Model Answer Paper

B.Sc. –III Semester Chemistry 2013

Inorganic Chemistry -II

AS -2808

By

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AS -2808

B.Sc. (Hon's) III Semester Examination, 2013

Inorganic Chemistry –II, paper : CBT- 302

Maximum Marks: 30

Section A

1. Choose the correct answer : 10x1 = 10

(i) Element which liberates oxygen gas from water (a) P (b) Na (c) F (d) I **Ans:** (c) F
[Fluorine reacts violently with water forming hydrogen fluoride, and liberates oxygen which is highly charged with ozone. $2 F_2 + 2 H_2O = 4 HF + O_2$]

(ii) Solar cell contains (a) Cs (b)Si (c) Sn (d)Ti
Ans: (b) Si

(iii) In bleaching action on bleaching powder liberates (a) Chlorine (b) Molecular Oxygen (c) Nascent oxygen (d) Calcium carbonates
Ans: (a) Chlorine

(iv) Permanent magnet is made from (a) Cast iron (b) Steel (c) Wrought iron (d) All of these. **Ans:** (c) Wrought iron

(v) Which is the strongest acid among following: (a) HI (b) H_2SO_4 (c) HCl (d) $HClO_4$
Ans: (d) $HClO_4$

(vi) What is the diagonal relationship? **Ans:** The relationship between two elements with similar chemical properties which are placed diagonally in periodic table is known as diagonal relationship. The chemical properties of boron and carbon resemble to a great extent due to diagonal relation.

(vii) Spin angular momentum calculated by the formula ……**Ans:** $\sqrt{S(S+1)}h/2\pi$.

(viii) What is banana bond? **Ans:** It is an extended covalent bond found in boranes in which a hydrogen atom is shared by two boron atoms and form of three-center two-electron bond.

(ix) Which is the first synthetic element? **Ans:** Technetium (Tc, atomic no. 43).

(x) Write the increasing order of stability of the following hydrides: H_2O, H_2S, H_2Se and H_2Te. **Ans:** $H_2Te < H_2Se < H_2S < H_2O$.

Section B:

2. (a) Why Boron has exceptionally high melting point? 2+2 = 4

(b) What do you mean by lanthanide contraction? What are its consequences?

Ans: (a) Boron exits in icosahedron structure where each corner contains boron with strong covalent bond. In each icosahedron, there are twelve boron atoms and each boron atom is bonded to five equidistance neighbours resulting in strong attractive interactions and form a gaint type molecule. So large amount of energy is necessary to break the bonds between atoms hence boron atom has exceptionally higher melting point.

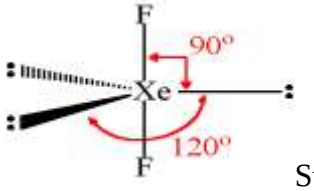
Icosahedron structure of Boron

(b) The decrease in size of elements in the lanthanide series with increase in atomic number due to the poor screening power of the f-orbital is known as Lanthanide contraction.

Some consequences of the lanthanide contraction: (i) The fifth- and sixth-period transition elements show remarkable similarities in their physical and chemical properties as hafnium and zirconium for their atomic radius and chemical behavior. Thus the two elements are difficult to separate. (ii) These elements have unusually high densities because their metallic radii are virtually the same as those of the fifth-period elements in the same group, while their atomic masses are almost twice as large.

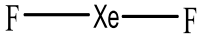
3. State the hybridization and structure of the following compounds: (i) XeF_2 (ii) XeF_6 (iii) XeO_3F_2 (iv) XeF_4 1x4 = 4

Ans: (i) sp^3d hybridization, three lone pairs and two bond pairs are present. Trigonal bipyramid structure (A) containing three lone pairs and two bond pairs and linear structure (B) without three lone pairs.

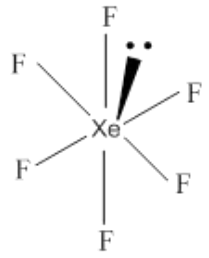


Structure A

Structure B

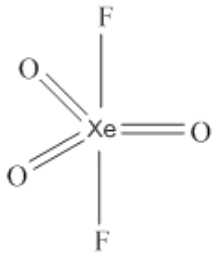


(ii) sp^3d^3 hybridisation



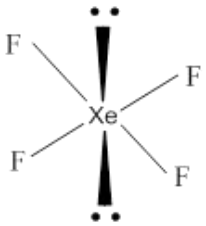
distorted octahedral with one lone pair

(iii) sp^3d hybridisation



trigonal bipyramid with five sigma bonds and three pi bonds

(iv) sp^3d^2 hybridisation



square planar without lone pairs and octahedral with lone pairs

4. What are the transition metals? Explain their magnetic and catalytic properties. 1+3 = 4

Ans: Transition metals are the set of metallic elements occupying a central block (Groups IVB–VIIIB, IB, and IIB) in the periodic table, e.g. iron, manganese, chromium, and copper. Chemically they show variable valency and a strong tendency to form coordination compounds, and many of their compounds are colored.

In presence of magnetic field, transition metals are classified as paramagnetic and diamagnetic transition metals. Those metals which are attracted by the applied magnetic field are called paramagnetic where as those which are repelled by the magnetic field are called diamagnetic. Paramagnetism is a property of transition metals due to the presence of unpaired electrons. Thus most of the transition metals are paramagnetic. As the number of unpaired electrons increases, the paramagnetic character also increases.

Many transition metals and their compounds have catalytic properties e.g. V_2O_5, Fe, $FeCl_3$, Ni, Pd etc. This property of transition elements is due to their variable oxidation states. In some cases the transition metals with their variable valency may form variable unstable intermediate compounds. In other cases the transition metal provides a suitable reaction surface.

5. Complete following equation and explain with few sentences: (i) $NCl_3 + H_2O$ = ?
(ii) $Na[BH_4] + I_2$ (diglyme) = ? 2+2 = 4

Ans: (i) $NCl_3 + 3H_2O = NH_3 + 3HOCl$. Here in this reaction one molecule of nitrogen trichloride reacts with three molecules of water and the products will be ammonia and three molecules of hypochlorus acid.

(ii) $2Na[BH_4] + I_2$ (diglyme) = $B_2H_6 + 2NaI + H_2$. Here in this reaction diglyme will act as a sovent and diborane and hydrogen gas will be formed.

6. What is the Hund's rule to assign ground state energy term of atom or ion? Derive the terms symbol for d^2 configuration. 2+2 = 4

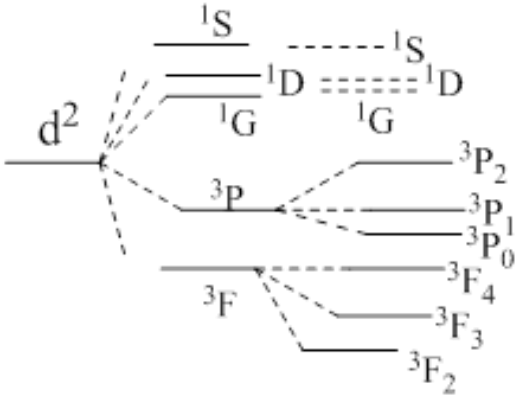
Ans: Once the energy terms are known, they can be arranged in order of energy and the ground state term identified by using Hund's rule

(i) The terms are placed in order depending on their multiplicities and hence their S values. The most stable state has the largest S value and stability decreases as S value decreases. The ground state therefore possesses the most unpaired spins because this give the minimum electrostatic repulsion

(ii) For a given value of S, the state with the heighest L value is the most stable state.

(iii) For a given values of S and L, the smallest J value is the most stable state if the subshell is less than half filled. The biggest J value is most stable if the subshell is more than half filled.

For d electrons, the azimuthal quantum no. **l** = 2 and the magnetic quantum no. **m** has values +**l**, **0**, -**l** giving the case +**2**, +**1**, 0, -**1**, -**2**. There are 45 micro states in which two d electrons may be arranged which do not violate the Pauli Exclusion principle. The height value of M_L = 4 can only arise if L = 4 which correspond ^1G state. Similarly of M_L = 3 indicates ^3F state for total 30 configurations. Remaining 15 terms are ^1D, ^3P and ^1S Applying above Hund's rule, the ground state is 3F and the energy of the various states is $^3F < ^3P < ^1G < ^1D < ^1S$.



ground term of d^2 configuration

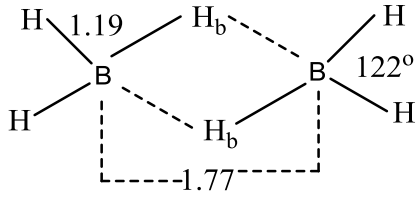
7. How diborane was synthesized? Explain briefly its structure. 2+2 = 4

Ans: Treatment of lithium aluminium hydride with boron trichloride in anhydrous diethyl ether, diborane is formed in 99.4% yield.

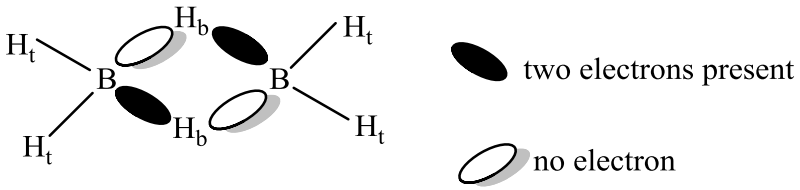
$$3LiAlH_4 + 4BCl_3 = 3LiCl + AlCl_3 + 2B_2H_6$$

Electron diffraction study of B_2H_6 molecule confirms this molecule has hydrogen bridged structure. Two boron atoms and four terminal hydrogen atoms (H_t) lie in one plane while

the remaining two hydrogen atoms (H_b) lie in another plane. These two planes are perpendicular to each other.



Structure of diborane



B-H_b-B indicates bridging bond of three centre two electrons.
B-H_t indicates terminal bond of two centre two electrons.

Each of the terminal bond is represented as 2c-2e bond and it is formed by sharing of two electrons between two atoms. It is normal covalent bond. On the other hand, each of the bridging bond is represented as 3c-2e bond and is formed by sharing of two electrons between three atoms. It is not a normal covalent bond.

8. Explain why: (i) Iodine is almost insoluble in water but dissolved in an aqueous solution of KI.
(ii) SF_6 is unreactive towards water but TeF_6 reacts.

Ans: (i) When iodine is treated with water it is almost insoluble because there is no reaction occurred. But when iodine is treated with an aqueous solution of KI, iodine reacts immediately with it and form potassium tri iodate spontaneously and it is a very quick process. Thus iodine dissolved in aqueous solution of KI.

$$KI + I_2 = KI_3$$

(ii) SF_6 is insoluble in water and extremely inert because size of the S is not essential for the reaction. But for TeF_6, it is hydrolyzed more rapidly because the larger size of Te which permits the larger coordination no. necessary in the first stage of hydrolysis.

$$TeF_6 + H_2O = 6HF + H_6TeO_6$$

$$TeF_6 + F^- = TeF_7^-$$

9. Explain the synthesis and structures of inter-halogen compounds 2+2 = 4

Ans: Interhalogen compounds: The halogen form among themselves binary compounds which are known as inter-halogen compounds. Except BrCl, ICl, IBr and ICl_3, the compouns are all halogen fluorides such as ClF, BrF_3, IF_5 and IF_7.
Inter-halogen compounds are of four types AX, AX_3, AX_5 and AX_7.
AX type: ClF, BrF, BrCl, ICl, IBr.
AX_3 type: ClF_3, BrF_3, ICl_3.
AX_5 type: BrF_5, IF_5
AX_7 type: IF_7

Synthesis:

(i) $Cl_2 + F_2$ (equal vol.) $\xrightarrow{200^oC}$ $2ClF$

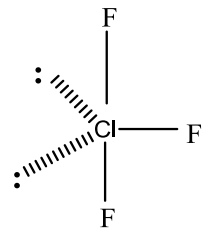
(ii) $Cl_2 + 3F_2$ (excess) $\xrightarrow{300^oC}$ $2ClF_3$

(iii) $Br_2 + 5F_2$ (excess) $\xrightarrow{200^oC}$ $2BrF_5$

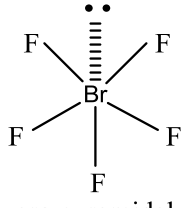
(iv) $IF_5 + F_2 \rightarrow IF_7$

Structures:

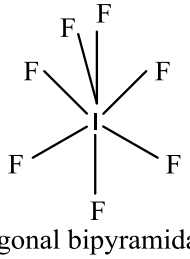
(i) ClF has linear structure containing three lone pair (without lone pair) and one bone pair.
(ii) ClF_3 has trigonal bipyramidal structure with bond angle of $87^o40^/$ and two positon held by two lone pairs. This finally gives rise to a T-shape molecules
(iii) BrF5 has square pyramidal structure containing one lone pair of electrons in other side of the pyramid to minimize the repulsion.
(iv) IF_7 has pengonal bipyramidal structure with seven sigma bonds.



T-shape structure with two lone pairs



square pyramidal with one lone pair



pentagonal bipyramidal with no lone pair