CBSE EXAMINATION PAPER-2025

CHEMISTRY (Theory)

Class-12th

(Solved)

(Delhi & Outside Delhi Sets)

Time : 3 Hours **Max. Marks : 70**

General Instructions:

Read the following instructions carefully and follow them:

*(i) This question paper contains **33** questions. **All** questions are **compulsory**.*

*(ii) This question paper is divided into **five** sections – Sections **A, B, C, D** and **E.***

*(iii) **Section A** – question numbers **1** to **16** are multiple choice type questions. Each question carries **1** mark.*

*(iv) **Section B** – question numbers **17** to **21** are very short answer type questions. Each question carries **2** marks.*

*(v) **Section C** – question numbers **22** to **28** are short answer type questions. Each question carries **3** marks.*

*(vi) **Section D** – question numbers **29** and **30** are case-based questions. Each question carries **4** marks.*

*(vii) **Section E** – question numbers **31** to **33** are long answer type questions. Each question carries **5** marks.*

*(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the sections except Section – **A.***

(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.

*(x) Use of calculators is **NOT** allowed.*

You may use the following values of physical constants wherever necessary:

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

Mass of electron (m_e) = 9.1×10^{-31} kg.

Mass of neutron = 1.675×10^{-27} kg.

Mass of proton = 1.673×10^{-27} kg.

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann's constant = 1.38×10^{-23} JK^{-1}

Delhi Set-1 **Code - 56/1/1**

SECTION – A (16×1 = 16)

Questions No. **1** to **16** are Multiple Choice type questions carrying 1 mark each.

1. In case of association, abnormal molar mass of solute will

(A) increase
(B) decrease
(C) remain same
(D) first increase and then decrease

2. Standard electrode potential for Sn^{4+}/Sn^{2+} couple is +0.15 V and that for the Cr^{3+}/Cr couple is –0.74 V. The two couples in their standard states are connected to make a cell. The cell potential will be

(A) +1.19 V **(B)** +0.89 V
(C) +0.18 V **(D)** +1.83 V

3. The magnetic moment is associated with its spin angular momentum and orbital angular momentum. Spin only magnetic moment value of Cr^{3+} ion (Atomic no. : Cr = 24) is ....

(A) 2.87 B.M. **(B)** 3.87 B.M.
(C) 3.47 B.M. **(D)** 3.57 B.M.

4. Acidified $KMnO_4$ oxidises sulphite to

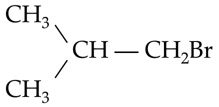
(A) $S_2O_3^{2-}$ **(B)** $S_2O_8^{2-}$
(C) $SO_2(g)$ **(D)** SO_4^{2-}

5. The correct IUPAC name of $[Pt(NH_3)_2Cl_2]^{2+}$ is

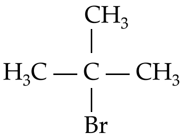
(A) Diamminedichloridoplatinum (II)
(B) Diamminedichloridoplatinum (IV)

(C) Diamminedichloridoplatinum (O)
(D) Diamminedichloridoplatinate (IV)

6. Arrange the following compounds in increasing order of their boiling points:

(i) 

(ii) $CH_3CH_2CH_2CH_2Br$

(iii) 

$H_3C-\overset{\overset{CH_3}{|}}{\underset{\underset{Br}{|}}{C}}-CH_3$

The correct order is

(A) (ii) < (i) < (iii)
(B) (i) < (ii) < (iii)
(C) (iii) < (i) < (ii)
(D) (iii) < (ii) < (i)

7. Alkyl halides undergoing nucleophilic bimolecular substitution reaction involve

(A) retention of configuration
(B) formation of racemic mixture
(C) inversion of configuration
(D) formation of carbocation

8. Which is the correct order of acid strength from the following?

(A) $C_6H_5OH > H_2O > ROH$
(B) $C_6H_5OH > ROH > H_2O$
(C) $ROH > C_6H_5OH > H_2O$
(D) $H_2O > C_6H_5OH > ROH$

9. The acid formed when propyl magnesium bromide is treated with CO_2 followed by acid hydrolysis is:

(A) C_3H_7COOH
(B) C_2H_5COOH
(C) CH_3COOH
(D) C_3H_7OH

10. The best reagent for converting propanamide into propanamine is ....

(A) excess H_2
(B) Br_2 in aqueous NaOH
(C) iodine in the presence of red phosphorus
(D) $LiAlH_4$ in ether

11. Which of the following statements is not true about glucose?

(A) It is an aldohexose.
(B) On heating with HI it forms *n*-hexane.
(C) It exists in furanose form.
(D) It does not give Schiff's test.

12. An unripe mango placed in a concentrated salt solution to prepare pickle, shrivels because ....

(A) it gains water due to osmosis
(B) it loses water due to reverse osmosis
(C) it gains water due to reverse osmosis
(D) it loses water due to osmosis

For questions number 13 to 16, two statements are given – one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below :

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false and Reason (R) is true.

13. **Assertion (A):** $[Cr(H_2O)_6]Cl_2$ and $[Fe(H_2O)_6]Cl_2$ are example of homoleptic complexes.

Reason (R): All the ligands attached to the metal are the same.

14. **Assertion (A):** The boiling points of alkyl halides decrease in the order :

RI > RBr > RCl > RF.

Reason (R): The boiling points of alkyl chlorides, bromides and iodides are considerably higher than that of the hydrocarbon of comparable molecular mass.

15. **Assertion (A):** The boiling points of ethanol is higher than that of methoxymethane.

Reason (R): There is intramolecular hydrogen bonding in ethanol.

16. **Assertion (A):** All naturally occurring α-amino acids except glycine are optically active.

Reason (R): Most naturally occurring amino acids have L-configuration.

SECTION – B

17. **(A)** Give reasons: **[1+1=2]**

(a) Cooking is faster in pressure cooker than in an open pan.

(b) On mixing liquid X and liquid Y, volume of the resulting solution decreases. What type of deviation from Raoult's law is shown by the resulting solution? What change in temperature would you observe after mixing liquids X and Y?

OR

(B) Define Azeotrope. What type of Azeotrope is formed by negative deviation from Raoult's law? Give an example. **[2]**

18. Complete and balance the following chemical equations:

(a) $2MnO_4^-(aq) + 10I^-(aq) + 16H^+(aq) \rightarrow$

(b) $Cr_2O_7^{2-}(aq) + 6Fe^{2+}(aq) + 14H^+(aq) \rightarrow$ **[2]**

19. Would you expect benzaldehyde to be more reactive or less reactive in nucleophilic addition reactions than propanal? Justify your answer. **[2]**

20. Identify A and B in each of the following reaction sequence: **[1+1=2]**

(a) $CH_3CH_2Cl \xrightarrow{NaCN} A \xrightarrow{H_2/Ni} B$

(b) $C_6H_5NH_2 \xrightarrow[0\text{-}5°C]{NaNO_2/HCl} A \xrightarrow[H^+]{C_6H_5NH_2} B$

21. Write the reaction involved when D-glucose is treated with the following reagents : **[1+1=2]**

(a) HCN
(b) Br_2 water

SECTION – C

22. A solution of glucose (molar mass = 180 g mol^{-1}) in water has a boiling point of 100.20 °C. Calculate the freezing point of the same solution. Molal constants for water K_f and K_b are 1.86 K kg mol^{-1} and 0.512 K kg mol^{-1} respectively. **[3]**

23. **(a)** State the following:

(i) Kohlrausch law of independent migration of ions and

(ii) Faraday's first law of electrolysis.

(b) Using $E°_{values}$ of X and Y given below, predict which is better for coating the surface of iron to prevent corrosion and why ?

Given $E°_{X^{2+}/X} = -2.36$ V,

$E°_{Y^{2+}/Y} = -0.14$ V,

$E°_{Fe^{2+}/Fe} = -0.44$ V **[3]**

24. A certain reaction is 50% complete in 20 minutes at 300 K and the same reaction is 50% complete in 5 minutes at 350 K. Calculate the activation energy if it is a first order reaction.

[R = 8.314 J K^{-1} mol^{-1}; log 4 = 0.602] **[3]**

25. The elements of 3*d* transition series are given as :

Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn **[1+1+1=3]**

Answer the following :

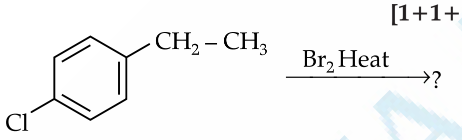
(a) Copper has exceptionally positive $E°_{M^{2+}/M}$ value, why ?

(b) Which element is a strong reducing agent in +2 oxidation state and why ?

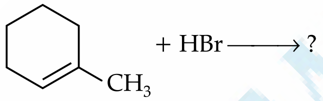
(c) Zn^{2+} salts are colourless. Why ?

26. **(A)** Draw the structure of the major monohalo product for each of the following reaction: **[1+1+1=3]**

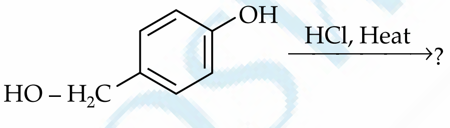
(a)



(b)



(c)



OR

(B) How do you convert: **[3×1=3]**

(a) Chlorobenzene to biphenyl

(b) Propene to 1-Iodopropane

(c) 2-bromobutane to but-2-ene.

27. **(a)** Arrange the following compounds in increasing order of their boiling point : **[1+2=3]**

$(CH_3)_2NH$, $CH_3CH_2NH_2$, CH_3CH_2OH.

(b) Give plausible explanation for each of the following :

(i) Aromatic primary amines cannot be prepared by Gabriel Phthalimide synthesis.

(ii) Amides are less basic than amines.

28. **(a)** What is the difference between native protein and denatured protein ? **[1+1+1=3]**

(b) Which one of the following is a disaccharide ? Glucose, Lactose, Amylose, Fructose

(c) Which vitamin is responsible for the coagulation of blood ?

SECTION – D

The following questions are case based questions. Read the passage carefully and answer the questions that follow.

29. The rate of a chemical reaction is expressed either in terms of decrease in the concentration of reactants or increase in the concentration of a product per unit time. Rate of the reaction depends upon the nature of reactants, concentration of reactants, temperature, presence of catalyst, surface area of the reactants and presence of light. Rate of reactions is directly related to the concentration of reactant. Rate law states that the rate of reaction depends upon the concentration terms on which the rate of reaction actually depends, as observed experimentally. The sum of powers of the concentration of the reactants in the Rate law expression is called order of reaction while the number of reacting species taking part in an elementary reaction which must collide simultaneously in order to bring about a chemical reaction is called molecularity of the reaction.

Answer the following questions: **[1+1=2]**

(a) **(i)** What is a rate determining step ?

(ii) Define complex reaction.

(b) What is the effect of temperature on the rate constant of a reaction ? **[1]**

OR

(b) Why is molecularity applicable only for elementary reactions whereas order is applicable for elementary as well as complex reactions ? **[1]**

(c) The conversion of molecule X to Y follows second order kinetics. If concentration of X is increased 3 times, how will it affect the rate of formation of Y? **[1]**

30. Phenols undergo electrophilic substitution reactions readily due to the strong activating effect of OH group attached to the benzene ring. Since, the OH group increases the electron density more to *o*– and *p*–positions therefore OH group is *ortho*, *para*-directing. Reimer–Tiemann reaction is one of the examples of aldehyde group being introduced on the aromatic ring of phenol, *ortho* to the hydroxyl group. This is a general method used for the *ortho*-formylation of phenols.

Answer the following questions:

(a) What happens when phenol reacts with

(i) Br_2/CS_2

(ii) Conc. HNO_3 **[2]**

(b) Why phenol does not undergo protonation readily ? **[1]**

(c) Which is a stronger acid – phenol or cresol ? Give reasons. **[1]**

OR

(c) Write the IUPAC name of the product formed in the Reimer–Tiemann reaction. **[1]**

SECTION – E

31. **(A) (a)** Write the cell reaction and calculate the e.m.f. of the following cell at 298 K : **[3+2=5]**

$Sn(s) | Sn^{2+} (0.004\ M) || H^{+} (0.02M | H_2(g)\ (1\ Bar) | Pt(s)$

(Given : $E^\circ_{Sn^{2+}/Sn} = -0.14\ V, E^\circ_{H^+|H_2(g), Pt} = 0.00V$)

(b) Account for the following :

(i) On the basis of E° values, O_2 gas should be liberated at anode but it is Cl_2 gas which is liberated in the electrolysis of aqueous NaCl.

(ii) Conductivity of CH_3COOH decreases on dilution.

OR

(B) (a) Write the anode and cathode reaction and the overall cell reaction occurring in a lead storage battery during its use. **[2+3=5]**

(b) Calculate the potential for half-cell containing 0.01 M $K_2Cr_2O_7$(aq), 0.01 M Cr^{3+} (aq) and 1.0×10^{-4} M H^{+}(aq).

The half cell reaction is

$$Cr_2O_7^{2-}(aq) + 14H^{+}(aq) + 6e^{-} \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$$

and the standard electrode potential is given as $E^\circ = 1.33$ V. [Given : log 10 = 1]

32. **(A)** Answer the following: **[5]**

(a) Low spin tetrahedral complexes are not known.

(b) Co^{2+} is easily oxidised to Co^{3+} in the presence of a strong ligand [At. No. of Co = 27]

(c) What type of isomerism is shown by the complex $[Co(NH_3)_6]\ [Cr(CN)_6]$?

(d) Why a solution of $[Ni(H_2O)_6]^{2+}$ is green while a solutions of $[Ni(CN)_4]^{2-}$ is colourless. (At. No. of Ni = 28)

(e) Write the IUPAC name of the following complex : $[Co(NH_3)_5(CO_3)]\ Cl$

OR

(B) (a) What is meant by 'Chelate effect' ? Give an example.

(b) Write the hybridisation and magnetic behaviour of $[Fe(CN)_6]^{4-}$.

(Atomic number : Fe = 26)

(c) If $PtCl_2{\cdot}2NH_3$ does not react with $AgNO_3$, what will be its formula ? **[2+2+1=5]**

33. **(A) (a)** Carry out the following conversions :

(i) Ethanal to But-2-enal

(ii) Propanoic acid to ethane **[2+3=5]**

(b) An alkene A with molecular formula C_5H_{10} on ozonolysis gives a mixture of two compounds B and C. Compound B gives positive Fehling test and also reacts with iodine and NaOH solution. Compound C does not give Fehling solution test but forms iodoform. Identity the compounds A, B and C.

OR

(B) An organic compound (A) (molecular formula $C_8H_{16}O_2$) was hydrolysed with dilute sulphuric acid to get a carboxylic acid (B) and an alcohol (C). Oxidation of (C) with chromic acid produced (B). (C) on dehydration gives But-1-ene. Identify (A), (B) and (C) and write chemical equations for the reactions involved. **[5]**

Delhi Set-2 — Code - 56/1/2

Note: *Except these, all other questions have been given in Delhi Set-1*

SECTION – B

18. When $FeCr_2O_4$ is fused with Na_2CO_3 in the presence of air it gives a yellow solution of compound (A). Compound (A) on acidification gives compound (B). Compound (B) on reaction with KCl forms an orange coloured (C). An acidified solution of compound (C) oxidises iodide to (D). Identify (A), (B), (C) and (D). **[2]**

21. Give reasons for the following :

(a) The melting points of α-amino acids are generally higher than that of the corresponding carboxylic acids.

(b) Amino acids show amphoteric behaviour. **[2]**

SECTION – C

22. A solution containing 15 g urea (molar mass = 60 g mol^{-1}) per litre of solution in water has the same osmotic pressure (isotonic) as a solution of glucose (molar mass= 180 g mol^{-1}) in water. Calculate the mass of glucose present in one litre of its solution. **[3]**

23. Calculate $\Delta_r G^\circ$ and log K_c of the reaction :

$Fe^{2+}(aq) + Ag^{+}(aq) \rightarrow Fe^{3+}(aq) + Ag(s)$

Given $E^\circ_{Ag^+/Ag} = 0.80$ V, $E^\circ_{Fe^{3+}/Fe^{2+}} = 0.77$ V

[R = 8.314 J $K^{-1}mol^{-1}$, F = 96500 C mol^{-1}] **[3]**

24. **(a)** Arrange the following in decreasing order of pK_b:

Aniline, *p*-nitroaniline, *p*-methylaniline :

(b) Account for the following:

(i) Diazonium salts of aromatic amines are more stable than those of aliphatic amines.

(ii) Methylamine in water reacts with $FeCl_3$ to precipitate hydrated ferric oxide. **[1+2=3]**

28. **(a)** Write the reaction when D-glucose reacts with the following:

(i) NH_2OH

(ii) Acetic anhydride

(b) Why vitamin C cannot be stored in our body? **[3]**

SECTION – E

32. **(A)** For the complex $[Fe(en)_2Cl_2]\,Cl$, identify: **[5]**

(a) the oxidation number of iron.

(b) the hybridisation and the shape of the complex.

(c) the magnetic behaviour of the complex

(d) whether there is an optical isomer of the complex ? If so draw its structure.

(e) IUPAC name of the complex.

(At. no. of Fe = 26)

OR

(B) **(a)** Using IUPAC norms write the names of the following :

(i) $[Co(NH_3)_4\,Cl(NO_2)]Cl$

(ii) $K_3[Fe(CN)_6]$

(iii) $[Cr(C_2O_4)_3]^{3-}$

(b) What is crystal field splitting energy? Why low spin tetrahedral complexes are not formed ? **[3+2=5]**

Delhi Set-3 Code - 56/1/3

Note: *Except these, all other questions have been given in Delhi Set-1 & Set-2*

SECTION – B

18. Complete and balance the following chemical equations :

(a) $8MnO_4^- + 3S_2O_3^{2-} + H_2O \rightarrow$

(b) $Cr_2O_7^{2-} + 3\,Sn^{2+} + 14H^+ \rightarrow$ **[2]**

21. What are the hydrolysis products of:

(a) Sucrose **(b)** Lactose

SECTION – C

22. Henry's law constant for CO_2 in water is 1.67×10^8 Pa at 298 K. Calculate the number of moles of CO_2 in 500 ml of soda water when packed under 2.53×10^5 Pa at the same temperature.

23. Calculate $\Delta_r G°$ and $\log K_C$ of the reaction.

$2Cr(s) + 3Cd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Cd(s)$

Given $E°_{Cr^{3+}/Cr} = -0.74$ V

$E°_{Cd^{2+}/Cd} = -0.40$ V

$[R = 8.314\ J\ K^{-1}\ mol^{-1},\ F = 96500\ C\ mol^{-1}]$

24. The rate of a reaction quadruples when the temperature changes from 293 K to 313 K. Calculate the energy of activation of the reaction assuming that it does not change with temperature.

[Given: log 4 = 0.602, log 2 = 0.301, $R = 8.314\ J\ K^{-1}\ mol^{-1}$]

28. Define the following terms :

(a) Native protein

(b) Nucleotide

(c) Essential amino acid

SECTION – E

32. **(A)** In the following complex ions, explain the type of hybridisation, shape and magnetic property:

(a) $[Fe(H_2O)_6]^{2+}$ **[2.5×2=5]**

(b) $[NiCl_4]^{2-}$

(At. Nos.: Fe= 26, Ni = 28)

(B) **(a)** Write IUPAC names of the following: **[3+2=5]**

(i) $[Co(H_2O)(CN)(en)_2]^{2+}$

(ii) $[PtCl_4]^{2-}$

(iii) $[Cr(NH_3)_4Cl(ONO)]^+$

(b) What is spectrochemical series? Write the difference between a strong field ligand and a weak field ligand.

Outside Delhi Set-1 Code - 56/2/1

Note: *Please follow the Since General Instructions as given in Delhi Set-1*

SECTION – A

Questions No. 1 to 16 are Multiple Choice type questions carrying 1 mark each.

1. The charge required for the reduction of 1 mol of MnO_4 to MnO_2 is

(A) 1 F **(B)** 3 F

(C) 5 F **(D)** 6 F

2. Which among the following is a false statement ?

(A) Rate of zero order reaction is independent of initial concentration of reactant.

(B) Half-life of a zero order reaction is inversely proportional to the rate constant.

(C) Molecularity of a reaction may be zero.

(D) For a first order reaction, $t_{1/2} = 0.693/k$

3. The number of molecules that react with each other in an elementary reaction is a measure of the :

(A) activation energy of the reaction

(B) stoichiometry of the reaction.

(C) molecularity of the reaction

(D) order of the reaction

4. The element having $[Ar]3d^{10}4s^1$ electronic configuration is:

(A) Cu **(B)** Zn

(C) Cr **(D)** Mn

5. The complex ions $[Co(NH_3)_5\,(NO_2)]^{2+}$ and $[Co(NH_3)_5\,ONO)]^{2+}$ are called

(A) Ionisation isomers

(B) Linkage isomers

(C) Co-ordination isomers

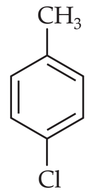
(D) Geometrical isomers

6. The diamagnetic species is :

(A) $[Ni(CN_4)]^{2-}$ **(B)** $[NiCl_4]^{2-}$

(C) $[Fe(CN)_6]^{3-}$ **(D)** $[CoF_6]^{3-}$

7. Which is the correct IUPAC name for



(A) Methylchlorobenzene
(B) Toluene
(C) 1–Chloro–4–Methylbenzene
(D) 1–Methyl–4–Chlorobenzene

8. What will be formed after oxidation reaction of secondary alcohol with chromic anhydride (CrO_3)?
(A) Aldehyde **(B)** Ketone
(C) Carboxylic acid **(D)** Ester

9. The conversion of phenol to salicylic acid can be accomplished by
(A) Reimer–Tiemann reaction
(B) Friedel–Crafts reaction
(C) Kolbe reaction
(D) Coupling reaction

10. Which of the following is/are examples of denaturation of protein?
(A) Coagulation of egg white
(B) Curdling of milk
(C) Clotting of blood
(D) Both (A) and (B)

11. Nucleotides are joined together by
(A) Glycosidic linkage
(B) Peptide linkage
(C) Hydrogen bonding
(D) Phosphodiester linkage

12. Scurvy is caused due to deficiency of
(A) Vitamin B1 **(B)** Vitamin B2
(C) Ascorbic acid **(D)** Glutamic acid

For question number 13 to 16, two statements are given–one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below :

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

13. **Assertion (A):** In a first order reaction, if the concentration of the reactant is doubled, its half-life is also doubled.
Reason (R): The half-life of a reaction does not depend upon the initial concentration of the reactant in a first order reaction.

14. **Assertion (A):** Cu cannot liberate H_2 on reaction with dilute mineral acids.
Reason (R): Cu has positive electrode potential.

15. **Assertion (A):** Aromatic primary amines cannot be prepared by Gabriel Phthalimide synthesis.
Reason (R): Aryl halides do not undergo nucleophilic substitution reaction with the anion formed by phthalimide.

16. **Assertion (A):** Vitamin D cannot be stored in our body.
Reason (R): Vitamin D is fat soluble vitamin and is not excreted from the body in urine.

SECTION – B

17. **(A)** The rate constant for a zero order reaction A→P is 0.0030 mol $L^{-1}s^{-1}$. How long will it take for the initial concentration of A to fall from 0.10 M to 0.075 M? **[2]**

OR

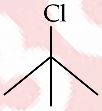
(B) The decomposition of NH_3 on platinum surface is zero order reaction. What are the rates of production of N_2 and H_2 if $k = 2.5 \times 10^{-4}$ mol L^{-1} s^{-1} ? **[2]**

18. Define the following terms: **[2×1=2]**
(a) Pseudo first order reaction
(b) Half-life period of reaction ($t_{1/2}$)

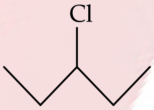
19. Examine the following observations: **[2×1=2]**
(a) Transition elements generally form coloured compounds.
(b) Zinc is not regarded as a transition element.

20. Name the following coordination compounds according to IUPAC norms : **[2×1=2]**
(a) $[Co(NH_3)_4(H_2O)Cl]Cl_2$
(b) $[CrCl_2(en)_2]Cl$

21. **(a)** In the following pair of halogen compounds, which compound undergoes S_N1 reaction faster and why? **[1]**



and



(b) Arrange the following compounds in increasing order of their reactivity towards S_N2 displacement : **[1]**
2–Bromo–2–methylbutane,
1–Bromopentane, 2–Bromopentane.

SECTION – C

22. At 25 °C the saturated vapour pressure of water is 24 mm Hg. Find the saturated vapour pressure of a 5% aqueous solution of urea at the same temperature. (Molar mass of urea = 60 g mol^{-1}) **[3]**

23. The electrical resistance of a column of 0.05 M NaOH solution of area 0.8 cm^2 and length 40 cm is 5 x 10^3 ohm. Calculate its resistivity, conductivity and molar conductivity. **[3]**

24. Complete and balance the following chemical equations: **[3×1]**
(a) $MnO_4 + C_2O_4^{2-} + H^+ \longrightarrow$
(b) $KMnO_4 \xrightarrow[513\,K]{Heat}$
(c) $Cr_2O_7^{2-} + H_2S + H^+ \longrightarrow$

25. Using valence bond theory, explain the hybridisation and magnetic character of the following: **[2×1.5=3]**
(a) $[Co(NH_3)_6]^{3+}$
(b) $[Ni(CO)_4]$
[At. no. : Co= 27, Ni = 28]

26. **(a)** Define the following: **[2+1=3]**

(i) Enantiomers

(ii) Racemic mixture

(b) Why is chlorobenzene resistant to nucleophilic substitution reaction?

27. **(A)** Explain the following reactions and write chemical equation involved: **[3×1=3]**

(a) Wolff–Kishner reduction

(b) Etard reaction

(c) Cannizzaro reaction

OR

(B) Write the structures of A, B and C in the following sequence of reactions: **[2×1.5=3]**

(a) $CH_3COOH \xrightarrow{SOCl_2} A \xrightarrow{H_2,Pd-BaSO_4} B \xrightarrow{H_2N-NH_2} C$

(b) $CH_3CN \xrightarrow[2.H_2O]{1.(DIBAL-H)} A \xrightarrow{Dil.NaOH} B \xrightarrow{\Delta} C$

28. Define the following terms: **[3×1=3]**

(a) Glycosidic linkage

(b) Invert sugar

(c) Oligosaccharides

SECTION – D

29. The spontaneous flow of the solvent through a semipermeable membrane from a pure solvent to a solution or from a dilute solution to a concentrated solution is called osmosis. The phenomenon of osmosis can be demonstrated by taking two eggs of the same size. In an egg, the membrane below the shell and around the egg material is semipermeable. The outer hard shell can be removed by putting the egg in dilute hydrochloric acid. After removing the hard shell, one egg is placed in distilled water and the other in a saturated salt solution. After some time, the egg placed in distilled water swells-up while the egg placed in salt solution shrinks. The external pressure applied to stop the osmosis is termed as osmotic pressure (a colligative property). Reverse osmosis takes place when the applied external pressure becomes larger than the osmotic pressure.

(a) Define reverse osmosis. Name one SPM which can be used in the process of reverse osmosis. **[2]**

(b) **(i)** What do you expect to happen when red blood corpuscles (RBC's) are placed in 0.5% NaCl solution? **[1]**

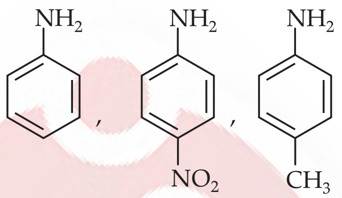
OR

(b) **(ii)** Which one of the following will have higher osmotic pressure in 1 M KCl or 1 M urea solution. Justify your answer. **[1]**

(c) Why osmotic pressure is a colligative property? **[1]**

30. Amines have a lone pair of electrons on nitrogen atom due to which they behave as Lewis base. Greater the value of K_b or smaller the value of pK_b, stronger is the base. Amines are more basic than alcohols, ethers, esters, etc. The basic character of aliphatic amines should increase with the increase of alkyl substitution. But it does not occur in a regular manner as a secondary aliphatic amine is unexpectedly more basic than a tertiary amine in aqueous solutions. Aromatic amines are weaker bases than ammonia and aliphatic amines. Electron releasing groups such as $-CH_3$, $-OCH_3$, $-NH_2$, etc., increase the basicity while electron-withdrawing substituents such as $-NO_2$, $-CN$, halogens, etc., decrease the basicity of amines. The effect of these substitute is more at p^- than at m^- position.

(a) Arrange the following in the increasing order of their basic character. Give reason: **[2]**



(b) Why pK_b of aniline is more than that of methylamine? **[2]**

(c) **(i)** Arrange the following in the increasing order of their basic character in an aqueous solution: **[2]**

$(CH_3)_3N$, $(CH_3)_2NH$, NH_3, CH_3NH_2

OR

(c) **(ii)** Why ammonolysis of alkyl halides is not a good method to prepare pure amines?

SECTION – E

31. **(A)** **(a)** Give IUPAC name of $CH_3 - CH = CH - CHO$. **[1]**

(b) Give a simple chemical test to distinguish between propanal and propanone. **[1]**

(c) How will you convert the following: **[3]**

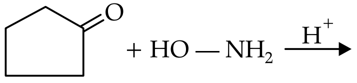
(i) Toluene to benzoic acid

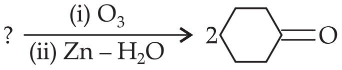
(ii) Ethanol to propan–2–ol

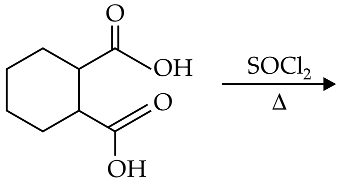
(iii) Propanal to 2–hydroxy propanoic acid

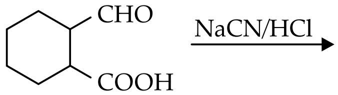
OR

(B) Complete each synthesis by giving missing starting material, reagent or products: **[5×1=5]**

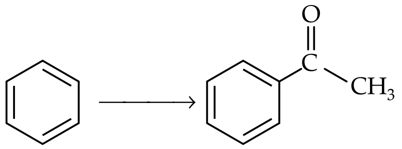
(a)


(b)


(c)


(d)


(e)



32. (A) (a) Calculate the standard Gibbs energy ($\Delta rG°$) of the following reaction at 25 °C: **[3+2=5]**

$Au(s) + Ca^{2+}(1M) \rightarrow Au^{3+}(1M) + Ca(s)$

$E°_{Au^{3+}/Au} = + 1.5\ V, E°_{Ca^{2+}/Ca} = –2.87\ V$

Predict whether the reaction will be spontaneous or not at 25 °C.

[1 F = 96500 C mol^{-1}]

(b) Tarnished silver contains Ag_2S. Can this tarnish be removed by placing tarnished silverware in an aluminium pan containing an inert electrolytic solution such as NaCl? The standard electrode potential for half reaction:

$Ag_2S(s) + 2e– \rightarrow 2Ag(s) + S^{2–}$ is –0.71 V and for $Al^{3+} + 3e^– \rightarrow 2Al(s)$ is –1.66 V

OR

(B) (a) Define the following: **[2+3=5]**

(i) Cell potential

(ii) Fuel cell

(b) Calculate emf of the following cell at 25 °C :

$Zn(s)_{(0.1M)} \mid Zn^{2+}{}_{(0.1M)} \mid\mid Cd^{2+}{}_{(0.01M)} \mid Cd(s)$

Given : $E°_{Cd^{2+}/Cd} = –0.40\ V$

$E°_{Zn2+/Zn} = –0.76\ V$

[log 10 = 1]

33. (A) An organic compound 'A', molecular formula C_2H_6O oxidises with CrO_3 to form a compound 'B'. Compound 'B' on warming with iodine and aqueous solution of NaOH gives a yellow precipitate of compound 'C'. When compound 'A' is heated with conc. H_2SO_4 at 413 K gives a compound 'D', which on reaction with excess HI gives compound 'E'. Identify compounds 'A', 'B', 'C', 'D' and 'E' and write chemical equations involved.

OR

(B) (a) Write chemical equations of the following reactions:

(i) Phenol is treated with conc. HNO_3

(ii) Propene is treated with B_2H_6 followed by oxidation by $H_2O_2/OH^–$.

(iii) Sodium *t*-butoxide is treated with CH_3Cl.

(b) Give a simple chemical test to distinguish between butan–1–ol and butan–2–ol.

(c) Arrange the following in increasing order of acid strength: phenol, ethanol, water

Outside Delhi Set-2 Code - 56/2/2

Note: *Except these, all other questions have been given in Outside Delhi Set-1*

SECTION – B

18. A reaction is of second order with respect to a reactant. How is the rate of reaction affected if the concentration of the reactant is **(i)** doubled **(ii)** reduced to half? **[2]**

19. When $FeCr_2O_4$ is fused with Na_2CO_3 in the presence of air it gives a yellow solution of compound (A). Compound (A) on acidification gives compound (B). Compound (B) on reaction with KCl forms an orange coloured (C). An acidified solution of compound (C) oxidises Na_2SO_3 to (D). Identify (A), (B), (C) and (D). **[2]**

20. Explain $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex. [At. No. Co = 27, Ni = 28] **[2]**

SECTION – C

22. A solution containing 15 g urea (molar mass = 60 g mol^{-1}) per litre of solution in water has the same osmotic pressure (isotonic) as a solution of glucose (molar mass = 180 g mol^{-1}) in water. Calculate the mass of glucose present in one litre of its solution. **[3]**

23. Calculate $\Lambda°m$ for acetic acid and its degree of dissociation (α) if its molar conductivity is 48.1 Ω^{-1} cm^2 mol^{-1}.

Given that

$\Lambda°m(HCl) = 426\ \Omega^{-1}\ cm^2\ mol^{-1}$

$\Lambda°m(NaCl) = 126\ \Omega^{-1}\ cm^2$ mol–1

$\Lambda°m(CH_3COONa) = 91\ \Omega^{-1}\ cm^2\ mol^{-1}$ **[3]**

24. (a) Of the d^4 species, Cr^{2+} is strongly reducing while Mn^{3+} is strongly oxidising. Why?

(b) Write two consequences of lanthanoid contraction.

(c) Which element of 3*d* series has lowest enthalpy of atomisation and why? **[3×1]**

25. Write IUPAC names of the following coordination entities:

(a) $[Fe(en)_2Cl_2]^+$

(b) $[Co(NH_3)_4H_2O)Br]SO_4$

(c) $[Ni\ (CN)_4]^{2–}$ **[3]**

28. (a) Write the product obtained when D-g1ucose reacts with $H_2N–OH$.

(b) Amino acids show amphoteric behaviour, why ?

(c) Why vitamin C cannot be stored in our body ?

Outside Delhi Set-3 Code - 56/2/3

Note: *Except these, all other questions have been given in Outside Delhi Set-1 & Set-2*

SECTION – B

18. What is meant by the Rate law and Rate constant of a reaction. Identify the order of a reaction if the units of its Rate constant are : **[2]**

(a) s^{-1} **(b)** $mol^{-1}\ Ls^{-1}$

19. Complete and balance the following chemical equations: **[2×1=2]**

(a) $8MnO_4^- + 3S_2O_3^{2-} + H_2O \longrightarrow$

(b) $Cr_2O_7^{2-} + 3Sn^{2+} + 14H^+ \longrightarrow$

21. Give reasons for the following observations :

(a) *p*-Chloronitrobenzene reacts with (aq)NaOH at 443 K to give *p*-nitrophenol whereas chlorobenzene reacts with the same reagent at 623 K and 300 atm. **[1+1]**

(b) Main product obtained when chloroethane reacts with KCN is propane nitrile while with AgCN it is ethyl isocyanide.

SECTION – C

22. Henry's law constant for CO_2 in water is 1.67×10^8 Pa at 298 K. Calculate the number of moles of CO_2 in 540 g of soda water when packed under 3.34×10^5 Pa at the same temperature. **[3]**

23. Give reasons: **[3×1=3]**

(a) Fuel cells are preferred for production of electrical energy than thermal plants.

(b) Iron does not rust even if zinc coating is broken in a galvanised pipe.

(c) In the experimental determination of electrolytic conductance, Direct Current (DC) is not used.

24. (a) $E^\circ_{(Mn^{2+}/Mn)}$ is –1.18 V. Why is this value highly negative in comparison to neighbouring *d*-block elements? **[3×1=3]**

(b) What is lanthanoid contraction?

(c) Zn, Cd and Hg are soft metals. Why?

25. (a) Using valence bond theory, explain the hybridisation and magnetic behaviour of the following: **[2+1=3]**

(i) $[Co(NH_3)_6]Cl_3$

(ii) $K_2[NiCl_4]$

(At. no.: Co= 27, Ni = 28]

(b) Write the electronic configuration of d^5 ion when $\Delta_o > P$.

28. Define the following terms: **[2+1=3]**

(a) Native protein

(b) Nucleotide

(c) Essential amino acid

ANSWERS

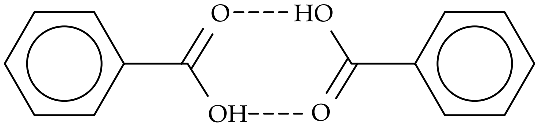
Delhi Set-1 **Code - 56/1/1**

SECTION – A

1. **Option (A) is correct.**

Explanation: Association results in the formation of bigger molecules that are held together by intermolecular hydrogen bond and behave like a single particle. Consequently, the experimentally determined molar mass increases.

For example: Benzoic acid exist a as a dimer:



2. **Option (B) is correct.**

Explanation: The cell is represented as: $Cr/Cr^{3+}||Sn^{4+}/Sn^{2+}$

$$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$$
$$= 0.15 - (-0.74)$$
$$= +0.89\text{ V}$$

3. **Option (B) is correct.**

Explanation: $Cr^{3+} = [Ar]3d^3 4s^0$, it has 3 unpaired electrons.

$$\mu = \sqrt{n(n+2)} = \sqrt{3(3+2)}$$
$$= \sqrt{15} = 3.87\text{ BM}$$

4. **Option (D) is correct.**

Explanation: $5\,SO_3^{2-} + 2\,MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 3\,H_2O + 5\,SO_4^{2-}$

5. **Option (B) is correct.**

Explanation: I.U.P.A.C. Name of ion will be: Diamminedichloridoplatinum(IV)

6. **Option (C) is correct.**

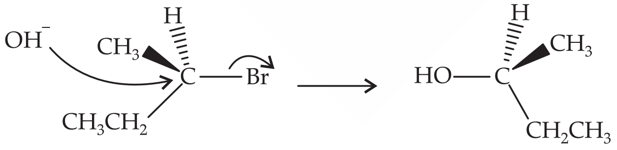
Explanation: The boiling points of isomeric haloalkanes decrease with an increase in branching because the higher the branching in the haloalkanes, the smaller their surface area becomes. This, in turn, reduces the Van der Waals forced of attraction in the molecule.

Order of boiling point:

2-Bromo-2-methylpropane<1-Bromo-2-methyl propane<1-Bromobutane

7. **Option (C) is correct.**

Explanation: Bimolecular mechanism in nucleophilic substitution is S_N2 which involves inversion of configuration, known as Walden inversion. Example:



(R) - 2 - Bromobutane (S) - 2 - Butanol

8. **Option (A) is correct.**

Explanation: $C_6H_5OH > H_2O > ROH$

The acidic nature depends on the stability of the conjugate base. Phenol forms a more stable phenoxide ion and is appreciably acidic.

ROH is the least acidic, as its conjugate base RO^- is unstable than OH^- which is formed by H_2O, because of positive inductive effect of alkyl group.

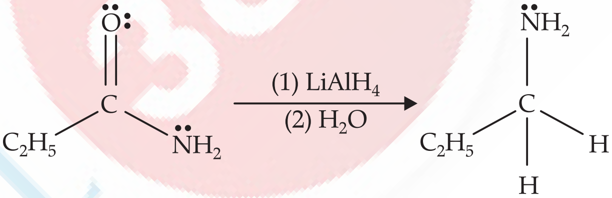
9. **Option (A) is correct.**

Explanation: Butanoic acid is formed as per the reaction:

$$CH_3CH_2CH_2MgBr + CO_2 \longrightarrow CH_3\text{—}CH_2\text{—}CH_2\text{—}COO\overset{-}{H}\overset{+}{Mg}Br \xrightarrow{H_2O/H^+} CH_3CH_2CH_2COOH + Mg(OH)Br$$

10. **Option (D) is correct.**

Explanation: $LiAlH_4$ in ether acts as a good reducing agent and reduces amide to primary amines.



Propanamide Propanamine

11. **Option (D) is correct.**

Explanation: It does not respond to Schiff's test, as glucose contains an aldehyde group in its open structure but forms a cyclic structure. This structure is quite stable and is not broken down by Schiff's reagent which is a weak base. Glucose exists primarily as pyranose structure but it also exists in furanose structure.

12. **Option (D) is correct.**

Explanation: When a raw mango is placed in a concentrated salt solution, it loses water due to osmosis. It shrivels up and is used to make pickle. Water flows from a solution of lower concentration to higher concentration.

13. **Option (A) is correct.**

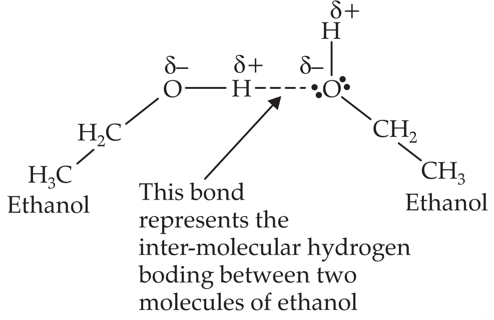
Explanation: A homoleptic complex is one in which all the ligands (molecules or ions surrounding the central metal ion) are identical. Since, both of these complexes have only water molecules as ligands, they are indeed homoleptic complexes.

14. **Option (B) is correct.**

For the same alkyl group, the boiling point of haloalkanes decreases in the order:
RI>RBr>RCl>RF.
This is due to the increase in Van der Waals forces when the size and mass of the halogen atom increase. The boiling point of alkyl halides are higher than hydrocarbon of comparable molecular mass because alkyl halides are polar while hydrocarbons are non polar in nature.

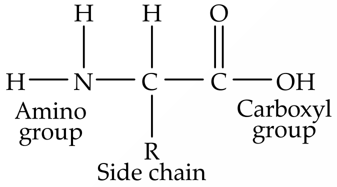
15. Option (C) is correct.

***Explanation*:** The boiling point of ethanol is higher than methoxymethane due to intermolecular hydrogen bonding and not intramolecular hydrogen bonding.



16. Option (B) is correct.

***Explanation*:** The optical activity is because of their asymmetric structure present in α alkyl substituted amino acids and not because of its *L* configuration.



SECTION – B

17. (A) (a) Pressure inside a pressure cooker is artificially increased. As the pressure inside the cooker rises, the boiling point of the liquid also increases. This higher temperature accelerates the cooking process significantly.

(b) On mixing *X* and *Y*, if the volume of the solution decreases, it means that the interaction between the *X-X* and *Y-Y* molecules reduces and the intermolecular interactions between *X* and *Y* increases. This leads to negative deviation of Raoult's law. Due to the decrease in vapour pressure, the boiling point of the solution increases. The temperature of the solution increases which means $\Delta H = -$ve.

So, it is an exothermic reaction.

OR

(B) Azeotropes: Azeotropes are binary mixture that have the same composition in the liquid and vapour phases and boil at constant temperatures. Azeotropes showing negative deviation from Raoult's law form maximum boiling azeotropes at a specific composition.

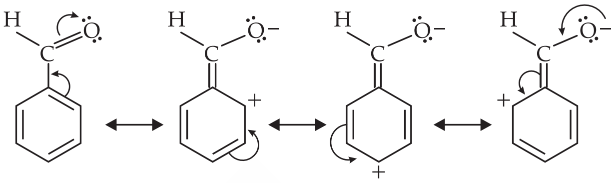
Example: Azeotrope formed from nitric acid and water.

18. (a) $2MnO_4^- + 10I^- + 16H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 5I_2$

(b) $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

19. Benzaldehyde is less reactive than propanal towards nucleophilic addition reactions.

In benzaldehyde, there is a resonance of carbonyl group which withdraw electron cloud towards itself, reducing the electrophilicity of the carbonyl carbon.

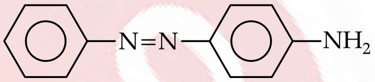


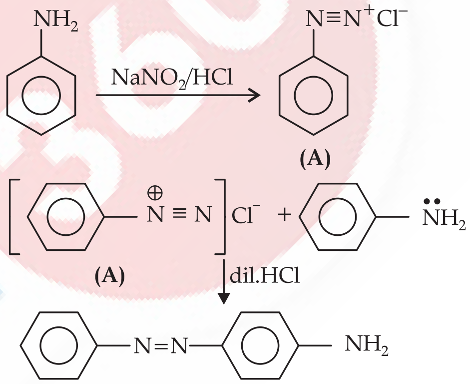
20. (a) $A = CH_3CH_2CN$

$B = CH_3CH_2CH_2NH_2$

$$CH_3CH_2Cl + NaCN \rightarrow \underset{\text{Ethyl cyanide (A)}}{CH_3CH_2CN} \xrightarrow{H_2/Ni} \underset{\text{Propanamine (B)}}{CH_3CH_2CH_2NH_2}$$

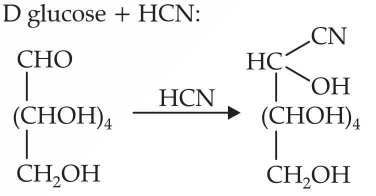
(b) $A = C_6H_5N^{2+}Cl^-$

B = 



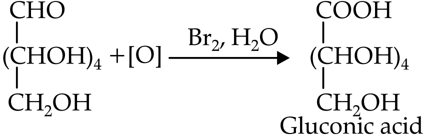
(B) (Yellow dye)

21. (a) D glucose + HCN:



Glucose Glucose cyanohydrin

(b) D-Glucose+ Br$_2$/water:



Gluconic acid

SECTION – C

22. T_b of glucose solution = 100.20°C,

$$\Delta T_b = 100.20 - 100 = 0.20°C$$
$$\Delta T_b = K_b \times m \text{ (where, } m = \text{molality)}$$
$$m = 0.20/0.512\ m = 0.390 \text{ mol/kg}$$
$$\Delta T_f = K_f \times m = 1.86 \times 0.390$$
$$= 0.725\ °C$$

Freezing point of solution = 0 – 0.725 = –0.725 °C

23. **(a)** **(i)** Kohlrausch's law states that the molar conductivity of an electrolyte at infinite dilution is equal to the sum of the limiting molar conductivity of the anions and cations.

$\Lambda_m^\circ = \nu_+ \lambda_+^\circ + \nu_- \lambda_-^\circ$

Here λ_+° and λ_-° are limiting molar conductivities of cations and anions.

(ii) Faraday's First Law of Electrolysis: The mass of a substance deposited at any electrode is directly proportional to the amount of charge passed.

(b) As corrosion is a phenomenon involving the oxidation of iron, it is essential to consider the oxidation potentials of all elements. An element with a higher oxidation potential than Fe will oxidise faster than iron preventing corrosion in iron.

As per given data, oxidation potential of: $E^\circ_{Fe^{2+}/Fe} = -0.44$ V, $E^\circ_{X^{2+}/X} = -2.36$ V, $E^\circ_{Y^{2+}/Y} = -0.14$ V

As $E^\circ_{X^{2+}/X}$ has higher oxidation potential than iron, it can be used for coating the surface of iron.

24.

$$t_{1/2} = 0.693/k$$

$$k = 0.693/t_{1/2}$$

$$k_1 = 0.693/20 = 0.03465 \text{ min}^{-1}$$

$$k_2 = 0.693/5 = 0.1386 \text{ min}^{-1}$$

$$\log k_2/k_1 = \frac{E_a}{2.303R} \times \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

substituting the values:

$\log 4 = E_a \times 50/2.303 \times 8.314 \times 300 \times 350$

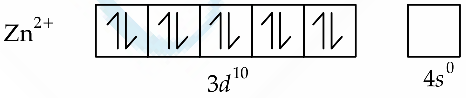
$0.602 = E_a \times 50/2.303 \times 8.314 \times 300 \times 350$

$E_a = 0.602 \times 2.303 \times 8.314 \times 2100 = 24205.8$ J/mol

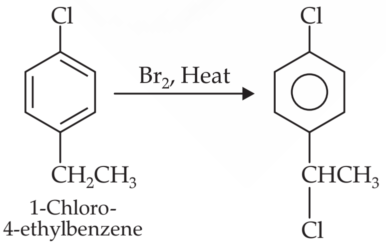
25. **(a)** The sum of enthalpy of atomization and ionisation enthalpy for copper is higher than hydration enthalpy due to this copper has positive value of $E^\circ_{Cu^{+2}/Cu}$.

(b) Cr, because Cr^{2+} which has $[Ar]3d^4 4s^0$ configuration, tends to lose one more electron forming Cr^{3+} to attain the more stable half-filled $t_{2g}^3 (d^3)$ configuration. This is proved by its negative reduction potential value.

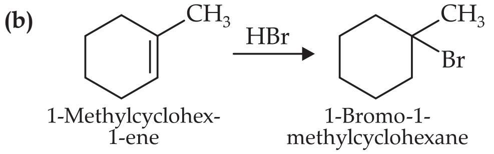
(c) Zn in its +2 state has the configuration $[Ar]3d^{10}4s^0$, indicating all electrons are paired in *d* orbitals. This does not allow *d–d* transition to occur and its salts are thus colourless.



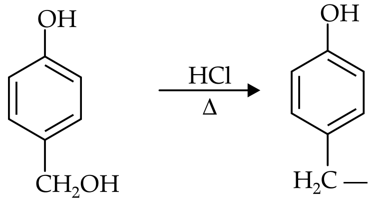
26. **(A)** **(a)**



(b)

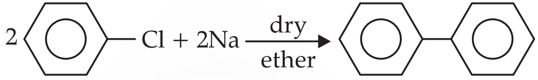


(c)



OR

(B) **(a)** Chlorobenzene to biphenyl: Fittig reaction



(b) Propene to 1-Iodopropane

$$CH_3CH = CH_2 + HBr \xrightarrow{H_2O_2} CH_3CH_2CH_2Br$$

$$CH_3CH_2CH_2Br + NaI \xrightarrow{\text{acetone}} CH_3CH_2CH_2I + NaBr$$

(c) 2 bromo butane to but-2-ene

$$CH_3CH(Br)CH_2CH_3 + \text{alcKOH} \longrightarrow CH_3CH = CHCH_3 + KBr + H_2O$$

27. **(a)** Stronger intermolecular H-bonding results in associated molecules that have higher boiling points.

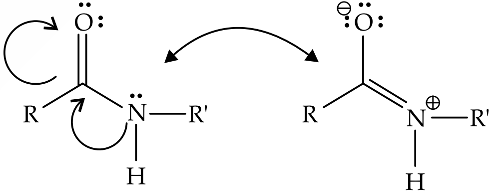
Alcohol > Amine, as O—H bond is more polar than N—H bond.

Thus, the increasing order of boiling point is:

$(CH_3)_2NH < CH_3CH_2NH_2 < CH_3CH_2OH$

(b) **(i)** Aromatic primary amines cannot be formed by this reaction as the aryl halides do not undergo nucleophilic substitution with potassium phthalimide which involves the cleavage of C—X bond. Aryl halides have double bond character in C—X bond.

(ii) In amides, the lone pair of nitrogen is involved in resonance with the carbonyl group and is not available for coordinate bond formation with a proton. But, in amine the lone pair of nitrogen available for protonation that's why amides are less basic than amines.



28. **(a)** Protein found in a biological system with unique three-dimensional structure and biological activity is called native protein.

When a protein in its native form is subjected to changes in temperature, etc, its structure is destroyed and it loses its biological activity. The protein thus formed is called denatured protein.

(b) Lactose

(c) Vitamin K

SECTION – D

29. **(a)** **(i)** The rate determining step is the slowest step of a chemical reaction that determines the speed at which the overall reaction proceeds.

(ii) When overall reaction does not occur in a single step, but occurs in multiple steps, such that order is not equal to the molecularity of the reaction. The mechanism of a complex reaction consists of more than one elementary step, and it may involve the formation of complex compounds or intermediates.

(b) With increase in temperature, the rate of the reaction and the rate constant increases.

OR

(b) A complex reaction proceeds through several elementary reactions. The number of molecules involved in each elementary reaction may be different, i.e., the molecularity of each step may be different. Therefore, it is impossible to determine the molecularity of overall complex reaction. Order of a complex reaction is determined by the slowest step in its mechanism and is not dependent on the number of steps involved in a reaction.

(c) For the reaction, $X \rightarrow Y$

For second order,

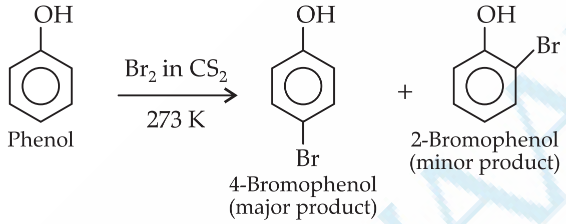
Rate $= k[X]^2$, $X =$ a mol/litre

When the concentration of X is increased three times, then $[X] = 3a$ mol/L

Rate $= k\,(3a)^2 = 9\,ka^2$

Thus, the rate of formation of Y will become 9 times.

30. **(a)** **(i)** Phenol + Br_2/CS_2:

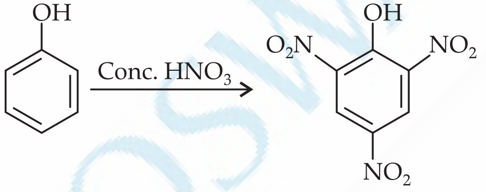


Phenol

4-Bromophenol (major product)

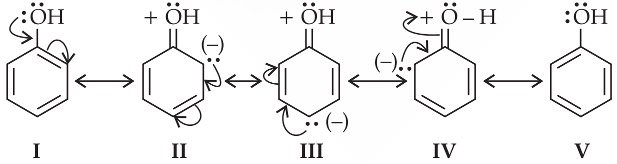
2-Bromophenol (minor product)

(ii) Phenol + conc. HNO_3:



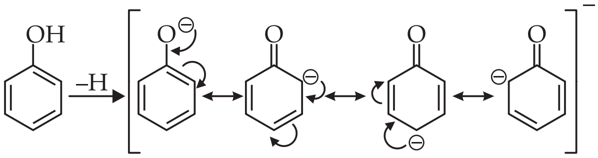
2, 4,6-Trinitrophenol (Picric acid)

(b) One lone pair of oxygen in phenol is involved in resonance with benzene ring, thus generating a positive charge on oxygen. It will not easily undergo protonation.



(c) Phenol is a stronger acid. In cresol, due to +I effect and hyper conjugation effect of methyl group, the density of electron towards oxygen atom increases, destabilising the conjugate base.

While in phenol, the phenoxide ion is resonance stabilised and that makes it a stronger acid than cresol.



OR

(c) The product is salicylaldehyde: IUPAC : 2-Hydroxybenzaldehyde

SECTION – E

31. **(A)** **(a)** At anode: $Sn \rightarrow Sn^{2+} + 2e^-$

At cathode: $2H^+ + 2e^- \rightarrow H_2$

$$E°cell = E°_{SHE} - E°_{Sn^{2+}/Sn}$$
$$= 0 - (-0.14)$$
$$= +0.14\ V$$
$$E_{cell} = E°_{cell} - 0.0591/2 \log [Sn^{2+}] \times P_{H_2}/[H^+]^2$$
$$= 0.14 - 0.0591/2 \log 0.004 \times 0.987/[0.020]^2$$
$$= 0.111V$$

(b) **(i)** On the basis of $E°$ values, O_2 gas should be liberated at anode but it is Cl_2 gas which is liberated in the electrolysis of aqueous NaCl. It is due to the phenomenon of over-voltage. Experimentally, it is observed that the actual voltage required for electrolysis is greater than that calculated from standard potentials. This addition voltage required is called over-voltage. It is required because the rate of transfer of electrons at the interface of electrode and solutions for both half reactions is slow. The over-voltage required for formation of oxygen is much larger than that required for the formation of chlorine.

(ii) Acetic acid (CH_3COOH) is known as a weak electrolyte because it ionizes only partially when dissolved in water. During dilution, the number of ions per unit volume decreases, despite an increase in the degree of ionization. Since the number of free ions in the solution affects conductivity, dilution leads to a decrease in overall conductivity even though ionization increases.

(B) **(a)** Anode: $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$

Cathode: $PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$

Overall cell reaction:

$Pb + PbO_2 + 4H^+ + 2SO_4^{2-} \rightarrow 2PbSO_4 + 2H_2O$

(b) $E_{cell} = E°_{cell} - 0.0592/n \log \dfrac{[Cr^{+3}]^2}{[Cr_2O_7^{-2}][H^+]^{14}}$

Substituting,

$= 1.33 - 0.0591/6 \log [0.01]^2/[0.01][10^{-4}]^{14}$

$= 1.33 - 0.0591/6\ [54\log 10]$

$= 1.33 - 0.0591/6\ [54 \times 1]$

$= 0.7981$ V

32. **(A)** **(a)** A tetrahedral compound has sp^3 hybridisation, where four ligands form a tetrahedron structure around the metal ion. During crystal field splitting, the *d*-orbitals split into two groups – one with a higher energy and the other with a lower energy.

Since, the ligands in a tetrahedral complex do not approach the *d*-orbitals directly, instead they approach between the axis, the splitting energy of *d* orbitals is much lower than that of the pairing energy, and thus the electrons jump to the higher energy level *d*-orbitals rather than pairing, resulting in high-spin complexes being formed.

(b) Co^{3+} can be oxidised to Co^{3+} in the presence of strong field ligands. Strong field ligands, such as CN^- (cyanide) or CO, create a strong ligand field that stabilizes the higher oxidation state of the metal ion. This stabilisation occurs because strong field ligands cause a significant splitting of the *d*-orbitals, making the +3 oxidation state more favourable.

(c) Coordination isomerism

In coordination isomerism, both positive and negative ions of a salt are complex ions and the two isomers differ in the distribution of ligands between the cation and the anion.

(d) In both complexes, Ni is in +2 oxidation state with a valence shell electronic configuration of $3d^8$. In the presence of weak field water ligands, two unpaired electrons do not pair up. The $[Ni(H_2O)_6]^{2+}$ has two unpaired electrons which result in green colour, due to *d–d* transition.

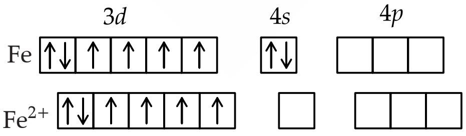
In presence of strong field cyanide ligand, the unpaired electrons in 3*d* orbital pair up. Due to an absence of unpaired electrons, no *d–d* transitions are possible and the $[Ni(CN)_4]^{2-}$ is colourless.

(e) Pentaamminecarbonatocobalt(III)chloride

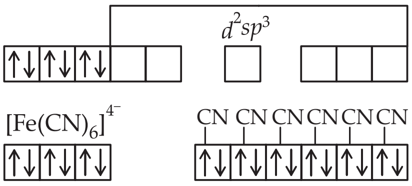
OR

(B) **(a)** When a ligand uses its two or more donor atoms, simultaneously a ring-like structure is formed. The formation of such ring-like structures is called a chelate effect. Compounds having chelate rings are more stable as compared to other compounds.

(b) The hybridisation is d^2sp^3 and it forms an inner orbital complex. Since, there are no unpaired electrons, the complex is diamagnetic and there is no resultant magnetic moment.



Hybridisation



(c) $[Pt(NH_3)_2Cl_2]$

33. **(A)** **(a)** **(i)** Ethanal to But-2-enal by aldol condensation:

$$\underset{\text{Ethanal}}{2CH_3\text{–}CHO} \xrightarrow{\text{dil.NaOH}} \underset{\text{3-Hydroxybutanal}}{CH_3\text{–}CHOH\text{–}CH_2\text{–}CHO}$$

$$\underset{\text{3-Hydroxybutanal}}{CH_3\text{–}CHOH\text{–}CH_2\text{–}CHO} \xrightarrow{H^+} \underset{\text{But-2-enal}}{CH_3\text{–}CH{=}CH\text{–}CHO} + H_2O$$

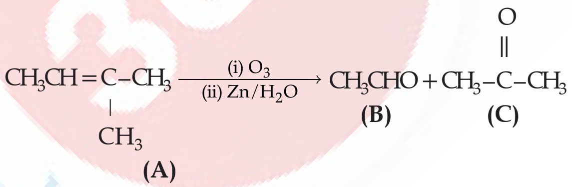
(ii) Propanoic acid to ethane

$$CH_3CH_2COOH \xrightarrow{NH_3/\text{Heat}} CH_3CH_2CONH_2 \xrightarrow{Br_2/KOH} CH_3CH_2NH_2 \xrightarrow{HNO_2} CH_3CH_2OH \xrightarrow{\text{conc. } H_2SO_4/170°C} CH_2{=}CH_2 \xrightarrow{H_2/Ni} H_3C\text{—}CH_3$$

(b) A = $CH_3CH = C(CH_3)_2$,

B = CH_3CHO,

C = CH_3COCH_3



$$\underset{\textbf{(A)}}{CH_3CH{=}\underset{\underset{CH_3}{|}}{C}\text{–}CH_3} \xrightarrow[\text{(ii) } Zn/H_2O]{\text{(i) } O_3} \underset{\textbf{(B)}}{CH_3CHO} + \underset{\textbf{(C)}}{CH_3\text{–}\overset{\overset{O}{\|}}{C}\text{–}CH_3}$$

$$\underset{\textbf{(B)}}{CH_3CHO} + 3I_2 + 4NaOH \rightarrow HCOONa + CHI_3 + 3NaI + 3H_2O$$

$$\underset{\textbf{(C)}}{CH_3COCH_3} + 4NaOH + 3I_2 \rightarrow CHI_3 + 3NaI + 3H_2O + CH_3COONa$$

OR

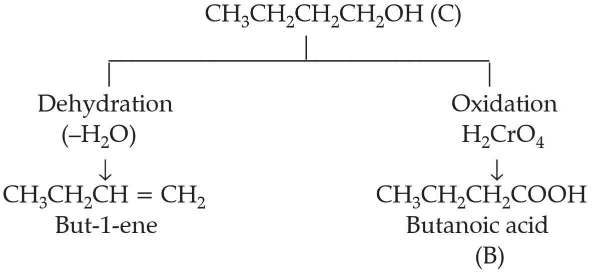
(B) $$\underset{(C_8H_{16}O_2)}{A} \xrightarrow[\text{dil. } H_2SO_4]{\text{hydrolysed}} \underset{(B)}{\text{carboxylic acid}} + \underset{(C)}{\text{alcohol}}$$

A ⟶ ester (butyl butanoate)

$$\underset{(A)}{CH_3CH_2CH_2COOCH_2CH_2CH_2CH_3} + H_3O^+ \longrightarrow \underset{(B)}{CH_3CH_2CH_2COOH} + \underset{(C)}{CH_3CH_2CH_2CH_2OH}$$

B ⟶ Butanoic acid

C ⟶ Butan-1-ol



SECTION – B

18. (*Since, the question is a 2 marks question and in the question, it is asked only to identify the compounds A, B, C and D we can give the below (or) answer as it is specific to the question, but if you want to provide detail step by step answer than add the below answer.)*

(i) When fused chromite ($FeCr_2O_4$) is reacted with sodium carbonate (Na_2CO_3) in the presume of air sodium chromate (Na_2CrO_4) is formed, which is yellow in colour.

$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \longrightarrow \underset{\text{(A) (Yellow solution)}}{8Na_2CrO_4} + 2Fe_2O_3 + 8CO_2$$

(ii) Upon acidification, sodium chromate (Na_2CrO_4) is converted into sodium dichromate ($Na_2Cr_2O_7$).

$$2Na_2CrO_4 + H_2SO_4 \rightarrow \underset{\text{(B)}}{Na_2Cr_2O_7} + Na_2SO_4 + H_2O$$

(iii) Sodium dichromate ($Na_2Cr_2O_7$) reacts with potassium chloride (KCl) to form potassium dichromate ($K_2Cr_2O_7$), which is orange in colour.

$$Na_2Cr_2O_7 + 2KCl \rightarrow \underset{\text{(C)}}{K_2Cr_2O_7} + 2NaCl$$

(iv) Potassium dichromate ($K_2Cr_2O_7$) is an acidic solution it acts as an oxidising agent and oxidises iodide (I^-) to iodine (I_2).

$$CrO_7^{2-} + 6I^- + 14H^+ \rightarrow 2Cr^{3+} + \underset{\text{(D)}}{3I_2} + 7H_2O$$

Compound (A) = Sodium chromate (Na_2CrO_4) (yellow solution)

Compound (B) = Sodium dichromate ($Na_2Cr_2O_7$)

Compound (C) = Potassium dichromate ($K_2Cr_2O_7$) (orange solution)

Compound (D) = Iodine (I_2)

21. (a) Amino acids exist as zwitter ions in the solid state, which results in strong electrostatic forces of attraction (ionic interactions) between the positively charged ammonium ion ($-NH_3^+$) and the negatively charged carboxylate ion ($-COO^-$). These strong electrostatic forces require more energy to break, leading to higher melting points compared to their corresponding carboxylic acids, which mainly form weaker hydrogen bonds, resulting in lower melting points.

(b) Amino acids contain both an acidic ($-COOH$) group and a basic ($-NH_2$) group. In acidic medium, the amino group ($-NH_2$) accepts a proton, forming $-NH_3^+$, which makes the amino acid behave as a base. In basic medium, the carboxyl group ($-COOH$) loses a proton, forming $-COO^-$, which makes the amino acid behave as an acid. Due to this dual nature, amino acids can react with both acids and bases, exhibiting amphoteric behaviour.

SECTION – C

22. The osmotic pressure formula for both solution is:

$$\pi = \frac{n}{V}RT$$

Since, both solutions are isotonic, their osmotic pressures are equal, meaning the equation simplifies to:

$$\frac{n_{\text{urea}}}{V_{\text{urea}}} = \frac{n_{\text{glucose}}}{V_{\text{glucose}}}$$

For 1 litre of each solution (where, $V_{\text{urea}} = V_{\text{glucose}} = 1$ L), this reduces to:

$$n_{\text{urea}} = n_{\text{glucose}}$$

Since, the volume is the same for both solutions, the values of R and T cancel out and are not required.

Now, let's calculate the number of moles of urea:

Mass of urea = 15 g (given)

Molar mass of urea = 60 g/mol (given)

Now,

$$n_{\text{urea}} = \frac{\text{mass of urea}}{\text{molar mass of urea}} = \frac{15}{60} = 0.25 \text{ mol}$$

The number of moles of urea equals the number of moles of glucose, we have:

$$n_{\text{glucose}} = 0.25 \text{ mol}$$

Calculating the mass of glucose:

- Molar mass of glucose = 180 g/mol

mass of glucose = n_{glucose} × molar mass of glucose

$= 0.25 \times 180 = 45$ g

Hence, the mass of glucose present in one litre of its solution is 45 g.

23. The formula for the standard Gibbs free energy change is:

$\Delta_r G^\circ = -nFE^\circ_{\text{cell}}$

where:

n = number of moles of electrons transferred (in this case, $n = 1$, as one electron is transferred in the reaction).

F = Faraday constant (96500 C mol^{-1})

E°_{cell} = standard cell potential.

The standard cell potential (E°_{cell}) is calculated using the standard reduction potentials

$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$

Given:

- $E^\circ_{Ag^+/Ag} = 0.80$ V (reduction of Ag^+).
- $E^\circ_{Fe^{3+}/Fe^{2+}} = 0.77$ V (reduction of Fe^{3+}).

For this reaction:

- Ag^+ is reduced (cathode).
- Fe^{2+} is oxidised to Fe^{3+} (anode).

So,

$E^\circ_{\text{cell}} = E^\circ_{Ag^+/Ag} - E^\circ_{Fe^{3+}/Fe^{2+}} = 0.80\text{ V} - 0.77\text{ V}$

$= 0.03$ V

Now, substitute values into the Gibbs free energy equation:

$\Delta_r G^\circ = -1 \times 96500 \text{ C/mol} \times 0.03 \text{ V}$

$\Delta_r G^\circ = -2895 \text{ J/mol} = -2.895 \text{ kJ/mol}$

The relationship between the standard cell potential and the equilibrium constant is given by the Nernst equation:

$$\Delta_r G^\circ = -RT \ln K_c$$

Rearranging for log K_c:

$$\log K_c = \frac{nE^\circ_{cell}}{0.0591}$$

Substitute the known values:

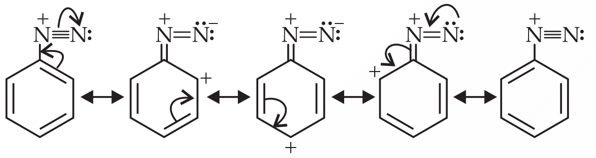
$$\log K_c = \frac{1 \times 0.03 \text{ V}}{0.0591} = 0.507$$

Hence, $\Delta_r G^\circ$ and $\log K_c$ for the reaction is –2.895kJ/mol and 0.507 respectively.

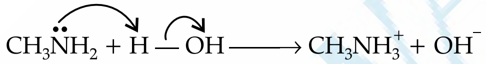
24. **(a)** *p*-Nitroaniline > Aniline > *p*-Methylaniline

(b) **(i)** Diazonium salts of aromatic amines are stabilised by resonance with the aromatic ring, where the positive charge on the nitrogen is delocalised into the ring. This delocalisation makes the diazonium ion more stable. In contrast, aliphatic amines do not have this resonance stabilisation, and their diazonium salts are less stable and more prone to decomposition.

Resonance in Diazonium Salt



(ii) When methylamine is added to water, it acts as a weak base, producing hydroxide ions (OH^-). These hydroxide ions then react with the ferric ions (Fe^{3+}) from ferric chloride ($FeCl_3$), resulting in the precipitation of hydrated ferric oxide ($Fe_2O_3.nH_2O$), a solid precipitate.



$$CH_3\ddot{N}H_2 + H—OH \longrightarrow CH_3NH_3^+ + OH^-$$

Methylamine

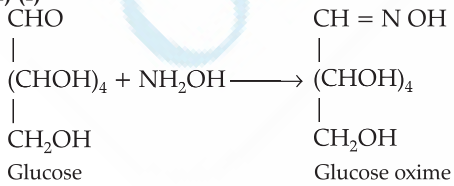
$FeCl_3 \rightarrow Fe^{3+} + 3Cl^-$

$2Fe^{3+} + 6OH^- \rightarrow 2Fe(OH)_3$ or $Fe_2O_3.3H_2O$

Hydrated ferric oxide

(Brown ppt.)

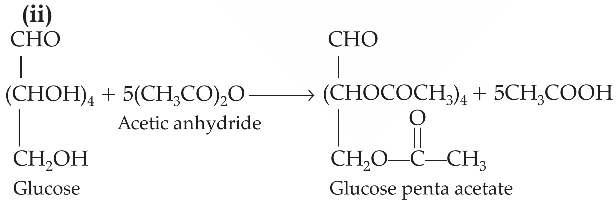
28. **(a)** **(i)**



$$\begin{array}{l} CHO \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} + NH_2OH \longrightarrow \begin{array}{l} CH = N\,OH \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array}$$

Glucose Glucose oxime

(ii)



$$\begin{array}{l} CHO \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} + \underset{\text{Acetic anhydride}}{5(CH_3CO)_2O} \longrightarrow \begin{array}{l} CHO \\ | \\ (CHOCOCH_3)_4 \\ | \\ CH_2O—\overset{\overset{\displaystyle O}{\|}}{C}—CH_3 \end{array} + 5CH_3COOH$$

Glucose Glucose penta acetate

(b) Vitamin C cannot be stored in large amounts in our body because it is water-soluble, meaning it dissolves in water. As a result, the body excretes excess vitamin C through urine.

SECTION – E

32. **(A)** **(a)** Let the oxidation number of iron be x. The ethylenediamine (en) is neutral, contributing 0 charge. Each chloride ion (Cl^-) contributes–1 charge. Thus,

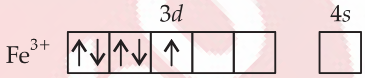
$x + 0 + 2(-1) + (-1) = 0$

$x - 3 = 0 \Rightarrow x = +3$

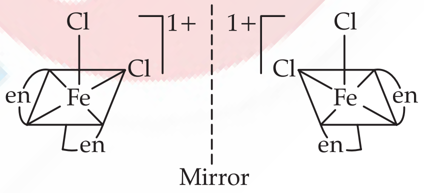
$\therefore$ Oxidation number of iron, $x = +3$

(b) The complex has two bidentate ligands and two monodentate ligands. Therefore, the hybridisation will be d^2sp^3 and shape will be octahedral.

(c) The oxidation state of iron is +3, which gives the electron configuration of Fe^{3+}: d^5 (since, the atomic number of Fe is 26). With 1 unpaired electrons in the *d*-orbital, the magnetic behaviour of the complex is paramagnetic.



(d) The ***cis*-isomer** of **$[Fe(en)_2Cl_2]Cl$** shows optical isomerism because it has non-superimposable mirror images due to the arrangement of the chloride ions. The ***trans*-isomer** does not show optical isomerism as it lacks chirality.



cis-isomer

(e) Dichloridobis(ethane-1, 2-diamine)iron(III)chloride.

OR

(B) **(a)** **(i)** Tetraamminechloridonitrito-N-cobalt(III) chloride

(ii) Potassiumhexacyanoferrate(III)

(iii) Trisoxalatochromate(III)ion

(b) Crystal field splitting energy refers to the energy difference between the split *d*-orbitals of a transition metal ion when it is surrounded by ligands in a coordination complex. Low spin tetrahedral complexes are not formed because in a tetrahedral field, the splitting energy (Δ_t) is smaller than in an octahedral field. The energy difference between the higher and lower sets of orbitals is too small to favour pairing of electrons. Therefore, tetrahedral complexes generally adopt a high-spin configuration, where electrons occupy all available orbitals to minimise repulsion, leading to more unpaired electrons.

SECTION – B

18. **(a)** $8MnO_4^-(aq) + 3S_2O_3^{2-}(aq) + H_2O(l) \rightarrow 8MnO_2(s) + 6SO_4^{2-}(aq) + 2OH^-\ (aq)$

(b) $Cr_2O_7^{2-} + 3Sn^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 3Sn^{4+} + 7H_2O$

21. **(a)** Glucose and Fructose

(b) Glucose and Galactose

SECTION – C

22. Soda water is typically water that is carbonated with CO_2 under pressure.

Henry's law constant for CO_2 in water $(K_H) = 1.67 \times 10^8$ Pa.

Pressure of CO_2 $(P_{CO_2}) = 2.53 \times 10^5$ Pa.

Volume of soda water = 500 mL = 0.500 L.

Using Henry's law to find the mole fraction of CO_2 in water

$$P_{CO_2} = K_H \times x_{CO_2}$$

$$x_{CO_2} = \frac{2.53 \times 10^5}{1.67 \times 10^8}$$

$$= 1.51 \times 10^{-3}$$

This gives the mole fraction of CO_2 in the solution.

Since, the density of water is 1 g/mL, the mass of water in 500 mL is:

Mass of water = 1 g/mL × 500 mL = 500 g

Calculate the moles of water in 500 mL of soda water:

$$n_{H_2O} = \frac{500\text{ g}}{18\text{ g/mol}} = 27.78\text{ mol}$$

Calculate the moles of CO_2 in soda water:

Using the mole fraction equation:

$$x_{CO_2} = \frac{n_{CO_2}}{n_{CO_2} + n_{H_2O}}$$

Substituting the values,

$$1.51 \times 10^{-3} = \frac{n_{CO_2}}{n_{CO_2} + 27.78}$$

Solving for n_{CO_2}:

$$n_{CO_2} = 1.51 \times 10^{-3} \times 27.78$$

$$= 0.042\text{ mol}$$

Hence, the number of moles of CO_2 in 500 mL of soda water is 0.042 mol.

23. The given reaction is:

$2Cr(s) + 3Cd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Cd(s)$

From the standard reduction potentials:

$$Cr^{3+}/Cr: E° = -0.74\text{ V}$$

$$Cd^{2+}/Cd: E° = -0.40\text{ V}$$

In the given reaction, chromium (Cr) is oxidised and cadmium (Cd^{2+}) is reduced, thus, we calculate the cell potential as:

$$E°_{cell} = E°_{cathode} - E°_{anode}$$

$$E°_{cell} = (-0.40V) - (-0.74V) = +0.34V$$

Now, the equation for Gibb's free energy is:

where:

- $n = 6$ (since, 2 Cr atoms)
- $F = 96500\text{ C mol}^{-1}$,
- $E°_{cell} = 0.34V$

$$\Delta_r G° = -nFE°_{cell}$$

$$= -6 \times 96500 \times 0.34$$

$$= -196860\text{ J/mol}$$

$$\Delta_r G° = -196.86\text{ KJ/mol}$$

Now, we will calculate $\log K_c$

Using the reaction,

$$\Delta_r G° = -2.303\ RT \log_{10} K_C$$

$$\log_{10} K_C = \frac{-\Delta_r G°}{2.303RT}$$

Taking $R = 8.314\text{ J K}^{-1}\text{ mol}^{-1}$ and

$T = 298$ K:

$$\log_{10} K_C = \frac{196860}{(2.303 \times 8.314 \times 298)}$$

$$\log_{10} K_C = \frac{196860}{5703.5} \approx 34.5014$$

Hence, $\Delta_r G°$ and $\log K_c$ for the given reaction is −196.86 kJ/mol and 34.5 respectively.

24. Given:

Initial temperature, $T_1 = 293$K

Final temperature, $T_2 = 313$K

Gas constant $R = 8.314\text{JK}^{-1}\text{mol}^{-1}$

Rate increase factor $\frac{k_2}{k_1} = 4$

Logarithm value: log4 = 0.602

The Arrhenius equation is given as:

$$\log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.303R} \times \left[\frac{T_2 - T_1}{T_1 T_2}\right]$$

Rearranging for E_a:

$$E_a = 2.303R \times \left(\frac{T_1 T_2}{T_2 - T_1}\right) \times \log\left(\frac{k_2}{k_1}\right)$$

Now, we will calculate $\frac{T_1 T_2}{T_2 - T_1}$

$$T_1 T_2 = (293) \times (313) = 91709$$

$$T_2 - T_1 = 313 - 293 = 20$$

$$\frac{T_1 T_2}{T_2 - T_1} = \frac{91709}{20} = 4585.45\text{K}$$

Now, activation energy, X

$E_a = 2.303 \times 8.314 \times 4585.45 \times 0.602$

$$= 52854.554\text{ J/mol}$$

Convert to kJ/mol:

$$E_a = \frac{52854.554}{1000} = 52.85\text{ kJ/mol}$$

Hence, the value of activation energy for the reaction is 52.85 kJ/mol.

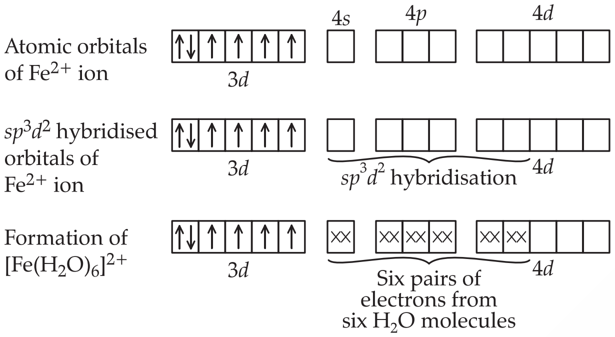
28. Refer to Outside Delhi Set- 3 Answer- 28

SECTION – E

32. (A) (a) The electronic configuration of Fe is [Ar] $4s^2$ $3d^6$.

The electronic configuration of Fe^{2+} is [Ar] $3d^6$ after losing two electrons.

H_2O is a weak field ligand, meaning it does not cause the pairing of electrons in the metal ion. Therefore, in this complex, Fe^{2+} will have its electrons arranged with unpaired electrons in the *d*-orbitals.

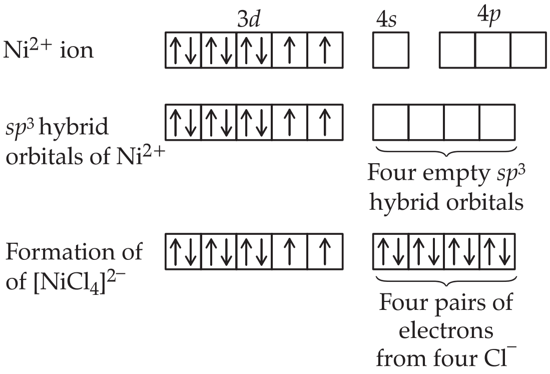


The complex has ***sp*³*d*² hybridisation** due to the coordination number of 6. This leads to an **octahedral shape**. Since, H_2O is a weak field ligand, it does not cause electron pairing, so the Fe^{2+} complex has **unpaired electrons.** Therefore, **$[Fe(H_2O)_6]^{2+}$ is paramagnetic.**

(b) The electronic configuration for **Ni** is **[Ar] $3d^8$ $4s^2$.**

The electronic configuration of **Ni^{2+} is[Ar]$3d^8$** after losing 2 electrons

Cl is a weak field ligand, meaning it does not cause pairing of electrons in the metal ion. Therefore, Ni^{2+} in this complex will have its electrons arranged with unpaired electrons in the *d*-orbitals.



Nickel in **Ni^{2+}** undergoes ***sp*³ hybridisation** because the coordination number is 4 due to the four Cl^- ligands. This results in a **tetrahedral geometry. Since Cl^-** is a **weak field ligand**, which does not cause pairing of electrons in the metal ion. Therefore, **Ni^{2+}** has **2 unpaired** electrons in the **$3d^8$** configuration. As a result, the complex is **paramagnetic** in nature.

OR

(B) (a) (i) Aquacyanobis(ethylenediamine)cobalt(III) ion

(ii) Tetrachloridoplatinate(II)ion

(iii) Tetraamminechloridonitrito-(o) chromium(III)ion

(b) The spectrochemical series is the arrangement of ligands in increasing order of their crystal field splitting energy (Δ or CFSE). Ligands on the left are weak field ligands, causing low splitting, while those on the right are strong field ligands, causing high splitting.

$I^- < Br^- < SCN^- < Cl^- < S^{-2} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS^- < edta^{4-} < NH_3 < en < CN^- < CO$

Strong Field Ligands	**Weak Field Ligands**
Cause high crystal field splitting (Δ).	Cause low crystal field splitting (Δ).
Often lead to low-spin complexes.	Often lead to high-spin complexes.
Example: CN^-, CO, NO_2^-	Example: I^-, Br^-, Cl^-, F^-.

Outside Delhi Set-1 Code - 56/2/1

1. **Option (B) is correct.**

   Explanation: In MnO_4^-, the oxidation state of Mn is +7. While in MnO_2, Mn has oxidation state of +4. Hence the change in oxidation state is +3. Therefore, the charge required is 3F.

2. **Option (C) is correct.**

   Explanation: Molecularity is the number of reacting species involved in simultaneous collisions in an elementary or the simplest reaction. Since at least one molecule must be present, the molecularity will be at least one. Hence the molecularity of any reaction can never be zero.

3. **Option (C) is correct.**

   Explanation: Molecularity is the number of reacting species involved in simultaneous collisions in an elementary or the simplest reaction.

4. **Option (A) is correct.**

   Explanation: Copper has atomic number 29. The electronic configuration of the copper is:

   $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$

5. **Option (B) is correct.**

   Explanation: The complexes $[Co(NH_3)_5(NO_2)]^{+2}$ and $[Co(NH_3)_5(ONO)]^{+2}$ are called linkage isomers due to the presence of NO_2 ligand. It is an ambidentate ligand.

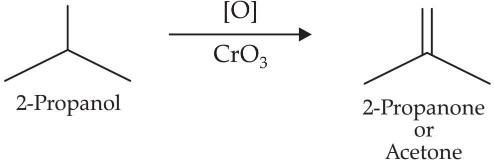
6. **Option (A) is correct.**

   Explanation: : It is diamagnetic because it does not have any unpaired electrons due to the presence of the cyanide ion (CN^-) which is a strong-field ligand, causing all the *d* electrons to pair up.

7. **Option (C) is correct.**

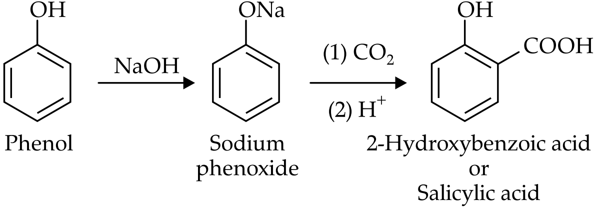
8. **Option (B) is correct.**

Explanation:



9. **Option (C) is correct.**

Explanation:



10. **Option (A) is correct.**
Explanation: When an egg is subjected to a physical change, such as a change in temperature, i.e., on boiling, coagulation of the egg white occurs due to denaturation of protein. During denaturation, hydrogen bonds are disturbed causing the globules to unfold, the helix to uncoil, and the protein to lose its biological activity.

11. **Option (D) is correct.**

12. **Option (C) is correct.**
Explanation: Scurvy is caused due to the deficiency of Vitamin C which is also known as ascorbic acid.

13. **Option (D) is correct.**
Explanation: In a first-order reaction, the half life is independent of the initial concentration of the reactant. This means that if the we double the concentration, the half-life remains the same. Hence assertion is incorrect.

14. **Option (A) is correct.**
Explanation: Copper cannot liberate hydrogen from acids as it has a positive electrode potential.

15. **Option (A) is correct.**
Explanation: Aromatic 1° amine cannot be prepared by gabriel phthalimide reaction because aryl halide do not undergo nucleophilic substitution reaction.

16. **Option (D) is correct.**
Explanation: Vitamin D can be stored in our body in fat cells and the liver.

17. **(A)**

$$\begin{aligned} K &= 0.0030 \text{ mol L}^{-1}\text{ s}^{-1} \\ [A_0] &= 0.10 \text{ M} \\ [A] &= 0.075 \text{ M} \\ K &= [A_0] - [A] / t \\ 0.0030 &= 0.10 - 0.075 / t \\ t &= 8.33 \text{ sec} \end{aligned}$$

OR

(B) For zero-order reaction rate of reaction = K
Rate of reaction = rate of production of N_2 = 1/3 [rate of production of H_2]
Rate of production of $N_2 = k = 2.5 \times 10^{-4}$ mol $L^{-1}s^{-1}$
Rate of production of H_2 $= 3k = 3 \times 2.5 \times 10^{-4}$
$= 7.5 \times 10^{-4}$ mol $L^{-1}s^{-1}$

18. **(a)** A **pseudo-first-order reaction** is a reaction that is inherently of a higher order but behaves as if it were first-order under certain conditions. This behaviour typically occurs when one reactant is present in such a large excess that its concentration remains effectively constant throughout the reaction. As a result, the reaction rate depends primarily on the concentration of the other reactant, making the overall reaction appear first-order.

$$CH_3COOCH_3 + H_2O \rightarrow CH_3COOH + CH_3OH$$

(b) The half-life of a reaction is the time required for the concentration of a reactant to decrease to half of its initial value.

19. **(a)** Transition metals form coloured solutions and compounds because these elements have unfilled *d* orbitals. Which allow electrons for transition between different energy level by absorption of specific wavelength and results a complementary colour.

(b) Zinc is not a transition metal since its *d* subshells are not partly filled (*n* – 1). As it does not have a vacant *d*-orbital it is not a transition element.

20. **(a)** Tetraammineaquachloridocobalt(III)chloride.

(b) Dichloridobis(ethane-1,2-diamine)chromium(III) chloride

21. **(a)** S_N1 reaction proceeds via the formation of carbocation. The alkyl halide (I) is 3° while (II) is 2°. Therefore, (I) forms a 3° carbocation, while (II) forms a 2° carbocation. The greater the stability of the carbocation, the faster the rate of the S_N1 reaction. Since a 3° carbocation is more stable than a 2° carbocation. (I), i.e., 2−chloro-2-methylpropane, undergoes an S_N1 reaction faster than (II) i.e., 3-chloropentane.

(b) The increasing order of a reactivity towards S_N2 displacement is 2−Bromo−2−methyl butane < 2−bromopentane < 1−Bromopentane. Due to steric reasons, the order of the reactivity in S_N2 reactions follows the order: 1° > 2° > 3°.

22.
$$\begin{aligned} \text{Mass of urea} &= 5\% \text{ of } 1000 \text{ g} = 50 \text{ g} \\ \text{Moles of urea} &= \frac{\text{mass}}{\text{molar mass}} \\ &= \frac{50}{60} = 0.8333 \text{ mol} \\ \text{Mass of water} &= 1000 \text{ g} - 50 \text{ g} = 950 \text{ g} \\ \text{Moles of water} &= \frac{\text{mass}}{\text{molar mass}} \\ &= \frac{950}{18} = 52.7778 \text{ mol} \end{aligned}$$

Mole fraction of water

$$= \frac{\text{Moles of water}}{\text{Moles of water + Moles of urea}}$$

$$= \frac{52.7778}{(52.7778 + 0.8333)} = 0.9844.$$

$$P^o \text{ solution} = P_{water} \times X_{water} = 24 \text{ mm Hg} \times 0.9844 = 23.634 \text{ mm Hg.}$$

23. $$\text{Resistivity } (\rho) = \frac{\text{Resistance (R)} \times \text{Area (A)}}{\text{Length (L)}}$$

$R = 5 \times 10^3$ ohm, $A = 0.8\ \text{cm}^2 = 0.8 \times 10^{-4}\ \text{m}^2$,
$L = 40$ cm $= 0.4$ m.

$$\text{Thus, } \rho = \frac{(5\times10^3\,\text{ohm})\times(0.8\times10^{-4}\,\text{m}^2)}{(0.4\text{m})}$$

$$= 1.0\ \text{ohm m.}$$

$$\text{Conductivity } k = \frac{1}{\rho} = \frac{1}{(1.0\ \text{ohm m})} = 1.0\ \text{S/m}$$

$$\text{Molar conductivity } \Lambda_m = k \times \frac{1000}{C}$$

$$= 1.0\ \text{S/m} \times \frac{1000}{0.05\times10^3\ \text{mol/m}^3}$$

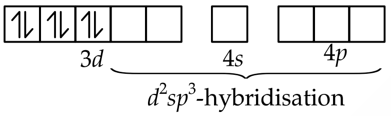
$$= 20\ \text{S m}^2\text{/mol.}$$

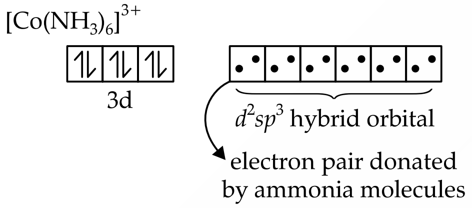
24. (a) $2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

(b) $2KMnO_4 \xrightarrow{\text{Heat 513 K}} K_2MnO_4 + MnO_2 + O_2$

(c) $3H_2S + 8H^+ + Cr_2O_7^{-2} \rightarrow 3S + 2Cr^{+3} + 7H_2O$

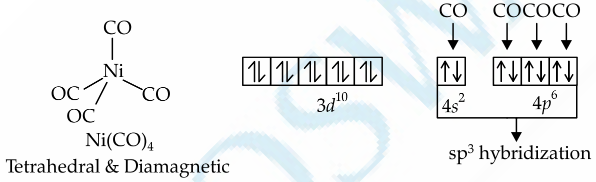
25. (a) In the presence of ammonia ligand, the electrons in $3d$ level get paired up leaving two of the $3d$ orbitals for hybridisation. Hence, the type of hybridisation is d^2sp^3.





The complex is diamagnetic as there are no unpaired electrons.

(b) The oxidation state of Ni is 0. The valence shell electronic configuration of the ground state of Ni is $3d^8\,4s^2$, but all the 10 electrons are pushed into $3d$ orbital due to the strong field CO ligands approaching the Ni atom, thereby forming sp^3 hybridisation.

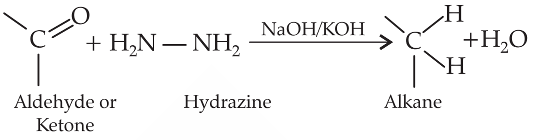


26. (a) (i) Enantiomers are a type of stereoisomer. They are molecules that are non-superimposable mirror images of each other. This means that if you were to place one enantiomer in front of a mirror, it would appear as a mirror image of the other enantiomer, but they cannot be aligned perfectly by rotation. Enantiomers arise from chirality. Enantiomers have the unique property of rotating polarised light in opposite directions.

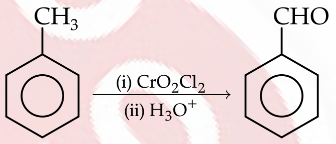
(ii) A racemic mixture is a mixture that contains equal amounts of two enantiomers of a chiral molecule. In other words, it is a 1:1 mixture of two mirror-image molecules that are non-superimposable (enantiomers).

(b) In chlorobenzene, the halogen atom is bonded to the highly electronegative sp^2 hybridised carbon atom and lone pair of halogen taking part in resonance with benzene ring. So, nucleophilic substitution reaction is not possible.

27. (A) (a) The Wolff-Kishner reduction works by treating the carbonyl compound (usually a ketone or aldehyde) with **hydrazine (N_2H_4)** and a strong **base**, typically **potassium hydroxide (KOH)**, in a high-temperature reaction.



(b) The **Etard reaction** is a specific organic reaction that oxidises **toluene** (methylbenzene) to **benzaldehyde**. This transformation is important in the organic synthesis as benzaldehyde is a valuable intermediate for further chemical modifications.



(c) The **Cannizzaro reaction** is a well-known **base-catalysed** reaction in organic chemistry where **non-enolisable aldehydes** (i.e., aldehydes that do not have a hydrogen on the α-carbon) under go a **disproportionation reaction**. In this reaction, two molecules of the aldehyde react in the presence of a strong base to produce two different products.

$2HCHO + NaOH \rightarrow CH_3OH + HCOONa$

OR

(B) (a) A- CH_3COCl

B- CH_3CHO

C- $CH_3CH{=}N.NH_2$

$$\underset{}{CH_3COOH} + SOCl_2 \rightarrow \underset{\text{(A)}}{CH_3COCl} + HCl + SO_2$$

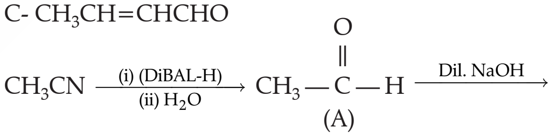
$$CH_3COCl + H_2 \rightarrow \underset{\text{(B)}}{CH_3CHO} + HCl$$

$$CH_3CHO + NH_2.NH_2 \rightarrow \underset{\text{(C)}}{CH_3CH{=}N.NH_2} + H_2O$$

(b) A- CH_3CHO

B- $CH_3CHOHCH_2CHO$

C- $CH_3CH{=}CHCHO$



$$CH_3CN \xrightarrow[\text{(ii) } H_2O]{\text{(i) (DiBAL-H)}} \underset{\text{(A)}}{CH_3-\overset{\overset{\large O}{\|}}{C}-H} \xrightarrow{\text{Dil. NaOH}}$$

$$\underset{\text{(B)}}{CH_3CHOHCH_2CHO} \xrightarrow{\Delta} CH_3-CH=CH\text{—}CHO$$

28. (a) A **glycosidic linkage** (or glycosidic bond) is a type of etheral linkage that joins a **sugar molecule** (monosaccharide) to another molecule, which can also be a sugar or a different type of molecule (like an alcohol or a lipid). This bond is crucial in the formation of complex carbohydrates like disaccharides, oligosaccharides and polysaccharides.

(b) Invert sugar is a mixture of **glucose** and **fructose** produced by the **hydrolysis** (splitting) of sucrose (table sugar) into its component monosaccharides. This process is called **inversion** because the optical rotation of the sugar changes direction due to glucose and fructose rotating light differently.

(c) Oligosaccharides are a class of **carbohydrates** that consist of a few monosaccharide units (typically 2 to 10 units) joined together by **glycosidic bonds**. The term "oligo" comes from the Greek word "*oligos*," meaning "few" or "a small number." Oligosaccharides are intermediate in size between **disaccharides** (2 monosaccharide units) and **polysaccharides** (large chains of monosaccharides, typically greater than 10 units).

29. (a) Reverse Osmosis (RO) is a water purification process that uses a semi-permeable membrane to remove impurities, contaminants and dissolved substances from water. In reverse osmosis, water is forced through the membrane under pressure, against the natural osmotic flow (hence the term "reverse"), from an area of higher solute concentration to an area of lower solute concentration. This process removes particles, salts, and other contaminants, leaving purified water on the other side of the membrane.

One of the most common materials used for semi-permeable membranes in reverse osmosis is Thin Film Composite (TFC) membranes.

(b) (i) RBCs placed in a 0.5% NaCl solution will swell and may undergo haemolysis (bursting), as water moves into the cells due to osmosis, leading to the rupture of the cell membrane if too much water is absorbed.

OR

(ii) The osmotic pressure of a solution depends on the **number of solute particles** in the solution, as described by **Raoult's Law** and the **van't Hoff equation**:

$$\pi = iCRT$$

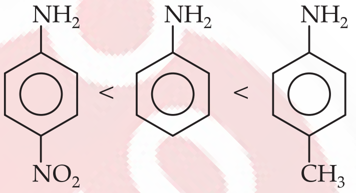
For KCl, $i = 2$

For urea, $i = 1$

Hence, osmotic pressure of KCl will be high.

(c) Osmotic pressure is considered a **colligative property** because it depends **only on the number of solute particles** in a solution, not on the nature or identity of the solute particles themselves.

30. (a) Basicity of a compound increased by electron donating group such as alkyl and decreased by electron withdrawing group such as NO_2, CN ext. So, the correct order of basicity of given compounds will be:



(b) In aniline, the lone pair of electrons on the N atom is delocalised over the benzene ring. As a result, the electron density on nitrogen decreases. Therefore, aniline is a weaker base than methylamine and hence its pK_b value is higher than that of methylamine.

(c) (i) $NH_3 < (CH_3)_3N < CH_3NH_2 < (CH_3)_2NH$

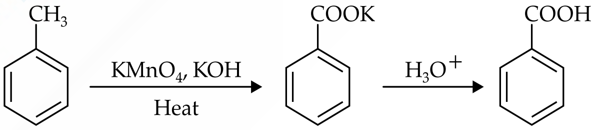
(ii) This is because the primary amine formed can react with the alkyl halide to form the secondary amine, which in turn will again react with the alkyl halide to form the tertiary amine, which also reacts with the alkyl halide leading to the formation of quaternary salt.

31. (A) (a) But-2-en-1-al

(b) Iodoform test: Propanone will give iodoform test while propanal will not give this test. Propanone gives yellow ppt of iodoform.

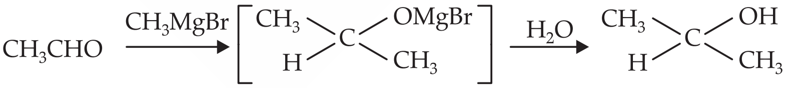
$$\underset{\text{Propanone}}{CH_3-CO-CH_3} + 3NaOI \rightarrow CH_3COONa + \underset{\substack{\text{Iodoform}\\\text{(yellow ppt)}}}{CHI_3} + 2NaOH$$

(c) (i)

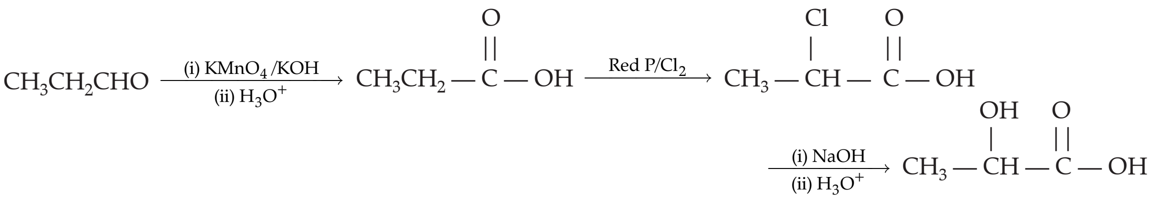


Toluene Benzoic acid

(ii) $CH_3CH_2OH \xrightarrow[573\ K]{Cu} CH_3CHO$



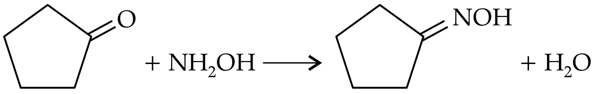
Ethanal Addition compound Propan-2-ol

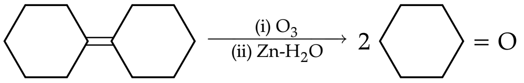
(iii) 

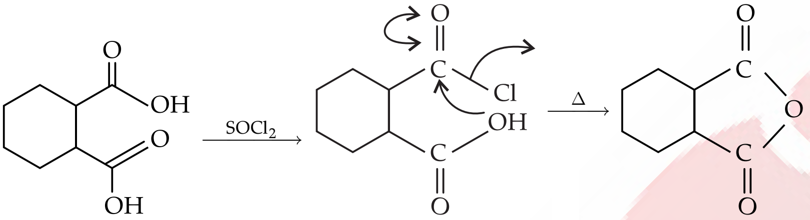
$$CH_3CH_2CHO \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } KMnO_4/KOH} CH_3CH_2-\overset{\overset{\displaystyle O}{||}}{C}-OH \xrightarrow{\text{Red P}/Cl_2} CH_3-\overset{\overset{\displaystyle Cl}{|}}{C}H-\overset{\overset{\displaystyle O}{||}}{C}-OH \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) NaOH}} CH_3-\overset{\overset{\displaystyle OH}{|}}{C}H-\overset{\overset{\displaystyle O}{||}}{C}-OH$$

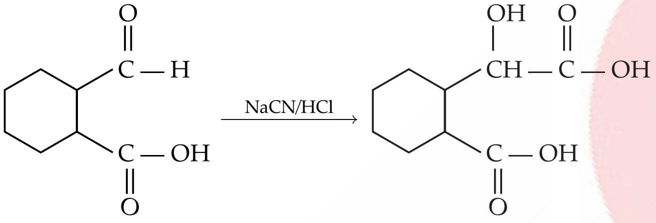
2-Hydroxy propanoic acid

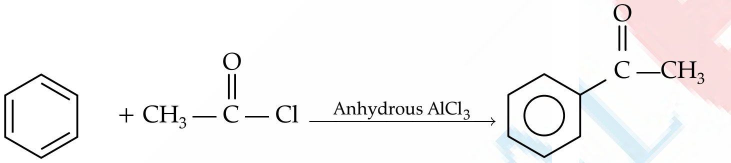
OR

(B) (a) 

(b) 

(c) 

(d) 

(e) 

32. (A) (a) $\Delta G^\circ = -nFE^\circ$

$Au(s) + Ca^{2+}(1M) \rightarrow Au^{3+}(1M) + Ca(s)$

$$E^\circ = E^\circ_{cathode} - E^\circ_{anode}$$
$$E^\circ = (-2.87\text{ V}) - (1.5\text{ V})$$
$$= -4.37\text{ V}$$

In this reaction, the oxidation half-reaction involves the loss of 3 electrons ($Au \rightarrow Au^{3+} + 3e^-$), and the reduction half-reaction involves the gain of 2 electrons ($Ca^{2+} + 2e^- \rightarrow Ca$). Therefore, the least common multiple (LCM) of 2 and 3 is 6, so the overall reaction involves the exchange of 6 electrons.

$\Delta G^\circ = -(6)\ (96500\text{C/mol})\ (-4.37\text{V})$

Since 1 V = 1 J/C, the units of voltage and charge cancel, leaving us with units of joules.

$\Delta G^\circ = -6 \times 96500 \times -4.37 = +2530230\text{ J/mol}$

$\Delta G^\circ \approx +2530.23\text{ KJ/mol}$

Since the value of ΔG° is positive, the reaction is non-spontaneous at 25°C.

(b) Yes, tarnished silver (which contains Ag_2S) can be removed by placing it in an aluminium pan containing an inert electrolytic solution like NaCl. This process works through an electrochemical reaction where aluminium (Al) acts as the reducing agent, and silver sulphide (Ag_2S) is reduced.

OR

(B) (a) (i) The **cell potential** (also known as **electromotive force** or emf) is a measure of the driving force or energy per unit charge available to move electrons through an electrochemical cell. It is the difference in potential between the two electrodes (cathode and anode) in a galvanic or electrolytic cell.

(ii) A fuel cell is an electrochemical device that converts the chemical energy of a fuel (typically hydrogen) and an **oxidising agent** (typically oxygen from air) directly into **electrical energy,** water and heat, through a redox reaction. This process occurs without combustion, making fuel cells highly efficient and environmentally friendly compared to traditional energy sources.

(b) $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$

$E^\circ_{cell} = (-0.40\text{ V}) - (-0.76\text{ V}) = 0.36\text{ V}$

$E^\circ_{cell} = E^\circ_{cell} - 0.0591/n \log Q$

$E^\circ_{cell} = 0.36\text{ V} - 0.02955 \log 10 = 0.33\text{ V}.$

33. (A) • Compound 'A': Ethanol (C_2H_5OH)

• Compound 'B': Acetaldehyde (CH_3CHO)

- Compound 'C': Iodoform (CHI_3)
- Compound 'D': Diethylether ($C_2H_5OC_2H_5$)
- Compound 'E': Ethyl iodide (C_2H_5I)

$C_2H_5OH + CrO_3 \rightarrow CH_3CHO$

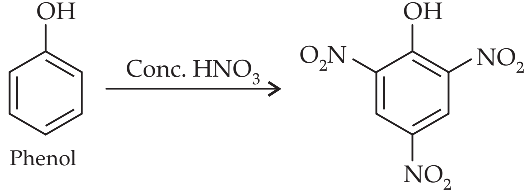
$CH_3CHO + 3I_2 + 4NaOH \rightarrow CHI_3$ (yellow precipitate) $+ HCOONa + 2H_2O + 3NaI$

$C_2H_5OH +$ (conc. H_2SO_4, 413 K) $\rightarrow C_2H_5OC_2H_5 + H_2O$

$C_2H_5OC_2H_5 + HI \rightarrow 2C_2H_5I + H_2O$

OR

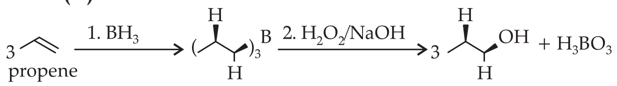
(B) (a) (i)



Phenol

Picric acid

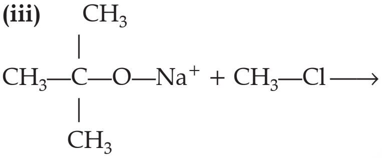
(ii)



propene

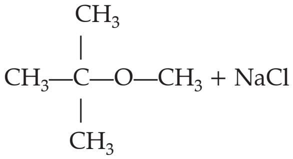
propan-1-ol

(iii)



$$CH_3-\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}-O-Na^{+} + CH_3-Cl \longrightarrow$$

Sodium tertbutoxide



$$CH_3-\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}-O-CH_3 + NaCl$$

Methyltert-butylether

(b) Add Lucas Reagent: Add a few drops of the Lucas reagent to the test tube containing the alcohol.

Observe the reaction:

Butan-1-ol: Being a primary alcohol, it reacts very slowly with Lucas reagent. There will be little to no turbidity (cloudiness) even after several minutes.

Butan-2-ol: Being a secondary alcohol, it reacts more quickly with Lucas reagent. You will observe turbidity or the formation of an oily layer within a few minutes.

(c) Ethanol (C_2H_5OH) < Water (H_2O) < Phenol (C_6H_5OH)

- Phenol is the strongest acid because its conjugate base is stabilised by resonance.
- Water and ethanol are both weak acids, but ethanol is weak acid as compare to water due to presence of alkyl(ethyl) group which decreases the acidity through +I effect.

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SECTION – B

18. Reactant $\rightarrow$ Product

Rate of reaction $(R) = k[A]^2$ ...(i)

(A is reactant, 2 signifies this is second order reaction)

(i) If the concentration of reactant is doubled:

$A \rightarrow 2A$

Substituting in Eq. (i)

$$R = k[2A]^2$$
$$R = k.\,4A^2$$

Change in rate of reaction =

$$\frac{\text{rate of reaction when concentration is doubled}}{\text{rate of reaction originally}}$$

$$= \frac{4kA^2}{kA^2} = 4:1$$

When concentration is doubled, rate of reaction increases four times.

(ii) If the concentration of the reactant is reduced to half:

$$A \rightarrow \frac{1}{2}A$$

$$R = k\,[\frac{1}{2}A]^2 = k.\frac{1}{4}A^2$$

Change in rate of reaction $= \frac{1}{4}kA^2 : kA^2$

$$= \frac{1}{4}:1$$

When concentration is reduced to half, rate of reaction is reduced to one-fourth.

19. Fusion of chromite ore ($FeCr_2O_4$) with sodium carbonate in free access of air results in production of sodium chromate and iron oxide

$$\underset{\text{Chromite Ore}}{4FeCr_2O_4} + \underset{\text{Sodium carbonate}}{8Na_2CO_3} + 7O_2 \rightarrow \underset{\substack{\text{Sodium chromate}\\(A)}}{8Na_2CrO_4} + \underset{\text{Iron(III) oxide}}{2Fe_2O_3} + 8CO_2$$

The yellow solution of sodium chromate is filtered and acidified (with sulphuric acid) to give solution (B) from which orange sodium dichromate, $Na_2Cr_2O_7 \cdot 2H_2O$ can be crystallised.

$$\underset{(A)}{2Na_2CrO_4} + H_2SO_4 \rightarrow \underset{(B)}{Na_2Cr_2O_7} + Na_2SO_4 + H_2O$$

Sodium dichromate combines with potassium chloride to form potassium dichromate.

$$\underset{(B)}{Na_2Cr_2O_7} + 2KCl \rightarrow \underset{\substack{\text{PotassiumDichromate}\\\text{(Orange) (C)}}}{K_2Cr_2O_7} + 2NaCl$$

$$\underset{(C)}{K_2Cr_2O_7} + 3Na_2SO_3 + 4H_2SO_4 \rightarrow \underset{(D)}{3Na_2SO_4} + K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O$$

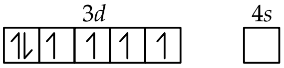
A: Sodium chromate (Na_2CrO_4)
B: Sodium dichromate ($Na_2Cr_2O_7$)
C: Potassium dichromate ($K_2Cr_2O_7$)
D: Sodium sulphate (Na_2SO_4)

20. $[Co(NH_3)_6]^{3+}$ – inner orbital complex.

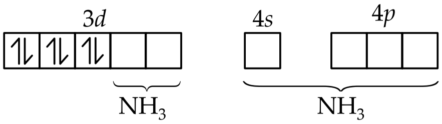
Co = $[Ar]3d^7\,4s^2$ (os of Co = 3^+)

Co^{3+} = $[Ar]\,3d^6\,4s^0$

Electronic configuration of Co^{3+} is,



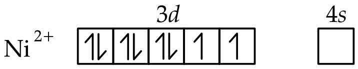
Ammonia in this case acts as strong field ligand due to +3 oxidation state of Co And six pairs of electrons from ammonia molecule occupy the six hybrid orbitals.



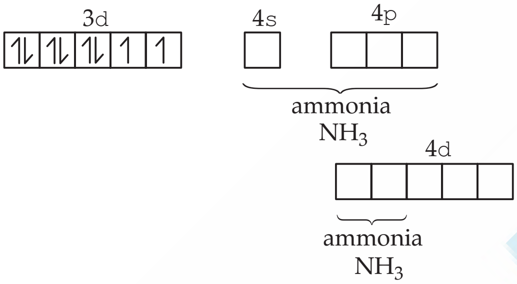
Thus, forming, d^2sp^3 hybridisation. Here, inner orbital 3*d* is involved in hybridisation, so it is called as inner orbital complex or low spin complex.

In $[Ni(NH_3)_6]^{2+}$, the electronic configuration of Ni is $[Ar]\ 3d^8 4s^2$.

Ni has +2 oxidation state, thus the configuration becomes $[Ar]3d^8\ 4s^0$



Ammonia in this case acts as weak field ligand due to +2 oxidation state of Ni.



It undergoes sp^3d^2 hybridisation. As outer *d*-orbital is involved it is outer orbital complex.

SECTION – C

22. Given:

W_A (of urea) = 15 g

Molar mass/molecular weight = 60 g/mol

Isotonic solution.

W_B (of glucose) = ?

Molar mass/molecular weight of glucose = 180 g/mol

$$\text{Moles of urea} = \frac{\text{wt. of urea}}{\text{molar mass}} = \frac{15}{60}$$

= 0.25 mol for 1 litre

For isotonic solution,

$$\pi = CRT$$

(where, *C* is concentration, *R* is constant and *T* is temperature)

$$\pi_{urea} = \pi_{glucose}$$

$$C_{urea}RT = C_{glucose}RT \qquad (RT \text{ is common})$$

(Taking $C = n/V$)

$$0.25 = n/1L$$

$$n \text{ glucose} = 0.25$$

$$\text{Moles of glucose} = \frac{\text{wt. of glucose}}{\text{molar mass}}$$

$$0.25 = \frac{W_B}{180}$$

$$W_B = 0.25 \times 180$$

$$W_B \text{ of glucose} = 45 \text{ g}$$

Mass of glucose in 1 L of solution = 45 g

23. According to kohlrausch law,

$HCl \rightarrow H^+ + Cl^-$

Λ°_m of HCl → Λ°_m of H^+ + Λ°_m of Cl^-

$426 = \Lambda^\circ_m$ of $H^+ + \Lambda^\circ_m$ of Cl^- ...(i)

Similarly,

$91 = \Lambda^\circ_m$ of $CH_3COO^- + \Lambda^\circ_m$ of Na^+ ...(ii)

$126 = \Lambda^\circ_m$ of $Na^+ + \Lambda^\circ_m$ of Cl^- ...(iii)

Solve Eq. (i) + (ii) – (iii)

(Hint: *We want* CH_3COO^- *and* H^+ *ions only)*

Λ°_m of $H^+ + \Lambda^\circ_m Cl^- + \Lambda^\circ_m$ of $CH_3COO^- + \Lambda^\circ_m$ of $Na^+ - \Lambda^\circ_m$ of $Na^+ - \Lambda^\circ_m$ of Cl^-

= 426 + 91 – 126

= 391 Ω^{-1} cm²/mol

Λ°_m of CH_3COOH = 391 Ω^{-1} cm²/mol

$$\alpha = \frac{\text{molar conductivity}}{\text{limiting molar conductivity}}$$

$$= \frac{48.1}{391} = 0.123$$

24. **(a)** Reducing agent means it undergoes oxidation which means it loses electrons.

Cr^{2+} is a strong reducing agent, it has $3d^4$ electronic configuration. Hence, it loses electron to form $3d^3$ configuration, which has half filled t_{2g} and is more stable.

But in case of Mn^{3+}, the electronic configuration $3d^4$ gains electron to become $3d^5$ (Mn^{2+}). It attains extra stability due to $3d^5$ electronic configuration. Hence it is a strong oxidising agent.

(b) **(1)** It causes the radii of the members of the third transition series to be very similar to those of the corresponding members of the second series. For example, the radius of Zr = radius of Hf and the radius of Nb = radius of Ta, and so on.

(2) The basic strength decreases from $La(OH)_3$ to $Lu(OH)_3$, as the size of the lanthanides decreases from the elements La to Lu, the covalent character of the hydroxides increases.

(Any other 2 correct answers)

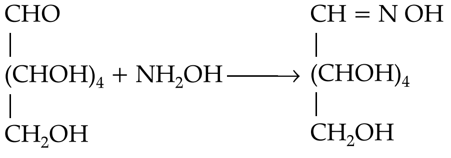
(c) In 3*d* elements, *d*-orbitals are involved in metallic bonding but not in case of zinc. Hence it shows lowest enthalpy of atomisation.

25. **(a)** Dichloridobis(ethane-1,2-diammine)iron(III)ion.

(b) Tetraammineaquabromidocobalt(III)sulphate.

(c) Tetracyanidonickelate(II)ion.

28. **(a)** When glucose reacts with hydroxylamine (NH_2OH) under acidic conditions, it undergoes an oxime formation reaction.



$$\mathrm{CHO{-}(CHOH)_4{-}CH_2OH + NH_2OH \longrightarrow CH{=}N\,OH{-}(CHOH)_4{-}CH_2OH}$$

Glucose　　　　Glucose oxime

(b) As amino acids contain both basic $-NH_2$ group and acidic –COOH group, they are said to be amphoteric.

(c) Vitamin C is water-soluble so it cannot be stored in the body. Excess amount of vitamin C is excreted through urine.

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SECTION – B

18. Rate law is the expression which expresses the rate of reaction in terms of molar concentration of the reactants with each term raised to some power, which may or may not be the same as the stoichiometric coefficient of that reactant in the balanced chemical reaction.

Rate = $k\,[A]^a\,[B]^b$

$[A]$ and $[B]$ are molar concentrations, k is the rate constant, a and b are the powers.

Rate constant may be defined as the rate of the reaction when the molar concentration of each reactant is taken as unity.

(a) First order reaction: $n = 1$

The unit of the rate constant is $\mathrm{mol}^{1-n}\,L^{n-1}\,\mathrm{s}^{-1}$

$= \mathrm{s}^{-1}$

(b) Second order reaction: $n = 2$

The unit of the rate constant is = $\mathrm{mol^{-1}Ls^{-1}}$

19. **(a)** $8MnO_4^- + 3S_2O_3^{2-} + H_2O \rightarrow 8MnO_2 + 6SO_4^{2-} + 2OH^-$

(b) $Cr_2O_7^{2-} + 3Sn^{2+} + 14H^+ \rightarrow 3Sn^{4+} + 2Cr^{3+} + 7H_2O$

21. **(a)** *p*-chloronitrobenzene reacts with aq. NaOH at lower temperature to form *p*-nitrophenol because the nitro group on the benzene ring is electron withdrawing group making the carbon attached to the chlorine significantly more electrophilic, enhances the reactivity of the chlorine atom towards nucleophilic substitution reaction thus readily allowing the hydroxide ion to replace the chlorine atom.

Whereas chlorobenzene reacts with aq NaOH at 623 K (high temperature) and 300 atm(high pressure)to overcome the stability of the C–Cl bond due to resonance stabilisation and thus facilitates the displacement of Cl atom by OH^- ion and forms phenol.

(b) In KCN, the bonds are ionic, so carbon atom is free to make bond that's why propane nitrile formed while in AgCN the bonds are covalent, so carbon atom is not free to make bond so nitrogen atom of cyanide part will attack on chloroethane to form ethyl isocyanide.

22.

$p = K_H \cdot \chi$

$\chi = p/K_H$: $3.34 \times 10^5/1.67 \times 10^8$

$= 2 \times 10^{-3}$

$N = 540/18 = 30$

$\chi = n_{CO_2}/N_{H_2O}$

$n_{CO2} = 2 \times 10^{-3} \times 30 = 60 \times 10^{-3}$

or $60/1000 = 0.06$ moles.

23. **(a)** Fuel cells have higher efficiency as they convert chemical energy into electrical energy directly and lower emission while in thermal plants release gases like CO_2.

(b) Zinc is more reactive than iron, so act as a sacrificial anode that corrodes instead of iron.

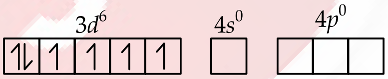
(c) When DC is applied, the ions in solution are attracted to the electrodes of opposite charge, leading to their deposition and the concentration of solution will change, so AC current is used which does not alter the concentration of solution.

24. **(a)** When Mn loses electron and form Mn^{2+}, it attains stable half-filled $3d^5$ electronic configuration, so exhibit more negative reduction potential as compare to neighbouring d block elements.

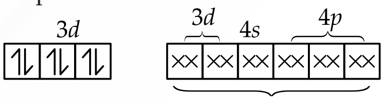
(b) The gradual decrease in the size of lanthanide atoms and ions as their atomic number increases from La–57 to Lu–71 is called lanthanoid contraction. This is due to poor shielding effect of $4f$ orbital.

(c) Zn, Cd and Hg have completely filled d orbitals, they do not have unpaired electrons in d subshell. so it is difficult to make strong metallic bonds that's why these are soft metals.

25. **(i)**

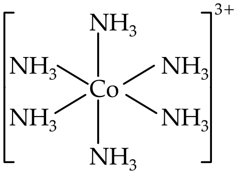


∵ Co^{3+} ion has 4 unpaired electrons in $3d$-subshell and NH_3 behaves as strong ligand due to +3 oxidation state of cobalt. Therefore, electrons get paired up:



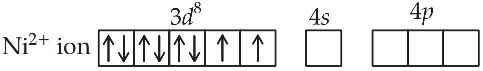
d^2sp^3-hybridised

Thus, Co^{3+} in $[Co(NH_3)_6]^{3+}$ is in d^2sp^3 (inner orbital octahedral complex) and is diamagnetic in nature due to absence of unpaired electrons.

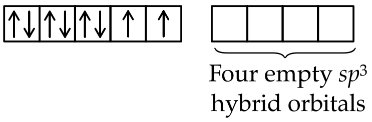


Octahedral

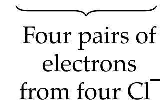
(ii) The central metal ion present in this complex is Ni^{2+}. With atomic number 28. Ni^{2+} – $[Ar]3d^84s^0$. so hybridisation is sp^3 with tetrahedral geometry and paramagnetic due to two unpaired electrons.



sp^3 hybrid orbitals of Ni^{2+}



Formation of $[NiCl_4]^{2-}$



(b) When (crystal field stabilisation energy) CFSE of d^5 is more than pairing energy, it indicates a low spin complex, the electron will pair in lower energy level before filling in higher energy level. Electronic configuration will be $t_{2g}^5 e_g^0$

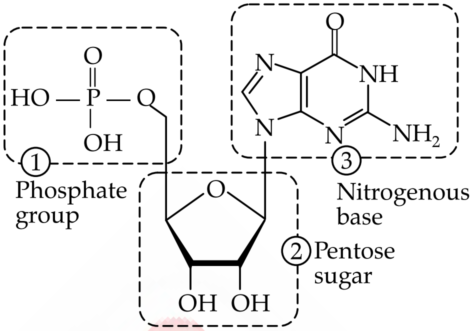
28. **(a)** The sequence in which amino acids are linked together with the help of peptide bonds determines the native state of a protein. A native protein is a protein that has folded into its unique three-dimensional structure under physiological conditions and possesses its specific biological activity.

(b) A nucleotide is the basic building block of nucleic acids (DNA and RNA). It consists of three components, i.e., a phosphoric acid group, a pentose sugar and a nitrogenous base. A nucleotide consists of three units, which are covalently linked. They are:

(i) Nitrogenous bases – Purine and Pyrimidine

(ii) Pentose Sugar – Ribose and Deoxyribose

(iii) Phosphate – monophosphate, diphosphate, triphosphate



(c) Essential amino are amino acids that the body can't make, so they must be supplied by diet. The nine essential amino acids are:

Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, Valine.

■■■