltammetry, Electrogravimetry.

5. **Electroactive layers and modified electrodes:** chemically modified electrodes, Types, preparation and properties of films and modified electrodes: monolayers, polymers, inorganic films, biologically related materials, composites and multilayers assemblies, role of cyclic voltammetry in sensing.

OUTCOMES: Students will learn principles, instrumentation and applications of different electroanalytical techniques, preparation methods of modified electrodes, study of different electrochemical sensors.

Books Recommended:

1. L. Meites, Polarographic Techniques, 2nd Edition (1965), John Wiley, New York.
2. J. Heyrovsky and K. Kuta, Principles of Polarography, 1st Edition (1966), Academic Press, New York.
3. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, 5th Edition (1998), Saunders College Publishing, Harcourt Brace & Company, U.S.A.
4. A.J. Bard and L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition (2000), Wiley, New York.
5. S. Ahuja, N. Jespersen, Modern instrumental analysis, Elsevier B.V., 2006, UK.

Additional References:

1. C.W.C. Milner and G. Phillips, Coulometry in Analytical Chemistry, Pregamon Press, New York (1967).

DSE-5: CYPDTD6- Special Topics in Inorganic Chemistry (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: Objective of this course is

1. The students should be able to know design and synthesis of Macrocyclic Complexes.
2. The students should able to describe Ligand design and ligand synthesis for the synthesis of metal complexes.
3. The students should be able to explain basic concepts of molecular magnetism and types of magnetic interactions.
4. The students should be able to know basic concepts, types of meso-phases, synthetic strategies for Liquid Crystal and Metallomesogens
5. The students should be able to knowNanostructured material and nanocatalysis.

1. **Macrocyclic Complexes:** Types of macrocyclic ligands – design and synthesis by coordination template effect, di- & poly-nuclear macrocyclic complexes; applications of macrocyclic complexes.

2. **Molecular Magnetic Materials:** Basic concepts of molecular magnetism, types of magnetic interactions, inorganic and organic ferro-magnetic materials, low-spin-high-spin transitions, isotropic interactions in Cu(II) dinuclear compounds.

3. **Liquid Crystal and Metallomesogens:** Basic concepts, types of meso-phases, synthetic strategies, characterization and applications.

4. **Chemistry in nanoscience and technology:** Introduction, definition of nanomaterials and Nano technology. History of nanomaterials, causes of interest in nanomaterials, properties and types. Synthesis of nanomaterials, their characterization techniques and applications of nanomaterials, Nanostructured material and nanocatalysis.

5. **Uses of Inorganic reagents in inorganic analysis:** General discussion and uses of some inorganic reagents: Potassium bromate (KBrO3), potassium iodate(KIO3), ammonium vanadate (NH4VO3), ceric sulphate [Ce(SO4)2], ethylenediamine tetra acetic acid (EDTA).

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Design and synthesis of Macrocyclic Complexes.
2. Ligand design and ligand synthesis for the synthesis of metal complexes.
3. Basic concepts of molecular magnetism and types of magnetic interactions.
4. Basic concepts, types of meso-phases, synthetic strategies for Liquid Crystal and Metallomesogens.
5. Nanostructured material and nanocatalysis.

Books Recommended:

1. Jean-Marie Lehn, Supramolecular Chemistry, VCH, Weinheim (1995).
2. J. L. Serrano, Metallomesogens, VCH, Weinheim (1996).
3. Oliver Kahn, Molecular Magnetism, VCH, Weinheim (1993).
4. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. BoCMTann, Advanced Inorganic Chemistry, 6th Edn., John Wiley & Sons (Asia) Singapore (2003).
5. P. Yang. The Chemistry of Nanostructured Materials World Scientific Publ. Co. Pte. Ltd. (2003) ISBN 981-238-405-7.
6. U. Heiz and U. Landman (Eds.) Nanocatalysis, Springer, 2007.
7. Vogel's Text book of Quantitative Inorganic Analysis, ELBS Press.

DSE-5: CYPDTD7- Reagents and Reactions in Organic Synthesis (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: To get the knowledge about importance of protection in organic synthesis, Use of reagents and catalysts in oxidation, reduction and other reactions. Metal ion promoted reactions.

1. **Protecting groups:** Importance of protection in organic synthesis, Hydroxy (acetate, MEM, MOM, Trityl), carbonyl (Acetal, ketal, Dithiane) and amines (BOC, F-MOC, CBZ, Bn, Acetate etc).

2. **Reduction:** (i) Complex metal hydride reductions: LiAlH4, NaBH4 and DIBAL; reduction of aldehydes and ketones, stereochemistry of ketone reduction, (ii) Reduction of conjugated systems: Birch reduction, (iii) Hydroboration (iv) Miscellaneous: Tributyltin hydride, Wilkinson's catalyst.

3. **Oxidation:** (i) Oxidation with peracids: Oxidation of carbon-carbon double bonds (Sharpless epoxidation), carbonyl compounds, allylic carbon-hydrogen bonds, (ii) Oxidation with selenium dioxide and Osmium tetroxide, (iii) Woodward and Prevost hydroxylation.

4. **Reagents and Reactions:**
   (i) Advantages and limitation of Homogeneous and heterogenous process
   (ii) Gilman's reagent – Lithium dimethylcuprate
   (iii) Lithium diisopropylamide (LDA)
   (iv) Dicyclohexyl carbodiimide (DDC)
   (v) 1,3-Dithiane (Umpolung reagent)
   (vi) Peterson's synthesis
   (vii) Organophosphorus compounds (Wittig reaction)

5. **Metal ion Promoted Reactions:** Heck reaction, Suzuki reaction, Sonogashira reaction, Nigeshi, Stille reaction, Metathesis reaction, Water gas shift reaction (WGSR), Wacker-Smidt synthesis.

OUTCOMES: On Completion of this module, the learner will be able to

- Take decision in selecting reagents for a particular organic synthesis
- Improve the yield of chemical reaction
- Perform direct inter-conversion of a particular functional group without protecting others
- Minimize formation of the by-products or un-wanted molecules by choosing suitable reagents
- Synthesize important organic scaffolds via benign reaction conditions.

Books Recommended:

1. H.O. House, Modern Synthetic Reactions, 2nd Edition (1972), Benjamin/Cummings Publishing Company, California.
2. L.F. Fieser and M. Fieser, Reagents for Organic Synthesis, Vol. 1-16, Wiley-Interscience, New York.
3. M.B. Smith and J. March, March's Advanced Organic Chemistry – Reactions, Mechanisms & Structure, 5th ed. (2001), Wiley-Interscience, New York.
4. M. B. Smith, Organic Synthesis, (1995) McGraw Hill Inc., New York.
5. J. Clayden, N. Greeves, S. Warren, and P. Wothers, Organic Chemistry, (2001) Oxford Univ. Press, Oxford.
6. P. R. Jenkins, Organometallic Reagents in Synthesis, (1992) Oxford Science Publ., Oxford.
7. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
8. J. D. Atwood, Inorganic and Organometallic Reaction Mechanisms, 2nd Edn, VCH, New York, 1997.
9. G. W. Parshall, Homogeneous Catalysis, Wiley, New York, 1980.
10. C. N. Satterfield, Heterogeneous Catalysis in Practice, McGraw-Hill, New York, 1980.

DSE-5: CYPDTD8- Chemical Kinetics (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: To understand the details of different Theories of reaction rates and their differences, the detailed study of thermodynamic and statistical approach of transition state theory, Kinetics of reactions in liquid state, Effect of substituent's on reaction rate, Hammette relations and Taft significance.

1. **Experimental Techniques for Fast Reaction:**Flow techniques, relaxation methods, flash photolysis.

2. **Transition State Theory:** Conventional transition state theory(CTST), some applications of transition state theory, Thermodynamic treatment of CTST, assumptions and limitations of conventional transition state theory, Application of statistical mechanics to transition state theory, extension of TST.

3. **Elementary gas phase reactions:** Bimolecular, trimolecular and Theories of unimolecular reactions--treatments of Lindmann, Hinshelwood, Rice-Ramsperger-Kassel (RRK), and Rice-Ramsperger-Kassel-Marcus (RRKM), combination and disproportionation reactions.

4. **Reactions in Solution:** Theories of the reaction rates applied to reaction in solution, Diffusion controlled reaction, reaction between molecules, Reaction between ions: Effect of solvent, interpretation of frequency factor and entropy of activation, reaction between dipoles, influence of ionic strength on rate of reaction, Influence of substituents on reaction rates, Linear free energy relationships, The Hammett equation, significance of s and r. The Taft equation.

5. **Homogeneous Catalysis:** General catalytic mechanism: equilibrium and steady state treatment, Mechanism of acid-base catalysis (protolytic and prototropic). Bronsted catalytic law, industrially important homogeneous catalysis processes, kinetics of enzyme catalyzed reaction.

OUTCOMES:

- Student will acquire knowledge of kinetics of some special reactions and different techniques of fast reaction.
- Students will be able to explain the concept of activation energy and its effects on the rates of chemical and calculate the entropy of activation
- Students will be able to explain Reaction between ions,Effect of solvent, interpretation of frequency factor and, reaction between dipoles, influence of ionic strength on rate of reaction and apply to see the influence of substituents on different organic reaction.

Books Recommended:

1. M. J. Pilling and A.P.W, Seakins, Reaction Kinetics, Oxford Science Publication, New York (1998).
2. K.J. Laidler, Chemical Kinetics, 3rd Edition (1967), Harper & Row Publishers, New York.
3. J. Rajaram and J.C. Kuriacose, Kinetics and Mechanism of Chemical Transformation, Ist Edition (1993), MacMillan India Ltd., New Delhi.
4. B. G. Cox, Modern Liquid Phase Kinetics, Oxford University Press, Oxford (1994).

DSE-6: CYPDTD9- Environmental Chemistry (Credit-5 Theory 04 + Tutorial 01)

OBJECTIVE AND LEARNING: Environmentally benign chemical reactions are nowadays growing concerns of academics and industries and this study will make students aware with environmental ethics and knowledge needed to pursue their further chemical research work.

1. **Introduction:**Concept and scope of environmental chemistry, Environmental terminology and nomenclatures, Environmental segments, Solar Energy. The natural cycles of environment (Hydrological, Oxygen, Nitrogen, Phosphorous and Sulphur cycles) and their importance.

2. **Particles, ion and radicals in the atmosphere, stratospheric chemistry:** chemistry of ozone layer, role of chemicals in ozone destruction, Temperature inversion and its effects, Chemistry of Smog and its harmful effects. The green-house effect and Global warming,

3. **Basic principles of Sustainable Chemistry**: Eco-Friendly catalysts, synthesis, solvents. Biodegradable polymeric composite sorbents, Eco-friendly protocols for heavy metal water pollutants. Chemistry of soil formation and role of fertilizers and insecticides in soil pollution. Plume and its significance.

4. **Sources and effects, of oxides of sulphur, oxides of nitrogen, oxides of carbon**: Monitoring of air pollutants by Instrumental methods. Control of air pollution by raw material change, process modification, adsorption, absorption and combustion methods.

5. **Classification of Water Pollutants:** Chemical Pollutants; Physical Pollutants; Physiological Pollutants; Thermal Pollution. Unique characteristics of water; Water and the Living Environment; Water and the Non-living Environment; Monitoring of Water Pollutants: Pollution indicators, Dissolved Oxygen; Biological Oxygen Demand; Chemical Oxygen Demand; Waste water: Constituents – Microorganisms; Solids; Inorganic constituents, Organic matter, Water Quality requirements, pH values of Wastes and Receiving water, Suspended solids. El-Nino phenomenon.

OUTCOMES: A student having studied a subject like 'ENVIRONMENTAL CHEMISTRY' will be capable of understanding about the Environment and the chemical sciences involved in it. The students improve their knowledge regarding the different pollutions/ pollutants occurring in the environment. The students also develop their knowledge regarding Toxic substances and their distributions in the environment and their anti-dotes.

Books Recommended:

1. G.W. Vanloon, S.J. Duffer, Environmental Chemistry - A Global Perspective, Oxford University Press (2000).
2. F.W. Fifield and W.P.J. Hairens, Environmental Analytical Chemistry, 2nd Edition (2000), Black Well Science Ltd.
3. Colin Baird, Environmental Chemistry, W.H. Freeman and Company, New York (1995).
4. A.K. De, Environmental Chemistry, 4th Edition (2000), New Age International Private Ltd.,New Delhi.

Additional References:

1. Peter O. Warner, Analysis of Air Pollutants, 1st Edition (1996), John Wiley, New York.
2. S.M. Khopkar, Environmental Pollution Analysis, 1st Edition (1993), Wiley Estern Ltd., New Delhi.
3. S.K. Banerji, Environmental Chemistry, 1st Edition (1993), Prentice-Hall of India, New Delhi. CMT-406: Photo Inorganic Chemistry C.

D: CYPDDD1-Project/Dissertation/Field work/Internship/Industry visit (Credit – 6)

OBJECTIVES AND LEARNING: The term courses also include a dissertation a research-based thesis project enhancing the students understanding.

Topic selection in consultation with the teacher; literature search from different reference books, scientific journals and using internet search; Bench work, typed write-up with proper tables, structures, figures and literature to be submitted; seminar lecture on this topic to be delivered in presence of all the teachers.

OUTCOMES: On successful completion of these semesters, students will be able to: (a) Describe and compare a range of analytical chemistry methods and explain the underlying theoretical principles. (b) Explain the broad role of chemists in quality control and assessment of experimental measurements and analytical tasks. (c) Employ a variety of analytical and instrumental methods to prepare, separate and quantify samples from various matrices. (d)Apply the scientific process, including statistical treatment of data, in the conduct and reporting of chemical analysis.

D: CYPCTC1-Value Added Course (Certificate Course)

1. Certificate Course in Lab Safety Management

- **Department:** Chemistry
- **Name of the Course**: Certificate Course in Lab Safety Management
- **Nature of Course**: Certificate Course
- **Mode of Course**: Online / Offline / Hybrid Mode
- **Number of Seats**: 20
- **Eligibility Criteria**: B. Sc. in any discipline with Chemistry as a paper
- **Introduction and relevance of Course**: Everywhere the safety comes first. Working safely in the laboratory is the basic requirement of every student. Laboratory safety management should be an integral part of every chemistry curriculum. The safety responsiveness must be included into each laboratory course. The primary goal of this course is to educate the students with the basics of laboratory safety. They will learn about common hazards found in the lab environment and effective ways to prevent risks to their safety and health. Through this course the students will learn general lab safety rules and guidelines, how to detect and control lab hazards and the requirements for a Chemical Hygiene Plan.

- **Objectives of the course:**1.The students must understand the importance of safety in the laboratory as it relates to themselves and those around them. 2. They must be able to explainthe meaning of common safety symbols used in specific scientific fields of study.3.They must demonstratecomplete knowledge of laboratory safety rules.4.The student must be able to displayproper safety practices in the laboratory setting.

- **Learning outcome of the course**: 1. The ability to understand the terms hazard and risk; 2. The ability to conduct risk assessments for chemical hazards; 3. The ability to understand the fire hazard; 4. A thorough knowledge of the legal requirements and best practice for the disposal of all types of solid and liquid waste; 5. to know the symbols for different types of hazards and the actions for remedial; 6. awareness of other key safety issues, such as lone working, stress, ergonomics
- **Number of lectures**: 2 hour per week (2 credits)
- **Number of practical**: 2 hour per week (1 credit)

- **List of experiments**: Hands on training on handling chemical hazards, fire hazards, waste management.
- **Syllabus**:
  Unit 1: Good Laboratory practices and safety guidelines:
  Safe working procedure and protective environment, Laboratory safety measures basic principles, Classification of dangerous materials with pictorial symbols, common hazard and commonprecautions for each class, Safe chemical use, Proper storage and disposal of hazardous

materials, Safety in bulk storage of hazardous substances. Safety in shelf storage of hazardous substances,

Unit 2: Handling radiation, Control of electrical hazards, Bio-hazardous and other toxic experimental materials.

Unit 3: Statutory provisions regarding fire safety. Factors contributing towards fire. Chemistry of fire, Classification of fires, Common causes of industrial fires, Determination of fire load, Fire resistanceof building materials, Prevention of fire, Portableextinguishers, Water systems, carbon-di-oxide systems, Foam extinguisher systems.

Unit 4:Chemical Hygiene and Safety, Chemical Safety for various Industries like Pharma, Food, Petrochemical, Pesticides, Fertilizers etc.

Suggestive Readings:

1. R.K.Jain and Sunil S.Rao , Industrial Safety, Health and Environment Management Systems, Khanna publishers , New Delhi.
2. Slote.L. Handbook of Occupational Safety and Health, John Willey and Sons, NewYork .
3. Frank P. Lees, Loss of prevention in Process Industries , Vol. 1 and 2, Butterworth- Heinemann Ltd., London (1991).
4. Industrial Safety -National Safety Council of India.
5. Handbook of Environmental Health and Safety: Herman Koren and Michel Bisesi, Jaico Publishing House, New Delhi.
6. Handbook of Environmental Risk Assessment and Management: Peter Calow, Blackwell Science Ltd. USA.
7. Risk Assessment and Environmental Management: D. Kofi Asvite-Dualy, John Willey & Sons, West Sussex, England.
8. Introduction to Environmental Engineering & Science: Gilbert M. M., Pearson Education, Singapore.
9. Fire Equipment David L. Bever
10. Industrial Safety National Safety Council of India
11. Fire Technology, R.S. Gupta

- **Course Coordinator (Name & Designation)**: Dr. G.K. Patra, Professor, Department of Chemistry, Guru Ghasidas Vishwavidyalaya Bilaspur; CG, India
- **Evaluation Criteria**:

Components	Class test	Hands on experiment	End semester	Total
Weightage (%)	15	15	70	100

- **Infra Structure requirement**: Basic Laboratory facilities available in the Department
- **Financial Requirement**: Rupees 1,00,000/- is initially needed to start the course
- **Proposed fee for the Course (if any)**: Rupees 5000/-
- **Budgetary provisions**: Rupees 1,00,000/- is initially needed to start the course

2. Certificate Course in Green Water Technology

Department: CHEMISTRY

Name of the Course: GREEN WATER TECHNOLOGY

Nature of Course: CERTIFICATE

Mode of Course: Online /Offline /Physical

Number of Seats: 20

Eligibility Criteria for Admission: B. Sc. (ongoing PG students)

Introduction and relevance of course: The green water technology course is designed for students who want a career in the power plants, automobile industries, municipal corporation, pharmaceutical industries, water treatment plants and package water industries. this unique course provides students with specific scientific knowledge and skills indifferent areas acquainting them with green water technology.

Objectives of the course: This course is intended to provide a comprehensive survey of water quality required by the different industries depending upon their usage. The course will emphasize greener trends in water treatment plants and industries. The chemistry and technology of polluted water treatment will be related to their utilization in the respective industries. In this way, it is intended to generate a better understanding of the contributions of green water technology principles. Emphasis will be placed on recognizing and dealing with problem areas associated with the use of different green technologies for water purification. Safety consideration and other concerned matters which can influence the treated water will be include in these discussions.

Learning outcome of the course

Course Outcomes: The students at the completion of the course will be able:

- To understand the quality of potable water.
- To learn and understand the types of water and its usage.
- To get the knowledge of water pollution and its effects on flora and fauna.
- To enable the students, develop skill and excellent knowledge of water testing.
- They can pursue jobs in municipal corporation.

Above all the students can communicate in their family and society about potable water qualities and how it can be checked in order to prevent an Epidemic. After completing the course, students may apply for chemist job in the different industries.

Number of lectures: 02 hrs. per week (2 Credit)

Number of practicals: 02 hrs. per week (1 Credit)

List of experiments: Recognizing soft and hard water, determining hardness of water, eliminating the hardness of water, determining the TDS of water, Osmosis, determination of D.O., B.O.D and C.O.D.

Syllabus:

UNIT - I: Distribution of water on Earth, types of water, water quality as given by W.H.O., Indian standard specifications laid down for potable water. Sampling and testing of various water bodies. Factors affecting quality and stability of particular water bodies. What is natural water.

UNIT - II: Determination of physical and chemical properties of water. What are D.O., B.O.D. and C.O.D. What are soft and hard water. Sources responsible for contaminating water. What are their effects on flora and fauna? Definition of pure water. What is potable water, why water is necessary for life, what is water pollution. How environment is affected by the polluted water.

UNIT III: Study of different water pollutants and their effects on flora and fauna. Water treatment methods. Brief introduction of the following water treatment technologies: Osmosis, Reverse Osmosis, Resins for Cationic and Anionic exchanges, Charcoal filtration, Sorbents of Phyto & Animal origin.

UNIT- IV: Some knowledge on composite materials. What is natural polymer based composite materials. Different methods of using such composite materials in addressing polluted water. How they are environment friendly.

14. Suggestive readings:

1. A Textbook of Engineering Chemistry, Dr S. S. Dara, S. Chand & Company.
2. Engineering Chemistry, Jain & Jain, Dhanpat Rai & Sons.
3. Environmental Pollution, Monitoring and Control, Khopkar. S. M., New Age International Publishers.
4. A Text Book of Engineering Chemistry, Shashi Chawla, Dhanpat Rai & Sons.
5. Engineering Chemistry by Dr Subita Rasttan, S. K. Kataria & Sons.
6. Engineering Chemistry by B. K. Sharma, Krishna Prakashan Medis (P) Ltd., Meerut.
7. Engineering Chemistry by Daniel Yesudian, Hi-Tech Publications
8. A Text Book on Engineering Chemistry by Balaram Pani, Galgotia Publications Pvt. Ltd.
9. Analytical Methods for Drinking Water: Advanced in Sampling and Analysis by K. Clive Thompson and Philippe Quevauviller. (2005) Wiley.
10. A Text Book n Water Chemistry: Sampling, Data Analysis and Interpretation by A.G.S. Reddy (2020) Nova.

15. Course coordinator (Name & Designation): Dr. Sunil Kumar Singh, Associate Prof
Dr. Uday Pratap Aza**d,** Assistant Prof.

16. Evaluation criteria:

Components	Class Test	Hands on Experiment	End Semester	Total
Weightage (%)	15	15	70	100

17.Infrastructure requirements: Basic laboratory with small equipment like magnetic stirrer, conductivity meter, pH meter and characterization and testing equipment.

18. Financial requirement: Approximate Rs 50,000 is required for the Water Kit in order to perform the tests of the eater on site.

19.Proposed fee for the course: 5000 (As per the GGV norms)

20. Budgetary provisions: Rs 50,000

3. Certificate Course in Agrochemical Formulation

1. **Department:** **CHEMISTRY**
2. **Name of the Course:** **AGROCHEMICALS FORMULATION**
3. **Nature of Course:** **CERTIFICATE**
4. **Mode of Course :** **Online/Offline/Physical**
5. **Number of Seats:** **20**
6. **Eligibility Criteria for Admission:** **B Sc (ongoing PG students)**
7. **Introduction and relevance of Course:** The Agro-chemicals formulation course is designed for students who want a career in the agrochemical and fertilizer industries. Agrochemicals are essential to the agricultural sector as they ensure farmers achieve healthy crop yields. This unique course provides students with skills indifferent areas of agrochemicals, and fertilizer industries.
8. The Pesticides Manufactures and Formulators Association of India (PMFAI) recognize the course as one of 'immediate relevance to the industry due to its scientific and technological curriculum.
9. **Objectives of the course:** This course provides basic knowledge of Pesticides and Formulation Technology. The course emphasizes current trends in formulations of pesticides including development and challenges for nanoscale formulation of botanical pesticides. Students will get an idea of residue analysis, optimum dose and eco-friendly formulations. Safety considerations and other pertinent matters which can influence ingredients election will be included in these discussions.
10. **Learning outcome of the course**

- After completing the course, students can set up on start-up for the making of agrochemicals, pesticides, insecticides, fertilizers.
- Students can give consultation to farmers regarding application of pesticides, insecticides and fertilizers.
- They can get jobs in agrochemical industries (manufacturing, consultation and R and D units).
- Students can give consultation to farmers regarding soil health.

11. **Number of lectures:** 02hr per week (2 Credit)
12. **Number of practicals:** 02 hrs per week (1 Credit)
13. **List of experiments:** Formulation of herbal pesticides, testing effectiveness of pesticides, residue analysis of agrochemicals using chromatographic techniques GC and HPLC.
14. **Syllabus:**

UNIT - I: Pesticides and Formulation Technology: Pesticide Products and the Modern Marketplace, An Overview of the Formulation Process, Common Pesticide Formulations, Formulations and Label Information, Classification, Synergists, Adjuvants, Liquid formulations, dry or solid formulations, Testing of pesticide formulations

UNIT - II:

Nanotechnology in agrochemical formulation**:** Development of stimuli-responsive nano-based pesticides, Development and Challenges for Nanoscale Formulation of Botanical Pesticides.

UNIT III: Application of GC & HPLC for pesticide detection: Basic principle of Chromatographic techniques, Instrumentation and method development, GC versus HPLC.

UNIT- IV: PesticideResidue Analysis: Introduction, Sample Collection, Reporting results: Detection and quantitation limits of the analytical method, Extraction and clean-up methods in pesticide residue analysis.

15. SuggestiveReadings:

1. Ware, G.W. *The Pesticide Book*, 4th ed; W.H. Freeman: Fresno, CA, 1994.
2. University of Nebraska Cooperative Extension Service. *A guide for private and commercial applicators: Applying pesticides correctly*. National pesticide applicator training core manual, University of Nebraska: Lincoln, 1992.
3. *Oregon Pesticide Applicator's Manual: a guide to the safe use and handling of pesticides*; Miller, T.L, ed. Oregon State University Extension Service: Corvallis, 1993.
4. *Label Review Manual*; U.S. Environmental Protection Agency, Office of Pesticide Programs, U.S. Government Printing Office: Washington, DC, 1998. https://www.epa.gov/pesticide-registration/label-review-manual
5. *Terms of the Environment*; U.S. Environmental Protection Agency, Office of Pesticide Programs, U.S. Government Printing Office: Washington, DC, 1997. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=4000081B.TXT
6. Bohmont, B.L. *The standard pesticide user's guide (revised)*. Prentice Hall: Princeton, NJ, 1990.
7. *Farm Chemicals Handbook 1997*; Meister Publishing Company, Willoughby, OH, 1997.
8. Official Methods of Analysis. AOAC. 17th Edition, pp. 1-10.
9. Indian Standard 14628:1999
10. G.H.Jeffery,J.Basset,J.Mendham,R.C.Denny(Rev.by)VogelsTextBookofQuantitativeChemical Analysis, 5thEdition 1989, ELBS.
11. PracticalHPLCmethoddevelopmentbyLloydR.Snyder,JosephJ.Kirkland,Joseph I. Glajch,JohnWileyandSons2ndEdition –1997
12. Chang.W.N"Nanofibresfabrication,performanceandapplications",NovaSciencePublishersInc, 2009.
13. Carbon Nanotubes: Synthesis, Structure, Properties, and Applications, Edited by M. S. Dresselhaus, G.Dresselhaus, P.Avouris,Springer-Verlag,2000.
14. Textbook of Nanoscience and Nanotechnology, B.S.Muty, P. Shankar, Baldev Raj, B.B Rathand James Murday,University Press,IIM(ISBN-9788173717383).
15. IntroductiontoNanotechnologybyCharlesP.PooleJrand.FrankJ.Owens,Wiley-Interscience,2003.
16. NanoscaleMaterialsinChemistryEditedbyKennethJ.Klabunde,JohnWiley&Sons,Inc.,ISBNs: 0-471-38395-3(Hardback);0-471-22062-0.

17. **Course Coordinator (Name & Designation):** Dr Charu Arora, Associate Prof.

18. EvaluationCriteria:

Components	ClassTest	Hands on Experiment	EndSemester	Total
Weightage (%)	**15**	**15**	**70**	**100**

19. **Infrastructure requirements:** Basic laboratory with equipments like magnetic stirrer, centrifugation and BOD incubator, Laminar flow, autoclave and
20. **Financial Requirement:** Approximate Rs 50,000 is required for the laboratory chemicals and minor instruments

21. **Proposed fee for the Course:**5000 (As per the GGV norms)
22. **Budgetary provisions: Rs 50,000**

4. Certificate Course in Cement Chemistry

- **Department** Chemistry
- **Name of the Course:** **Value Added Certificate Course** in Cement Chemistry
- **Nature of Course: Certificate: or Value Added Course** Certificate
- **Mode of Course:: Online / Offline / Physical** Hybrid Mode (Online + Offline)
- **Number of Seats:** 20
- **Eligibility Criteria for Admission:** B Sc, Ongoing M Sc student of any discipline
- **Introduction and relevance of Course**:

  In the present scenario cementing materials are very much required for the socio-economic development of the society and nation as well solves the sustainable development goals (SDGs). This course will enable the chemistry, skill and hands-on process involved and manufacture of cement to meet out the constructional material demand of the country. This will assist the students to be placed in industry ready to contribute effectively in the field of cement industry located in Chhattisgarh and India. In Chhattisgarh there are large scale cement Industry where they recruit the chemist having the knowledge and experience on chemistry and cement chemistry, therefore, this course will provide job opportunities too.
- **Objectives of the course**: The course will have the following objectives
  - To know about the various types of cement.
  - To study the raw materials of cement.
  - To know the chemical compositions of cement.
  - To study cement manufacturing and cement Industry in India.
  - To learn about properties and ISI specifications of Portland cement.
- **Learning outcome of the course**:
  - Understand the various types of cement.
  - Understand the chemistry that underpins coal and cement science and technology.
  - Students will understand the manufacturing processes used to produce cement and will know how differences in chemical composition affect properties of cement and their usage in different applications.
  - Understand the cement product specifications, various test methods used to qualify different standarization.
  - They will get experimental experience on cement
  - Students can get job opportunities in cement industries located in Chhattisgarh like Ambuja Cement, Ultratech, Nuvoco Lafarge, Century, Shree Cement etc.
- **Number of lectures**: 2 hour per week (02 Credit)
- **Number of practical's (if any)**: 2 hour per week (01 Credit)
- **List of experiments (If any)-**
  - Physical analysis of cement i.e. hardness, compressive strength etc.
  - Estimation of iron content in cement by spectrophotometer

- Chemical analysis of cement
- Determination of heat of hydration of cement
- Hydrophobicity of cement
- Determination of hardness of water
- Determination of water of absorption of cement
- Technical analysis of cement by flame photometer
- Industrial laboratories or mining visit may be done.

Syllabus:

CEMENT CHEMISTRY

Credits: 02 **30 Lectures**

UNIT-1

Origin, history and development of cement industries, lime and other building materials, different classes of building limeand their properties, Classification of cement. Raw materials, their selection and proportioning, calcareous andargillaceous materials,the present status and future of cementindustry in India.

UNIT- 2

Types of cements and their use: quick setting cement, rapid hardening cement, low heat cement, blast furnace slagcement, pozzolona and pozzolonic cement, high alumina cement, sorrel cement, hydrophobic cement, water proofcement, expanding and stressing cement, sulphate resisting cement, super-sulphate cement, trief cement.

UNIT-3

Calcareous Raw Materials: Source of Lime, Limestone, Chalk, Marl, Industrial waste, geological distribution of limestone deposits in India, Assessment of limestone deposits for Cement manufacture.
Argillaceous Raw Materials: Source of Silica, Alumina, Iron Oxide, Shale and effect of coal ash and additives use as corrective materials, Fly ash , Slag, lime sludge as cement raw materials.

UNIT-4

Cement quality requirements, corrective materials and additives, industrial waste and by-products,, Hydration of Portland cement – hydration and hydrolysis mechanisms and relatedtheories for C_3S phase and mechanisms of C_2S and C_3A, Setting and hardening of Portland cement, set regulations for gypsum.

Unit -5

Manufacture of Portland cement, physical and mechanical properties of Portland cement. ISI specifications of Portland cement. Decay of cement, Lime, plaster of Paris.

Suggestive Readings:

- A Text book of Engineering Chemistry 12 edition by S. S. Dara, S SUmare S. (1986) Chand New DelhiISBN : 9788121903592
- Engineering Chemistry 16th edition (2015) by Jain and Jain Dhanpat Rai Publishing House, ISBN : 9352160002
- Chemistry in Engineering and Technology Vol 1 by J. C. Kuriacose and J. Rajaram (1996), Tata McGraw-Hill Co. New-Delhi.ISBN:9780074517352.
- Text Book of Geology (2013) by P K Mukherjree Pub: World Press Private Ltd.ISBN:18187567546
- Advances in Cement Technology- Chemistry, Manufacture and Testing 2nd edition (2003)by S.N. Ghosh,.CRCPressISBN: 8188305049
- Cement Chemistry 2nd edition by HFW Taylor (1997), Thomas Telford Pub London
- Lea's Chemistry of Cement and Concrete, 4th edition (2003) by Peter Hewlett, Elsevier, Amsterdam, ISBN:9780080535418
- Text book of Cement and Concretes 3rd edition (1971) by F.M.Lee Chemical Publishing Co Inc.,U.SISBN:0820602124
- Concrete Engineering Handbook: McGraw Hill Handbooks (2013) by William S La Londe Jr Pub. Literary Licensing, LLC ISBN: 1258715279
- Cement Data Book, Volume One: International Process Engineering in the Cement Industry3rd edition by Walter H. Duda (1985) by Pub: French & European ISBN 0828802041
- Norms for limestone exploration for cement manufacture : National Council for Cement and Building MaterialsNCCBM (https://www.ncbindia.com)
- National Inventory of cement grade limestone deposits in India : National Council for Cement and Building Materials (NCCBM-https://www.ncbindia.com/geology-mining-and-raw-materials.php)

- **Course Coordinator** (Name & Designation): Dr S S Thakur Asst Prof
- **Co-Coodinator**: Prof G, K Patra, Professor

5. Certificate Course in Smart Materials and technology

- **Department**: Chemistry
- **Name of the Course**: Certificate Course in **Chemistry of Smart Materials and Technology**
- **Nature of Course**: Certificate or Value Added Course: Certificate
- **Mode of Course**: Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
- **Number of Seats**: 20
- **Eligibility Criteria for Admission**: B Sc in any discipline with Chemistry as a paper
- **Introduction and relevance of Course**: Nanostructured materials consist of nanoparticles (NPs), nanorods, nanowires, thin films, or bulk materials made of nanoscale building blocks or composed of nanoscale structures with at least one dimension falling on a

nanometer scale. The use of nanomaterials in chemical sensors and biosensors has brought progress in this field over the past decade, leading to substantial improvements in performance. Nanostructures have exceptional physicochemical properties that are absent from their bulk counterparts. For this reason, nanomaterials have been actively explored and applied as the foundation of advantageous sensing applications over the last few decades An example structure of a chemical sensor containing biopolymer nanostructures. Polymer is a natural or artificial chemical compound consisting of large molecules which is made up of smaller, joined-together molecules called monomers. Due to their broad spectrum of properties, both synthetic and natural polymers play essential and versatile roles in everyday life.Polymers range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function. Chemical sensors currently represent a valuable new technology that provides advantageous options in a wide range of applications in terms of simplicity, time, and cost-effectiveness. The goal of sensing technology is to revolutionize the way in which we measure key parameters related to diagnostics, monitoring of the environment, safety, and protection. Chemical sensors can be divided into several types, such as optical, electrochemical, mass, magnetic, and thermal. This course will provide the opportunity to the learner to get job in various industries. Learner can start own small level work based on different materials Processing that are one of the part of Syllabus.

- **Objectives of the course**: To study the methods for preparation of variety of nanomaterials and its application in sensing by introducing the host guest type material
  To study the utilization of polymeric materials with nanoparticles in the preparation of different industrial articles along with other important compounds.
- **Learning outcome of the course**: This course will educate the students on the subject of polymers, nanomaterials and supramolecules that constitute one of the most important materials used presently. The course will include fundamentals of synthesis, characterization, properties and include discussion on the applications of polymers nanomaterials and supramolecules, as well as challenges pertaining to contemporary research based on nanomaterials.
- Number of lectures (I hour =1 credit per week): 1 (01 hour)
- Number of practicals (if any) (2 hours = 1 Credit per week) 1(2 Hour)
- List of experiments (If any)- attached with annexure I
- Syllabus:

Syllabus on Chemistry of Smart Materials and technology
(Certificate Course)

Credits: 02 **30 Lectures**

Syllabus

Unit 1: Chemistry of Nanostructured Materials: Intermolecular forces during the formation of nanostructured materials, Synthesis, sol – gel chemistry, micro, meso and macroporous materials, mesoporous and mesostructured materials.

Unit 2:Application of Nanomaterial: Ferroelectric materials, coating, molecular electronics and nanoelectronics, biological and environmental, membrane based application, polymer based application

Unit 3: Chemistry of polymeric materials: Introduction about Advance polymeric materials and its industrial application. Preparation, properties and applications of polycarbonates,Gels, epoxy resins – polyamides – Nylon and Kevlar.

Unit 4: Chemistry of Sensor: Forces of interactions (Covalent and non-covalent), Fundamental sensing processes (electrical, chemical, molecular sensors). Transduction processes (PET, ICT, FRET, ESIPT, electrochemical redox process etc.).

Unit 5: Host Guest Chemistry: Introduction to chemosensor, Design of chemosensor for cations, anions, neutral molecules, different sensing techniques: Fluorescence sensors, colorimetric sensors, electrochemical sensors, Array-based sensors, molecular switches, Gas sensor, Nanomaterial based biosensors and its importance Applications.

- Suggestive Readings:

1. Van Vlack, Lawrence H, "Elements of Material Science and Engineering", 6th edition, New York Addison, Wesley, (1989).
2. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
3. Introduction to Nanotechnology- Charles P Poole & Frank J. Ownes.
4. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
5. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press.
6. Processing & properties of structural naonmaterials - Leon L. Shaw. Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.
7. Nanoscale Materials - Luis M. Liz-Marzán and Prashant V. Kamat
8. Carbon Nanomaterials for Environmental and Biological Applications, Bergmann and Machado, Springer.
9. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge, UK (2005).
10. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey-Interscience, New York.
11. G. Odian, P. W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, New York.
12. G. Odian, Principles of Polymerization, 3rd edition (1991) John Wiley, Singapore
13. P.Bahadur and N.V. Sastry, Principle of Polymer Sciences , Narosa Publishing House, New Delhi (2002)
14. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester, 2002.
15. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
16. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
17. Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.
18. Supramolecular Chemistry from Molecules to Nanomaterials, Gale and Steed, 2012.
19. Modern Supramolecular Chemistry, Diederich, Stang, Tykwinski, 2008.
20. J. W. Steed, D. R. Turner, K. J. Wallace, Core Concepts in Supramolecular Chemistry and Nanochemistry, John Wiley & Sons, 2007

21. Steed, J. W., and Atwood, J. L., Supramolecular Chemistry, Wiley, Chichester, 2009

- **Course Coordinator**: 1. Dr Arti Srivastava, Assistant Professor
  2. Dr Niraj Kumari, Assistant Professor

Evaluation Criteria (to be decided by HOD and Course Teacher) by Written examination of theory and practical.

- Infra-Structure requirements (if any): Available in the department, 01 instrument required
- Financial Requirement (if any):
- Proposed fee for the Course (if any): 5000/-
- Budgetary provisions – See annexure II
-

(Existing staff will handle all the classes, No separate/additional Faculty will be provided for the conduct of the course, however guest faculty may be called on demand basis, payment of which may be made as per budgetary provisions of the course)

Suggested list of Experiments (based on availability of the resources)

1. Synthesis and characterization of nanomaterials.
2. Radical polymerization vinyl monomers.
3. Determination of molecular weight of polymer by viscometric method.
4. Determination of molecular weight of polymer by GPC method
5. Synthesis of Nylon.
6. Synthesis of Hydrogel and its application.
7. Application of nanomaterials in Sensors
8. Application of polymer Nano composite in sensor.
9. Synthesis of nanomaterial complexes and study of the host guest relation.

A Visit to suitable Industry

Amount of Minimum Proposed Budget: Rs 50,000/-
Amount required for Chemical: Rs 40,0000/-
Miscellaneous budget: Rs 10,000/-

6. Certificate Course in Food Adulteration and Testing

1. Department: CHEMISTRY

2. Name of the Course: **FOOD ADULTERATION AND TESTING**

3. Nature of Course: CERTIFICATE

4. Mode of Course: Online /Offline/Physical

5. Number of Seats: 20

6. Eligibility Criteria for Admission: B. Sc. (ongoing PG students)

7. **Introduction and relevance of Course:** The certificate course in *food adulteration and testing* is designed for undergraduate students seeking career in food industry. The course focuses on processes that are followed to preserve a food product, especially to provide the knowledge for developing their practical approach about the selection and application of additives to preserve the processed food. The proposed course is the most recognized and important part of curriculum of food technology/science designed for professional studies towards strengthen the manpower in terms of basic knowledge of theory and experiments to be used in various food industries.

8. Objectives of the course: The course is proposed to fulfill the need and scope of undergraduate students to educate them about food chemistry perspectives, especially; processes that are followed to preserve a food product, and to test the adulteration and food quality. The course would provide the basic as well as necessary components of knowledge to the students to establish them in food industry and to develop their practical approach about the selection and application of additives to preserve the processed food and testing in adulteration. Furthermore, this course is aimed to provide the undergraduate students a conceptual understanding of food safety and analysis along with their limitations. Testing of foods is incessantly demanding the development of more robust, efficient, sensitive, and cost-effective analytical methodologies to guarantee the safety, quality, and traceability of foods in compliance with legislation and consumer demands. *This is usually used as a specialization by those who want to further continue their studies in the food science industry. But one can be placed in beginner level jobs under food analyst and as marketing assistants.*

9. Learning outcome of the course:

Course Outcomes: The student at the completion of the course will be able:

- To understand the history, relevance of food basics.
- To learn and understand the types of food and its functions.

- To get the knowledge of food adulteration.
- To gain knowledge by food preservation.
- To enable the students to get the excellent knowledge of adulteration testing in food
- To enable the students to get sufficient knowledge about food industry.

10. Number of Lectures: 2 h per week (2 Credit)

11. Number of Practicals: 2 h per week (1 Credit)

12. List of experiments: (1) Testing of Adulteration in Milk products (2) Testing of Food Colorants in food items (3) Testing of Adulteration in Food Materials (4) Testing of Adulteration in Spices.

13. Syllabus:

Unit I.**Introduction to Food Chemistry:**

Food Chemistry, Food and its Components: Food Proteins, Enzymes, Carbohydrates *etc*. Food additives: Food preservative, Food Color *etc*. Food Standards and Permissible Limits.

Unit II.**Food Pigments and Colors:**

Food Oxidants, Food Pigments: Alizarin, Azo- pigments (the yellow, orange and red colour range), Phthalocyanine (blue and green colour range), Quinacridone (a lightfast red-violet pigment), Inorganic pigments of mineral origins. Natural and Synthetic food colors (Allura Red, Tartrazine, Carmine, Amaranth *etc.*). Flavoring agents, Sweeteners, Emulsifiers and Stabilizers, Spices and Herbs.

Unit III.**Adulteration of Food:**

Food Adulteration, Types of Adulteration: Intentional adulteration, Incidental adulteration. Poisonous or deleterious substances, Economic adulteration, Microbial contamination.Adulteration through hazardous chemicals, Filth and Foreign Matter.

Unit IV.Evaluation of Food Quality:

Evaluation of food quality, sensory tests, types of tests, objective evaluation and instruments used for texture evaluation.

14. Suggestive Readings:

1. Desrosier NW and Desrosier JN, The Technology of Food Preservation, CBS Publication, New Delhi, 1998
2. Paine FA and Paine HY, Handbook of Food Packaging, Thomson Press India Pvt Ltd, New Delhi-1992
3. Potter NH, Food Science, CBS Publication, New Delhi, 1998
4. Ramaswamy H and Marcott M, Food Processing Principles and Applications CRC Press, 2006
5. Rao PG, Fundamentals of Food Engineering, PHI Learning Pvt Ltd, New Delhi, 2010

6. Toledo Romeo T, Fundamentals of Food Process Engineering, Aspen Publishers, 1999.
7. Bamji MS, Krishnaswamy K, Brahmam GNV (2009). Textbook of Human Nutrition, 3rd edition.Oxford and IBH Publishing Co. Pvt. Ltd.
8. Srilakshmi (2007). Food Science, 4th Edition. New Age International Ltd.
9. Girdharilal, Siddappaa, G.S and Tandon, G.L.1998. Preservation of fruits & Vegetables, ICAR, New Delhi.

15. Course Coordinator (Name & Designation):

1. Dr Vijai K. Rai, Assistant Professor
2. Dr Manorama, Assistant Professor

16. Evaluation Criteria (to be decided by HOD and Course Teacher):

Components	Class-Test	Experiment	End Semester	Total Marks
Weightage (%)	**20**	**20**	**60**	**100**

17. Infrastructure requirements (if any): Basic laboratory system with pH meter, magnetic stirrer, characterization and small testing equipments.

18. Financial Requirement (if any): Approx. Rs 50,000

19. Proposed fee for the Course (if any): Rs.5000.00 (As per the University's norms).

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Course Work for Ph.D. (Chemistry)

(Effective from May 2019)

Department of Chemistry
School of Physical Sciences
Guru Ghasidas Vishwavidyalya
Bilaspur-495 009

Course Work for Ph.D. (Chemistry)
(To be implemented from the Session 2018-19)

Proposed in the
Board of Studies Meeting in Chemistry
Held On
25.04.2019

A. School-Specific Common Courses:

S. No	Title of the paper	Paper Type	Credits
SPC-R1	Research Methodology& Computer Applications	Common course Compulsory	4

B. Discipline-Specific courses: Total **10 credits:** All these courses are compulsory to each student.

S. No	Title of the paper	Paper Type	Credits
CH-R1	Modern Techniques in Chemical Sciences	Compulsory for Chemistry	4
CH-R2	Emerging Area in Chemical Sciences	Compulsory for Chemistry	4

C. Research theme-specific courses:

6 **credits**

S. No	Title of the paper	Paper Type	Credits
CH-R3	Seminar on research topic with written report by student Mode of study includes: Assigning the topic to students based on their basic background and presentation in the form of seminar which will be followed by discussion and submission of the write-up. This will be evaluated by group of teachers.	Successful	No Credit

Paper I **Credit 4**

Research Methodology & Computer Applications

Unit 1: Research methodology

Definition of Research, Components of Research Problem, Various Steps in Scientific Research : Hypotheses, Research Purposes, Research Design, Literature searching, Literature Survey, defining the question and formulating hypothesis/ hypothesizes, Collection of research data, tabulating and cataloging. Sampling and methods of data analysis.

Unit 2: Errors in measurements and statistical methods:

Types of errors; mean deviation, standard deviation and probable errors; propagation of errors with summation, difference, product and quotient,Probability Theories – Conditional Probability, Poisson Distribution, Binomial Distribution and Properties of Normal Distributions, Estimates of Means and Proportions; Chi-Square Test, Association of Attributes – t-Test – Standard deviation – Co-efficient of variations. Correlation and Regression Analysis, plotting of graphs.

Unit 3: Laboratory practices and safety guidelines:

Safe working procedure and protective environment, Laboratory safety measures, Handling radiation, Chemical hazards and their types, Safe chemical use, Proper storage and disposal of hazardous materials, Bio-hazardous and other toxic experimental materials, Maintenance of equipments.

Unit 4: Computer applications in scientific writing skills

Applications of Microsoft Excel, power point and origin for data processing and data analysis, research paper –presentation using power point (which include texts, graphs, pictures, tables, references etc.)(oral in power point/poster);

Curve fitting, Method of least square fit, least square fit (straight line) to linear equations and equation reducible to linear equations. Non-linear curve fitting, back ground correction and mathematical manipulation in data using **origin**.

Structure and Components of Research Report, Types of Report: research papers, thesis, Research Project Reports, Pictures and Graphs, citation styles, writing manuscript in Latex, Steps to better writing.

Unit 5: Ethics in Science:

The source of ethical issues in science: examples from different disciplines. Ethical issues in science research and reporting: objectivity and integrity, the problem of plagiarism and related issues, international norms and standards, Scientific temper and virtues, expectations from scientific community.

IPR and Patent regime: Recording and storage/retention of recorded materials.Management and use responsibilities in proper utilization of the facilities. Socio-legal issues, originality

References:

1. “How to write and Publish” by Robert A. Day and Barbara Gastel, (Cambridge University Press).
2. “Survival skills for Scientists” by Federico Rosei and Tudor Johnson, (Imperial College Press).
3. “How to Research” by Loraine Blaxter, Christina Hughes and Malcum Tight, (Viva Books).
4. “Probability and Statistics for Engineers and Scientists” by Sheldon Ross, (Elsevier Academic Press).
5. “The Craft of Scientific Writing” by Michael Alley, (Springer).
6. “A Students’s Guide to Methodology” by Peter Clough and Cathy Nutbrown, (Sage Publications).

Paper II **Credit 6**

CH-R1 Modern Techniques in Chemical Sciences

1. Basic theory, instrumentation and analytical applications: Spectroscopic techniques [NMR, ESR, MS (EI, FAB, MALDI-TOF), IR, UV-Vis, Fluorescence and Phosphorescence, Atomic Absorption, Biosensors.

2. Techniques for Materials Characterization

Basic theory and analytical applications of the following physical methods: X-ray diffraction methods (single crystal and powder method), Thermoanalytical methods (TGA, DSC, DTA), Microscopic methods (SEM, TEM, AFM), Surface Properties (XPS, BET), Cyclic Voltammetry, SQUID.

3. Separation Techniques:

Introduction, classification of chromatographic methods, terms and relationships in chromatography, sample characterization High performance liquid chromatography (HPLC), Gas chromatography (GC) and ion exchange chromatography, GPC.

Principle, Instrumentation and Application of :
Reverse Osmosis (RO), Nanofiltration (NF), Ultra Filtration (UF) and Micro Filtration (MF), gel electrophoresis, chiral separations.

4. Computational Chemistry: Theoretical Chemistry a quantum approach, MO theory, Ab initio calculation, Geometry optimization, basis set, electronic structure calculations.,

Books Recommended

1. F.W Fifield & D.Keal, Principles and Practice of Analytical chemistry Blackwell Publishing Company, (2004)
2. Pradyot Patnaik, (2004), Dean's Analytical chemistry, Hand Book Second edition McGraw- Hill Hand Books
3. J. D Seader /Ernest J. Henley, Separation Processes Principles; John Wiley & Sons Inc. N.Y. (1998)
4. Skoog, Holler, Nieman, H.B Principles of Instrumental Analysis Fifth edition College publishers.
5. G.H. and H. Freiser, Solvent Extraction in Analytical Chemistry, 1st edition (1958), John Wiley, New York.
6. B. L. Karger, L.R. Snyder and C. Howarth, An Introduction to Separation Science, 2nd Edition (1973) John Wiley, New York.
7. E.W. Berg, Chemical Methods of Separation, 1st edition (1963), McGrw Hill New York.
8. D.G. Peters, J.M.Hayes and C.M. Hieftj, Chemical Separation and Measurements, 2nd edition 1974, Saunders Holt, London.
9. R.M. Silverstein and F.X. Webster, Spectroscopic Identification of Organic Compounds, 6th Edition (2003) John Wiley, New York.F
10. J.R.Dyer, Application of Absorption Spectroscopy of Organic

Compounds, Prentice Hall, New Delhi (1978).
11. J.M. Hollas, Modern Spectroscopy, 4th edition (2004), John Wiley and Sons, Chichester.
12. C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.
13. R. S. Drago, *Physical Methods in Chemistry*, International Edition (1992), Affiliated East-West Press, New Delhi.
14. D.A. Skoog, F.J. Holler and T.A. Nieman, *Principles of Instrumental Analysis*, 5th Edition (1998), Harcourt Brace & Company, Florida.
15. H.A. Strobel, *Chemical Instrumentation – A Systematic Approach*, 2nd Edition (1973), Addison Wesley, Mass.
16. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern *Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York.

Paper III **Credit 6**

CH-R2: Thrust Area in Chemical Sciences

1. **Emerging Green Chemistry**: Green chemistry, introduction, 12 principles, Solvent-free synthesis; Environmentally benign solvents: Water and Ionic liquids as green solvents and catalysts in organic synthesis. Microwave in chemical synthesis: Basic principles, advantages and examples. Sonochemistry and green aspects;

2. **Nano-Chemistry**: Introduction, Nucleation and growth, heterogeneous nucleation, Size effect, Synthesis and assembly, techniques, General methods of preparation and synthesis. Types of nano materials, their Properties and applications. Carbon nanotube, micro- and mesoporous materials.

3. **Formation of Carbon-Carbon bonds *via* organometallic reagents:** (i) Palladium-Catalyzed Coupling Reactions, (ii) Organoboron Reagents, (iii) Organozinc Reagents, (iv) Organocopper Reagents.

4. **Multicomponent reactions (MCRs):** Definition, Advantages and examples particularly, Ugi reaction, Biginelli reactions, Strecker amio acid synthesis, Passerini synthesis, Mannich reaction,

5. **The chemistry of molecular recognition:** Host and Guest Chemistry. Supramolecular interactions and their characterization, Supramolecular catalysis and transport processes, Cyclodextrin- a naturally occurring cyclic host, calixarene- a versatile host; Chemosensor, Electrochemical sensors, Origin and source of chirality, chiral ligands, chiral drugs, asymmetric epoxidation

6. **Polymers**: Mechanism and kinetics of radical, condensation and living radical polymerizations. Spectroscopic characterization and testing of polymers. Measurement of molecular weights: viscosity, light scattering, osmotic and size exclusion chromatographic method. Properties and applications of commercial polymers: polyamides, polyesters, phenolic resins, epoxy resins and silicones. Fire retarding polymers, conducting polymers, and biocompatible polymers.

Books Recommended

1. Mike Lancaster, Green Chemistry: An Introductory Text, Royal Society of Chemistry, 2002.
2. Nina Hall(Editor-in-chief), The new Chemistry, Cambridge university Press, 2000.
3. CNR Rao, Muller and Cheetham, The Chemistry of Nano Materials, Vol.I & II, Wiley-VCH (2005)
4. Geoffrey A. Ozin, and Andre Arsentte, Nano Chemistry, RSC Publishing, 2005
5. S.C. Tjong, Nano Crystalline Materials Elsevier, 2006
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CH-R3 : Seminar on research topic with written report by student

No Credit

Mode of study includes: Assigning the topic to students based on their basic background and presentation in the form of seminar which will be followed by discussion and submission of the write-up. This will be evaluated by group of teachers.

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Other Activities

Visit of Honorable Vice Chancellor Sir

Cyber Jagrookta Diwas

Teachers' day

Library Day

Tree Plantation by NSS

Scientific Lectures

Important Telephone Numbers

1	Vice-Chancellor	260283, Fax: 260148, 260351(Res.)
2	Registrar (Acting)	260209, Fax: 260154
3	Controller of Examination	260003,
4	Finance Officer (Acting)	07752-260487
5	Dean Student Welfare	260204, 9981401993
6	Proctor	260206, 7587472651
7	Dean, School of Studies of Physical Science	260149, 9424154024
8	Assistant Registrar, Academic	260342, 9425533328
9	Assistant/ Deputy Registrar (Administration)	07752-260017, 9406302426
10	Assistant/Deputy Registrar (Development)	07752-260401
11	Assistant Registrar (Finance)	07752-260036
12	Central Library	260041
13	Computer Centre	260356
14	University Guest House	260024
15	University Health Centre	202317
16	Punjab National Bank, Extension Counter	260034
17	Police Station, Koni	260039