List of Courses Focus on Employability/ Entrepreneurship/ Skill Development

Department : *Chemistry*

Programme Name : *M. Sc.*

Academic Year : 2021-22

List of Courses Focus on Employability/ Entrepreneurship/Skill Development

Sr. No.	Course Code	Name of the Course
01.	CYPATT1	Analytical Chemistry I
02.	CYPATO1	Polymer Chemistry
03.	CYPALT2	Inorganic Chemistry Practical I
04.	CYPALT3	Organic Chemistry Practical I
05.	CYPALT4	Physical Chemistry Practical I
06.	CYPALT1	Analytical Chemistry Practical I
07.	CYPALO1	Polymer Chemistry Practical I
08.	CYPATC1	Value added courses
09.	CYPBTT1	Analytical Chemistry II
10.	CYPBLT2	Inorganic Chemistry Practical II
11.	CYPBLT3	Organic Chemistry Practical II
12.	CYPBLT4	Physical Chemistry Practical II
13.	CYPBLT1	Analytical Chemistry Practical II
14.	CYPBTD1	Instrumental Analytical Techniques
15.	CYPBTD3	Chemistry of Heterocycles
16.	CYPATC1	Value-Added Course
17.	CMT-301	Molecular Spectroscopy (Core Paper)
18.	CMT-302	Bio-Molecules and Bio-Catalysts (Core Paper)
19.	CMT-401	Computer Applications in Chemistry (Core Paper)
20.	CMP-409	Project
21.	CMT-305	Forensic Analysis
22.	CMT-405	Environmental Chemistry
23.	CMT-307	Medicinal Chemistry (Core Paper)
24.	CMT-408	Materials Chemistry
25.	CMT -304A	Microanalytical Techniques
26.	CMT -304(O)	Chemistry of Natural Products

27.	CMP -309 (A)	Analytical Chemistry Practical
28.	CMP -309 (I)	Inorganic Chemistry Practical
29.	CMP -309 (O)	Organic Chemistry Practical
30.	CMP -309 (P):	Physical Chemistry Practical
31.	CMT -402 (A)	Separation Techniques
32.	CMT -402 (O)	Application of Spectroscopy to Structural Analysis
33.	CMT -403 (O)	Reagents and Organic Synthesis
34.	CMP-409	Project

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Scheme and Syllabus

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

	Semester-III	
CMT-301	Molecular Spectroscopy (Core Paper)	3
CMT-302	Bio-Molecules and Bio-Catalysts (Core Paper)	3
CMT-303	Specialization Paper-I (A/I/O/P)*	3
CMT-304	Specialization Paper-II (A/I/O/P)*	3
CMT-305-308	Elective Paper I (Any one out of the four papers)+	3
CMP-309	Practical (A/I/O/P)*	6
	Total :	**21**
	Semester-IV	
CMT-401	Computer Applications in Chemistry (Core Paper)	3
CMT-402	Specialization Paper-I (A/I/O/P)*	3
CMT-403	Specialization Paper-II (A/I/O/P)*	3
CMT-404	Specialization Paper-III (A/I/O/P)*	3
CMT-405-408	Elective Paper II	3
CMP-409	Project	6

I- Inorganic Chemistry O-Organic Chemistry P-Physical Chemistry +4

Elective Papers

+Elective – I		++Elective - II	
CMT-305	Forensic Analysis	CMT-405	Environmental Chemistry
CMT-306	Chemical Applications of Group Theory	CMT-406	Photo Inorganic Chemistry
CMT-307	Medicinal Chemistry (Core Paper)	CMT-407	Bioorganic Chemistry
CMT-308	Physical Methods in Chemistry	CMT-408	Materials Chemistry

* Details of specialization courses are given on the next page

* Details of Specialization Papers

Semester – III

Specialization Papers - I & II

		Credit
Analytical Chemistry		
CMT-303 (A):	Principles of Analytical Chemistry	3
CMT -304 (A):	Microanalytical Techniques	3
Inorganic Chemistry		
CMT -303 (I):	Organometallic Chemistry of Transition Metals	3
CMT -304 (I):	Bio-inorganic Chemistry	3
Organic Chemistry		
CMT -303 (O):	Stereochemistry, Reactions and Rearrangements	3
CMT -304 (O):	Chemistry of Natural Products	3
Physical Chemistry		
CMT -303 (P):	Electrochemistry	3
CMT -304 (P):	Quantum Chemistry	3
CMT 305 Practical		
CMP -309 (A):	Analytical Chemistry Practical	6
CMP -309 (I):	Inorganic Chemistry Practical	6
CMP -309 (O):	Organic Chemistry Practical	6
CMP -309 (P):	Physical Chemistry Practical	6

Semester – IV

Specialization Papers – I, II, III

Analytical Chemistry		
CMT -402 (A):	Separation Techniques	3
CMT -403 (A):	Electroanalytical Methods	3
CMT -404 (A):	Spectrochemical Analysis	3
Inorganic Chemistry		
CMT -402 (I):	Structural Methods in Inorganic Chemistry	3
CMT -403 (I):	Inorganic Rings, Chains, and Clusters	3
CMT -404 (I):	Special Topics in Inorganic Chemistry	3
Organic Chemistry		
CMT -402 (O):	Application of Spectroscopy to Structural Analysis	3
CMT -403 (O):	Reagents and Organic Synthesis	3

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.

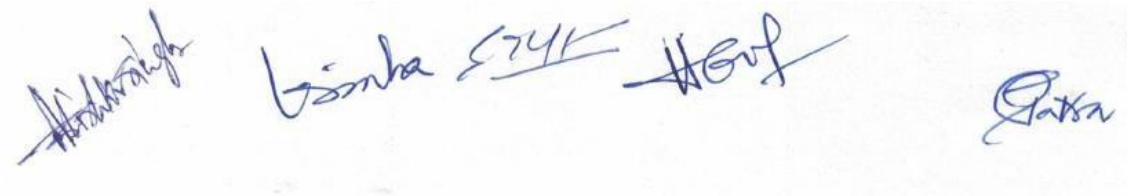
2. **Nucleophilic Substitution at Saturated Carbon:** Mechanism and Stereochemistry of SN1, SN2, SNi and SN2′ reactions. The reactivity effects of substrate structure, solvent effects, competition between SN1 and SN2 mechanisms.

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 (H2-Br2 reaction, decomposition of ethane and acetaldehyde) and oscillatory reactions (Belousov-Zhabotinskii reaction), branching chain: Hydrogen oxygen reaction (H2O2) 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.

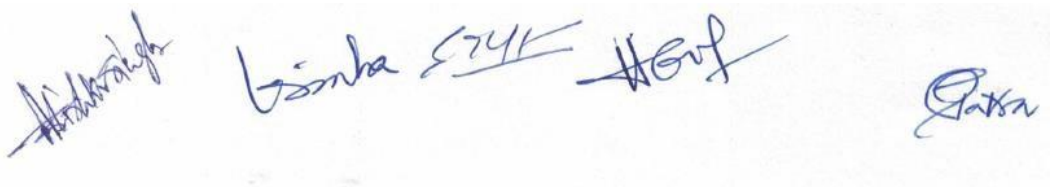
Books Recommended:

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 I2 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.

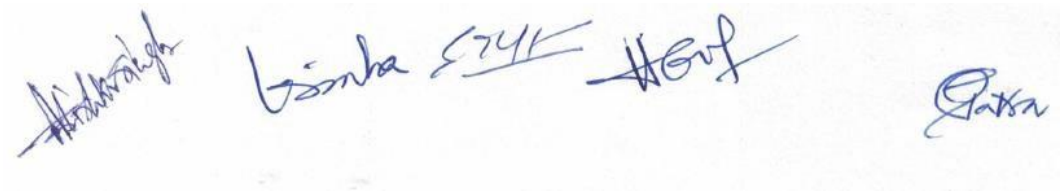
3. **Polymer solutions:** Thermodynamics of polymer dissolution, The Flory-Huggins Theory of Polymer solutions, Nature of polymer macromolecules in solution, Size and shape of macromolecules in solution.

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:

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.

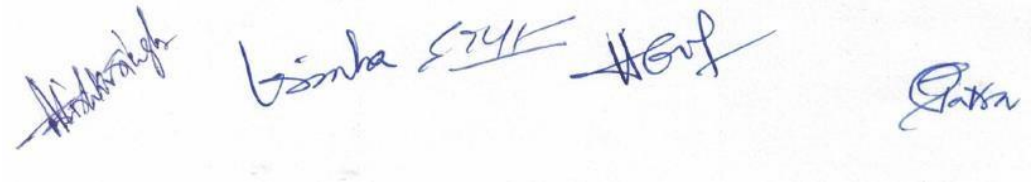
- **Objectives of the course:**1.The students must understand the importance of safety in the laboratory as it relates to themselves and those around them. 2. They must be able to explainthe meaning of common safety symbols used in specific scientific fields of study.3.They must demonstratecomplete knowledge 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

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.

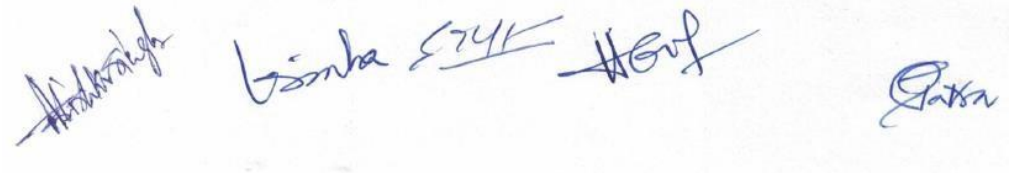
2. **Aromatic Nucleophilic Substitution:** The Aromatic SN1, SN2 and Benzyne mechanisms. Reactivity – effect of substrate structure, leaving group, and attacking nucleophile. Nucleophilic aromatic substitution of naphthalene, phenanthrene and antharcene.

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.

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 micellar 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)

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: 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,

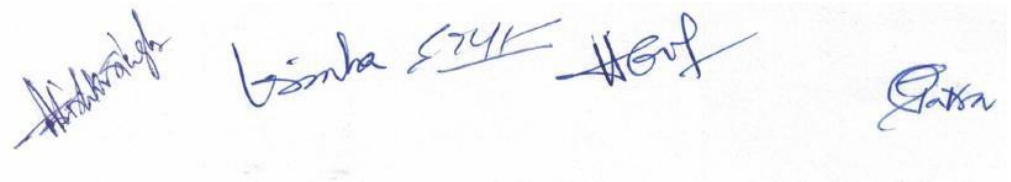
4. **Six Membered Heterocyclics with Two Hetero Atoms:** Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyridazine, Pyrimidine. Pyrazine, Oxazine, thiazine: Fused heterocycle: Benzimidazole, benzoxazole and benzthiazole.

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.



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.

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.

Outcome of teaching -learning:
Students will explain and describe the synthesis of amino acids, proteins including their structures, lipids, nuclic acids, carbohydrates, metallo proteins, metallo enzymes and their role in metabolic pathways. They also learn in details about types of enzyme, enzyme kinetic reaction, inhibition of enzyme kinetic reactions, inhibitors, glycolysis, citric acid cycle, phophorylations and molecular recognitions.

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*

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Specialization Papers I & II
Analytical Chemistry Specialization

CMT-303 (A): Principles of Analytical Chemistry

Credits: 3

Teaching and learning: Study of acid-based equilibria treatment in aqueous medium, pH calculation, introduction to buffer solution and applications, pH calculations, photometric titrations, Construction and applications of different types of sensors.

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).

Outcome of teaching -learning:

Student will learn theoretical approach to acid-base equalibria 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.
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.

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CMT-304(A): Chemical Analysis

Credits:3

Teaching 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.

Outcome of teaching -learning:

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:

- To develop an understanding of the range and uses of analytical methods in chemistry.
- To establish an appreciation of the role of chemistry in quantitative analysis
- To develop an understanding of the broad role of the chemist in measurement and problem solving for analytical tasks.
- To provide an understanding of chemical methods employed for elemental and compound analysis.
- To provide experience in some scientific methods employed in analytical chemistry.
- To develop some understanding of the professional and safety responsibilities residing in working 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).*

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Inorganic Chemistry Specialization
CMT-303 (I): Organometallic Chemistry of Transition Metals

Credits: 3

Teaching and learning: A brief study of metal carbonyls, role of transition metal compounds in catalysis, porous materials organic-inorganic hybrid materials.

1. **Metal Carbonyls:** Dioxygen and Dinitrogen, Semibridging carbonyl group; metal nitrosyl carbonyls; tertiary phosphines and arsines as ligands; carbenes and carbynes.
2. **Transition Metal Compounds in Catalysis**: Hydrogenation, hydroformylation and polymerization; Waker process, Monsanto process.
3. **Transition Metal Compounds with M-H bonds**: Metal hydrides (classical and non-classical). Agostic 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.

Outcome of teaching -learning:

- Student will learn the use of organometallic catalysis in manufacture of different organic compounds by hydrogenation, hydroformylation and polymerization; Waker process, Monsanto process the etc.
- Will be able to know about classical and non-classical metal hydrides, agnostic interactions and proton NMR in studying hydrido complexes.
- Knowing about preparation, properties 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).

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CMT-304 (I): Bio-inorganic Chemistry

Credits: 3

Teaching and learning: A vast knowledge about 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: NO_3 and NO_2 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). Iron storage and transport proteins: Ferritin, Transferritin and Hemosiderin

1. **Role of alkaline earth metal ions in biological systems :** (i) Catalysis of phosphate transfer by Mg^{2+} ion, (ii) Ubiquitous regulatory role of Ca^{2+} -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: NO_3 and NO_2 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.

4. **Interaction of metal complexes with DNA:** DNA probe and chemotherapeutic agents.
5. **Iron storage and transport proteins:** Ferritin, Transferritin and Hemosiderin

Outcome of teaching -learning:

- Student will learn biological process and application of different enzymes in it.
- Understanding electron transfer reactions in biological process.
- Knowing about biological nitrogen fixation and photosynthetic process and its synthetic models.
- Transport of iron in micro- and macro-organism.

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).*

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ORGANIC CHEMISTRY SPECIALIZATION

CMT-303(O): STEREOCHEMISTRY, REACTIONS & REARRANGEMENTS

Credits: 3

Teaching 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: definitions, classifications; configuration and conformation; relative and absolute configuration; determination of relative configuration: Prelog's rule, Cram's rule (Felkin modification), and Sharpless rule; 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 ($IpcBH_2$), $(Ipc)_2BH$, 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 (Chiral enolate & Achiral Aldehyde and Achiral enolate and chiral aldehyde).

3. **Conformation**: conformations of acyclic and cyclic system (3 to 6 membered rings), fused (5/5 & 6/6), Spiro and bridged bicyclo systems; stability, reactivity and mechanism; allylic strain; reactions of 5/6-membered ring containing trigonal carbon (s).

4. **Reactions & Rearrangements:** Sharpless Asymmetric epoxidation, Sommelet-Hauser rearrangement, Favorskii, rearrangements, Chichibabin reaction, Wittig reaction, Hofmann-Loffler-Freytag reaction, Barton reaction, Shapiro reaction, Curtius, Schmidt and Lossen rearrangement, Olefin metathesis.

Outcome of teaching -learning:

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 centres of symmetry.
- Recognise 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

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CMT-304(O): CHEMISTRY OF NATURAL PRODUCTS

Credits: 3

Teaching 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 and Morphine.

2. **Terpenoids:** Structure elucidation, Retrosynthetic analysis and synthesis of Camphor, and Abietic acid.

3. **Steroids:** 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 $PGF_{2\alpha}$), bicycloheptane precursors (Corey's synthesis of prostaglandins E and F)

5. **Carbohydrates:** Conformational analysis of monosaccharides (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 per-iodic oxidation, Smith degradation.

Outcome of teaching -learning:

momenta–Clabsch-Gordan series, Term symbols for two equivalent electrons, Total angular momentum and spin-orbit interaction. Condon Slater Rules.

4. **Ab initio Methods for Closed Shell Systems:** Review of molecular structure calculations, dipole moments. Hartree-Fock method for molecules. Roothaan-Hartree-Fock method. Selection of basis sets. Density functional Method. Population analysis.

Outcome of teaching -learning:

- After completion of the designed course students will be enriched with knowledge to deal microscopic world with the help of quantum chemistry.
- The concept of operator and their properties will help students to find out different observable quantity in microscopic chemical systems.
- The knowledge of various approximation methods helps course learner to evaluate the properties of many molecular systems.
- In particular the time dependent approximation methods will help to predict the spectroscopic transition in molecules.
- First principle Ab-inition calculation will help students to predict different physiochemical properties of different chemical species.

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).

Elective Papers

Elective-I (Group A)

CMT-305: Forensic Analysis

Credits:3

Teaching and learning: To study the different aspects of forensic analysis, real case studies and forensic toxicology, applications of various instrumentation in forensic analysis.

1. **Introduction:** Profile of a forensic laboratory, Forensic Scientists role and quality control, Crime-scene investigation, Collection and preserving physical evidences and evidentiary documentation, Future prospects of forensic analysis

2. **Real Case Analysis:** Liquor analysis, Trap-case analysis, Petroleum product analysis, Fire and Debris analysis, Injuries, Firearm wounds, Asphyxia and stress analysis (only analytical identifications).

3. **Forensic Toxicology:** Analysis of various types of poisons (corrosive, irritant, analgesic, hypnotic, tranquillizer, narcotic, stimulants, paralytic, antihistamine, domestic and industrial (gaseous and volatile) poisoning and food poisonings), Explosive and explosion residue analysis, Lethal drug analysis (sampling, sealing, packing, laboratory methods of testing, reporting the analysis results, court evidence and medico-legal aspects for the consideration of chemical data as a proof for crime), Importance of physiological tests in forensic toxicology

4. **Instrumentation for Forensic Analysis**

5. **(a) *Physical, Biological and Chemical Methods:*** Non-destructive testing probes including radiography, Xera-radiography, Surface penetrations method (SEM and Laser Probes), Fluoroscopy, Clinical methods: ELISA, RIA and immunodiffusion , analysis of glucose, bilirubins, total cholesterol , creatinine, blood urea nitrogen and barbiturates in biological fluids, DNA-finger printing, Examination and grouping of blood strains and seminal strains, Data retrieval and automation techniques for forensic examination with reference to presence of drugs, glasses, paints, oils and adhesives at crime spot.

(b) *Instrumental Methods:* Sample preparation, Calibration of the instruments for its accuracy and producibility of results in forensic analysis, Method validation technique and requirements, Procurement of standard samples, Forensic applications of TLC, HPTLC, HPLC, GC, FT-IR, AAS, GC-MS, UV-visible spectrophotometer with emphasis over standard operational procedures (SOPs) for test samples.

Outcome of teaching -learning:

Student will learn about the importance of forensic analysis in real case studies and using different types of instrumental techniques.

Books Recommended

1. W.J. Welcher (Ed.), *Scott's Standard Methods of Chemical Analysis*, Vol. III A, 6th Edition (1966), and vol. III B, 5th Edition (1975), Van Nostrand Reinhold Co. London.
2. Peter Fordham, *Non-destructive Testing Techniques,* 1st edition (1968), London Business Publications Ltd., London
3. W. Horwitz, *Official Methods of Analysis*, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC.
4. K. Simpson and B. Knight, *Forensic Medicine*, 9th Edition (1985), Edward Arnold Publishers Ltd., London.

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CMT-306: Chemical Applications of Group Theory

Credits: 3

Teaching and learning: To study the classification of groups, symmetry elements and point groups, Matrices and chemical applications of group theory in IR, Raman, Crystal field theory, MOT and electronic spectra.

1. **Group Theory in Chemistry:** Classification of Groups; Matrix representation of symmetry elements and point groups, matrices of C_{3v} and C_{4v} point groups, transformation matrices; Structure of character tables, determination of symmetry species for translations and rotations, Construction of Character tables (C_{2v}, C_{3v}, C_{4v} groups)

2. **Chemical Applications of Group theory**

3. **IR and Raman Spectroscopy:** Brief introduction to molecular vibrations; selection rules for fundamental vibrational transitions, symmetry of normal modes of molecules, Infrared and Raman activity of some typical molecules (molecules of C_{2v}, C_{3v}, C_{4v}, D_{2h}, D_{3h}, and D_{4h} point groups)

4. **Crystal Field Theory:** Splitting of levels and terms in chemical environment, construction of energy level diagrams, selection rules and polarizations.

5. **Molecular Orbital Theory:** Introduction, transformation properties of atomic orbitals; hybridization schemes for σ- and π-bonding, hybrid orbitals as LCAOs; Molecular Orbital Theory for some typical AB_n types (n = 2, 3, 4, 6) of molecules (H_2O, NH_3 and BH_3)

6. **Electronic Spectra:** General considerations, typical examples from tetrahedral and octahedral systems, Orgel energy level diagrams

Outcome of teaching -learning:
Student will learn about the different types of groups, Matrices, symmetry, and the application of group theory in various techniques such as IR, Raman, MOT etc.

Books Recommended

1. F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edn. (1999), John Wiley & Sons, New York.
2. G. L. Miessler and D. A. Tarr, *Inorganic Chemistry*, 2nd Edn. (1999), Prentice Hall International Inc., London.
3. K. Veera Reddy, *Symmetry and Spectroscopy of Molecules*, New Age International Pvt. Ltd., New Delhi (1999).

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CMT-307: MEDICINAL CHEMISTRY

Credits: 3

Teaching and learning: To get the knowledge of structure and activity of drugs, Antibiotics, Antimalarials, Anti-inflammatory drug etc.

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
   (b) **Antimalarials:** Chemotherapy of malaria. SAR. Chloroquine, Chloroguanide and Mefloquine
   (c) **Non-steroidal and Anti-inflammatory Drugs**: Diclofenac Sodium, Ibuprofen and Netopam
   (d) **Antihistaminic and antiasthmatic agents**: Terfenadine, Cinnarizine, Salbutamol and Beclomethasone dipropionate.

Outcome of teaching -learning:

Understanding of the basic biological and pharmacological interactions by using both natural products and total synthesis of bioactive molecules. Use of corresponding knowledge for the development of biologically and clinically active drugs. It will include advanced courses in natural products, organic synthesis, medicinal chemistry; fundamentals of cell biology, molecular biology, drug design and analytical methods.

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.

CMT-308: Physical Methods in Chemistry

Credits: 3

Teaching and learning: To study the principles nd applications of Photoelectron spectroscopy, AES and XRF, STM, AFM and fluorescence techniques.

1. **Photoelectron Spectroscopy and Related Techniques:** Principle and applications to studies of molecules and surface. UPES and XPS. Auger electron and X-ray fluorescence spectroscopy (AES and XRF).
2. **Techniques for Studying Surface Structure:** Low energy electron diffraction (LEED). Scanning tunneling and atomic force microscopy (STM and AFM).
3. **Neutron Diffraction:** Principle and applications.
4. **Fluorescence techniques:** Steady state fluorescence spectroscopy. Time-resolved (Time correlated single photon counting-TCSPC) fluorescence spectroscopy. Introduction to Single molecule fluorescence and fluorescence imaging.

Outcome of teaching -learning:
Student will learn about the principles and instrumentation of photoelectron spectroscopy, techniques for surface studies such as STM, AFM *etc*. Use of fluorescence techniques.

Books Recommended

1. J.M. Hollas, *Modern Spectroscopy*, 4th edition (2004), John Wiley and Sons, Chichester.
2. C.N. Banwell and E.M. Mc Cash, *Fundamentals of Molecular Spectroscopy*, 4th edition (1994), Tata McGraw Hill, New Delhi.
3. E.M. Mc Cash, *Surface Chemistry*, Oxford University Press, Oxford (2001).
4. A.K. Cheetham and P Day, *Solid State Chemistry Techniques*, Oxford Univ. Press, Oxford (1988).
5. Joseph R. Lakowicz, *Fluorescence Spectroscopy*, 2nd edition, Plenum Press, New York. (1999).

Practical

CMP-309 (A): Analytical Chemistry Practical

Credits: 6

Teaching and learning: The learners should be able to validate the conceptual understanding acquired from the theory classes

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. Determination of nitrogen and phosphorus in soil samples
6. Determination of ascorbic acid by titration method
7. Estimation of the purity of oxalic acid employing standard Ce (IV) solution.

Outcome of teaching -learning:

- The module will provide the hands -on 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, such as performance drugs.

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CMP-309(I):Inorganic Chemistry Practical ***Credits: 6***

Teaching and learning: The learners should be able to validate the conceptual understanding acquired from the theory classes

Section-A

1. (a) Synthesis and structural characterization (IR, electronic spectra and magnetic susceptibility) of $[Ni(py)_4(NCS)_2]$.

   (b) Synthesis of a series of Ni(II) complexes (with ligands of varying ligand field strength), electronic spectral interpretation and calculation of various ligand-field parameters.
2. Synthesis and structural characterization (IR, Electronic spectra) of the *cis*- and *trans*-isomers of $[Co(en)_2Cl_2]$
3. Synthesis and characterization (IR and PMR & CMR) of $[Al(acac)_3]$

Section-B

1. Synthesis, purification by sublimation and structural characterization (IR and electronic spectra) of ferrocene.
2. Acetylation of ferrocene and separation of the acetyl derivative by column chromatography.

Outcome of teaching -learning:

- 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.

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CMP-309(O): Organic Chemistry Practical ***Credits: 6***

Teaching 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. Estimation of Nitrogen by Kjheldal method and Sulphur by Messenger method.
3. Organic Synthesis involving 2-3 steps.

Outcome of teaching -learning:

On Completion of this module, the learner will be able to:

- Independently 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.

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CMP-309 (P): Physical Chemistry Practical ***Credits: 6***

Teaching and learning: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Kinetics of decomposition of benzene diazonium chloride.
2. Conductometric study of the kinetics of saponification of ethyl acetate.
3. Determination of transport numbers of Cu^{2+} and SO_4^{2-} by Hittorf's method.
4. Conductometric titration of triple mixture (HCl+NH_4Cl+KCl) with (i) NaOH and (ii) $AgNO_3$.
5. Analysis of halide mixture by differential potentiometry.
6. Conductometric titration of a polybasic acid.
7. Verification of the Nernst law of electrode potential.
8. Ternary phase diagram of water, benzene, and acetic acid.
9. Determination of molecular weight of a macromolecule by viscometry.
10. Electrochemical Impedance study of metal/solution interface.
11. Cyclic Voltammetry of the $[Fe(CN)_6]^{3-}/[Fe(CN)_6]^{4-}$ system.
12. Corrosion study of steel in an acid solution.

Outcome of teaching -learning:

At the end of the course, the learners should be able to: Explain the principle behind the experiments performed in the laboratory Plan and Perform experiments and Interpret experimental results

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

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Semester-IV

CMT-401: Computer Applications in Chemistry
(Core Paper)

Credits: 3

Teaching and learning: To get a brief knowledge of FORTRAN 77 and other numerical methods.

1. **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
2. **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.

Outcome of teaching -learning:

Student 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

Analytical Chemistry Specialization

CMT-402(A): Advanced Separation Techniques

Credits: 3

Teaching and learning: To study about different types of separation techniques like solvent extraction, chromatography etc. A detailed knowledge of Mass spectrometry and other hyphenated techniques.

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.

Outcome of teaching -learning:

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 Ediion, 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).

CMT-403 (A): Electroanalytical Methods

Credits:3

Teaching and learning: To study about origin and detailed knowledge of polarography, Three electrode system, modes of electron transfer, other modern electroanalytical techniques, electroactive layers and modified electrodes.

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:** Ilkovic equation and its derivation, Criteria of polarographic reversibility, Interpretation of catalytic, kinetic, adsorption and capacitive currents. Polarographic maxima and maximum suppresors.

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.

Outcome of teaching -learning:

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).*

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CMT-404 (A): Instrumental Analytical Techniques

Credits: 3

Teaching and learning: To get the detailed knowledge about principle and instrumentation of IR, Raman, NMR, ESR, SEM, TEM and plasma emission spectroscopy.

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.

Outcome of teaching -learning:

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.*

Inorganic Chemistry Specialization

CMT-402 (I)- Structural Methods in Inorganic Chemistry

Credits: 3

Teaching and learning: A detailed study of Infrared, ESR, NMR, Mass Spectroscopy and Raman Spectroscopy. Applications in the interpretation of spectra especially in inorganic chemistry.

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 ^{13}C NMR, (iv) Use of Chemicals as NMR auxillary reagents (shift reagents and relaxation reagents (v) ^{1}H 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**: 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).

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)

Outcome of teaching -learning:

Student will have idea about vibrational spectroscopy of different geometry metal complexes and fingerprint applications in the interpretation of mass spectra of inorganic compounds.

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. *R. S. Drago, Physical Methods in Inorganic Chemistry, 1st Edn. (1971), Affiliated East-West Press, New Delhi.*
4. *K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 4th Edn. (1986), John Wiley & Sons, New York.*
5. *W. Kemp, Organic Spectroscopy, 3rd Edn. (1991), Macmillan, London.*
6. *G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India Pvt. Ltd., New Delhi (2001).*

CMT-403 (I): Inorganic Rings, Chains, and Clusters

Credits: 3

Teaching and learning: Metal Clusters and Metal-Metal Bonds: Compounds with metal-metal multiple bonds, metal carbonyl, halide and chalcogenide clusters. Parallels between main group

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.*

ORGANIC CHEMISTRY SPECIALIZATION

CMT-402(O) : Application of Spectroscopy to Structural Analysis

Credits: 3

Teaching and learning: Structure elucidation of the different organic compounds using UV, IR, PMR, CMR and Mass spectroscopy.

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. 2 DNMR: COSY, NOESY and HETCOR.

4 **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.

Outcome of teaching -learning:

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.

CMT-403(O) : Reagents and Reactions in Organic Synthesis

Credit: 3

Teaching 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: $LiAlH_4$, $NaBH_4$ 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 tetraoxide, (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.

Outcome of teaching -learning:

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 byproducts 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.

CMT-404(O): Heterocycles and Vitamins

Credits: 3

Teaching and learning: To study general considerations, chemistry of condensed Indoles and Azoles, Six membered heterocyclic compounds and vitamins.

1. General Considerations: The Disconnection Approach and Retrosynthesis.
2. The chemistry of condensed Indoles, and Azoles such as Oxazoles, isoxazoles, pyrazoles, imidazoles and thiazoles,
3. Six-membered Heterocyclic compounds: Pyrimidines and purines. Structure and synthesis of Caffeine.
4. Vitamines: Structure determination and synthesis of (i) Thiamine (B1), (ii) Pyridoxine (B6) and (iii) Biotin (H).

Outcome of teaching -learning:

Heterocyclic compounds (five and six membered containg two atoms like O, N, S) and Vitamins are very interesting due to their distinct structure and the availability in medicinal drugs. So the technique of synthesis of heterocyclic compounds and vitamins is important. This course gives the quantitative ideas about the synthesis, properties and uses of such heterocyclic compounds and vitamins. This course aims at providing theoretical understanding of heterocyclic chemistry which includes various methods for ring synthesis and application of those methods for the preparation of specific groups of heterocyclic systems and vitamins. The students will be made familiar with particular properties, reactions, and applications of the most important as well as less common heterocycles and vitamins.

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.

PHYSICAL CHEMISTRY SPECIALIZATION

CMT-402 (P): Statistical Mechanics

Credits: 3

Teaching and learning: To learn the laws of Thermodynamics, To learn Ensembles: Phase

Biosynthesis: terpenoids - C_5, C_{10}, C_{15}, C_{20} units; alkaloids- quinine and morpholine, steroids- cholesterol.

Molecular Recognition : Fullerenes : as host as well as guest , enzyme modeling using an artificial host frame work , cyclodextrins as esterase mimics , functionalized cyclodextrins ; chiral corands.Drug design(enzymes as targeted for drug design).

Outcomes of teaching -learning:
Student will learn enzymes and their classifications, Enzyme kinetics, Coenzyme chemistry, Biosynthesis and molecular recognition.

Books Recommended

1. A.L. Lehninger, *Principles of Biochemistry,* (1992) CBS Publishers, Delhi.
2. D. Voet, J.G. Voet & CW Pratt, *Fundamentals of Biochemistry*, (1999) John Wiley & Sons, New York.
3. H.R. Mahler and E.H. Cordes, *Biological Chemistry*, 2nd Edition, (1971) Harper and Row Pub., New York.
4. T.C. Bruice and S. Bentkovic, *Bioorganic Mechanisms*, Vol. I & II, (1966) W. A. Benjamin, New York.
5. H. Dugas and C. Penney, *Bioorganic Chemistry: A Chemical Approach to Enzyme Action*, (1981) Springer- Verlag, New York.
6. C. Walsh, *Enzymatic Reaction Mechanisms*, W.H. Freeman & Co., New York.
7. Supramolecular Chemistry by Jonathan, W. Steed and Jerry L. Atwood, John Wiley & Sons Ltd. 2000.
8. Oligonucleotides and analogues: A Practical approach. F. Eckstein. IRL Press, Oxford.
9. Methods in Molecular Biology. Vol. 20. Sudhir Agrawal. Humana Press Totowa, New Jersey.
10. Oligonucleotide Synthesis. A Practical Approach. M. J. Gait. IRL Press, Oxford.

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CMT-408: Materials Chemistry

Credits: 3

Teaching and learning: Students will learn about introduction of materials, their synthesis and characterizations, Superconductors, Non-linear and organic materials.

1. **Introduction:** Materials and their classification, Role of Chemistry in Material design.

2. **Synthesis and characterization of materials:** Preparative techniques: Ceramic methods; chemical strategies, chemical vapour deposition; preparation of nanomaterials, Langmuir-Blodgett Films. Fabrication of ordered nanostructures. Composition and purity of materials.

3. **High- Tc Oxide Superconductors:** Structural features of cuprate superconductors. 1-2-3 and 2-1-4 cuprates; structure. Normal state properties: anisotropy and temperature dependence of electrical resistance. Superconducting state: heat capacity, coherence length, relation between Tc and hole concentration in cuprates; mechanism of superconductivity in cuprates. Applications of high Tc-cuprates

4. **Organic Materials:** Conducting organics - Metals from molecules, charge transfer materials and conducting polymers. Organic superconductors. Fullerenes. Molecular ferromagnets and ferroelectrics. Liquid crystals: mesomorphic behaviour, optical properties of liquid crystals, display devices.

5. ***Non-linear materials:*** *Second and third order non-linear effects; molecular rectifiers and frequency doublers; unimolecular electronic devices. Photochromic materials; optical datastorage, memory and switches.*

Outcomes of teaching -learning:

Students will learn about the structure and characterizations of different types of materials such as Semiconductors, Organic and Non linear materials.

Books recommended:

1. *A.R. West, Solid State Chemistry and its Applications, John Wiley & Sons, Singapore (1984)*
2. *C.N R. Rao and J. Gopalkrishnan, New Directions in Solid State Chemistry, Cambridge Univ. Press (1997).*
3. *T. V. Ramakrishnan and C.N. Rao, Superconductivity Today, Wiley Eastern Ltd., New Delhi (1992).*
4. *P. Ball, Designing the Molecular World: Chemistry at the Frontier, Princeton Univ. Press, (1994).*

CMP-409: Projects

Credits : 6

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.

Teaching and Learning: The term courses also include a dissertation a research-based thesis project enhancing the students understanding.

Outcomes of learning:

- formulating and solving problems in the laboratory
- The principles and applications of modern chemical instrumentation, experimental design, and data analysis
- the underlying chemical and physical of instrumental methods of analysis, searching scientific journals and using internet search etc.
- how to work with others as part of a team to solve scientific problems
- 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

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