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63 (FY)SEM-5/MAJ/CHMMAJ3014

2025

**CHEMISTRY**

(Major)

Paper : CHMMAJ3014

**(Inorganic Chemistry-3)**

Full Marks : 50

Pass Marks : 20

Time : Two hours

***The figures in the margin indicate full marks for the questions.***

1. Choose the correct answer :  $1 \times 5 = 5$
- (i) In the ion exchange methods for the separation of Lanthanoids, which factor are primarily responsible for the sequential elution of the different Lanthanide ions from the resin column ?
- (a) The varying degree of hydration and the stability of the complexes form with the eluting agent

- (b) The ability of lighter lanthanides to reach a +4 oxidation state
- (c) The  $Ln^{3+}$  ions' colour and spectral differences
- (d) The magnetic moment differences between the  $Ln^{3+}$  ion
- (ii) The preparation of  $Fe(CO)_5$  from finely divided iron metal and CO gas at high temperature and pressure is an example of which general preparation method?
- (a) Thermal decomposition
- (b) Reductive carbonylation
- (c) Photochemical substitution
- (d) Direct combination
- (iii) In an ethereal solution of a Grignard reagent  $RMgX$ , the dynamic Schlenk equilibrium dictate the species present. Which two 'Mg' species interconvert in the equilibrium?
- (a) A monomeric  $RMgX$  and dimeric  $R_2Mg_2X_2$
- (b)  $R_2Mg$  and  $MgX_2$
- (c)  $RMgOH$  and  $MgX_2$
- (d)  $RMg^+$  and  $X^-$

- (iv) Which set of reactants are used for the high yield synthesis of  $Fe(\eta^5-C_5H_5)_2$  ?
- (a)  $FeCl_3$  and  $C_5H_6$  in presence of  $KOH$
  - (b)  $FeCl_2$  and  $C_5H_5Na$
  - (c)  $Fe(NO_3)_3$  and  $C_5H_5Li$
  - (d)  $Fe$ -metal and  $C_5H_6$  under high pressure and temperature
- (v) The toxicity due to heavy metal ions ( $Pb^{2+}$ ,  $Hg^{2+}$  and  $Cd^{2+}$ ) are primarily due to their strong ability/affinity to bind with which functional group bearing biological molecules ?
- (a)  $-CONH_2$  group in protein backbone
  - (b)  $-SH$  groups of cysteine residues in protein
  - (c)  $-COOH$  and  $-OH$  groups of carbohydrates
  - (d)  $-PO_4^{2-}$  and  $-SO_4^{2-}$  group of DNA and lipids

2. Answer the following questions : **(any five)**  
2×5=10

- (i) Define Lanthanide contraction and state *one* significant consequences of this effect for the 5*d* transitional elements that follow the Lanthanides. 1+1=2
- (ii) Define the term Hapticity ( $\eta^n$ ) of an organic ligand. Use  $Fe(\eta^5-C_5H_5)_2$  as an example to illustrate this concept.
- (iii) The dimeric structure  $Al_2R_6$  utilizes multicentre bonding. Briefly describe the nature of  $Al-C-Al$  bridging bond in terms of the number of centres of electrons.
- (iv) Explain the Synergic effect in metal carbonyls. How does this effect explains that the C-O stretching frequency ( $\nu_{CO}$ ) is lower than free carbon monoxide (CO) in the complex  $Ni(CO)_4$ ? 1+1=2
- (v) What is Wilkinson's catalyst? Name the *three* fundamental steps on the catalytic cycle of alkene hydrogenation and identify the electron count (16 or 18) at the metal center in the active species.

(vi) Describe the structural difference between the *Fe* (II) ion in oxyhaemoglobin and deoxyhaemoglobin.

(vii) Why Methyllithium exists as a tetramer ( $Me_4Li_4$ ) in the solid state rather than as a simple monomer?

3. Answer the following questions : (*any five*)

5×5=25

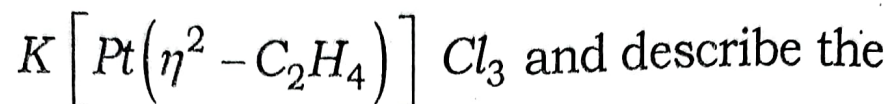
(i) (a) Write the general valence shell electronic configuration of Lanthanide and Actinide. 1

(b) Explain why Actinide shows a wider range of oxidation states compared to the lanthanide. 2

(c) Briefly define Actinide Contraction and state *one* key difference between it and lanthanide contraction. 1+1=2

(ii) Define organometallic compounds. Calculate the electron (valence) count and predict the structure of  $Mn_2(CO)_{10}$  and  $Ir_4(CO)_{12}$ . 1+4=5

(iii) Draw the structure of



and describe the bonding of  $Pt - C_2H_4$  in this complex.

1+4=5

(iv) What is Ziegler-Natta catalyst? Explain the crucial role of  $Al(Et)_3$  when used as a co-catalyst in the polymerisation of ethene.

1+4=5

(v) Write the overall balanced reaction for the Wacker process. Explain the specific role of the two metal components  $PbCl_2$  and  $CuCl_2$  in maintaining the cycle.

3+2=5

(vi) (a) Describe the overall chemical transformation accomplished by the Fischer-Tropsch reaction.  $2\frac{1}{2}$

(b) Briefly explain the role of metal-carbonyl complexes in the production of synthetic gas  
( $CO + H_2$ )  $2\frac{1}{2}$

(vii) Explain the reason for the toxicity of  $Pb$  at the molecular level using HSAB principle and also chemical mechanism by which chelating agent can be used as medicine to treat this toxicity.

2+3=5

(viii) (a) Classify *Na* and *Fe* according to their action in biological system (Bulk, macronutrient or trace).

2

(b) Describe the specific catalytic role of the metal ion in carbonic anhydrase and carboxypeptidase.

$1\frac{1}{2} + 1\frac{1}{2} = 3$

4. Answer the following questions : **(any one)**

10

(i) (a) Describe the entire chemical process for the extraction of Uranium from monazite ore to the purification of Uranium compound.

5

(b) Explain the mechanism of separation of  $Ln^{3+}$  by ion exchange methods. Which lanthanide ion is eluted first and why?

$3 + 2 = 5$

(ii) (a) Discuss how *MO* diagram of CO explain its role as a  $\pi$ -acceptor behaviour in metal carbonyl complexes.

5

(b) Predict and justify the structure of the binuclear complex  $Fe_2(CO)_9$  using VBT.

5