ISC 2026 EXAMINATION
Sample Question Paper - 3
Chemistry

Time Allowed: 3 hours and 15 minutes   **Maximum Marks: 70**

General Instructions:

1. You are allowed additional 15 minutes for only reading the question paper.
2. You must NOT start writing during the reading time.
3. This question paper has 11 printed pages.
4. It is divided into four sections and has 21 questions in all.
5. All questions are compulsory. Answer all questions.
6. Section A has fourteen subparts. Each question carries 1 mark.
7. While attempting Multiple Choice Questions in Section A, you are required to write only ONE option as the answer.
8. Section B has ten questions. Each question carries 2 marks.
9. Section C has seven questions. Each question carries 3 marks.
10. Section D has three questions. Each question carries 5 marks.
11. Internal choices have been provided in one question each in Sections B, C and D.
12. The intended marks for questions are given in brackets [ ].
13. All working, including rough work, should be done on the same sheet as, and adjacent to the rest of the answer.
14. Balanced equations must be given wherever possible and diagrams where they are helpful.
15. When solving numerical problems, all essential workings must be shown.

Section A

1. **Fill in the blanks by choosing the appropriate word(s) from those given in the brackets:**   **[4]**

    (a) **Fill in the blanks by choosing the appropriate word(s) from those given in the   [4]
    brackets:**

    [oxidation, reduction, increases, decreases, cathode, anode, Nernst, Gibbs free energy, concentration, fuel cell, lead accumulator, corrosion, emf]

    i. The electrode where oxidation takes place is called the _____, while the electrode where reduction takes place is the _____.

    ii. The variation of cell potential with the concentration of ions is given by the _____ equation.

    iii. The relationship between the emf of a cell and the _____ change can be expressed as:

    $\Delta G = -nFE$.

    iv. _____ is a type of galvanic cell where chemical energy is directly converted into electrical energy using a continuous supply of reactants.

2. **Select and write the correct alternative from the choices given below.**   **[7]**

(a) If two liquids A and B form minimum boiling azeotrope at some specific composition then: **[1]**

a) A-B interaction are stronger than those between A-A or B-B.

b) Vapour pressure of solution increases because more number of molecules of liquids A and B can escape from Utesolution.

c) Vapour pressure of solution decreases because less number of molecules of only one of Uteliquids escape from Utesolution.

d) A-B interactions are weaker than those between A-A or B-B.

(b) Benzaldehyde when heated with alcoholic solution of potassium cyanide gives **[1]**

a) $C_6H_5CH(OH)COOH$

b) $C_6H_5CH(OH)C_6H_5$

c) $C_6H_5CH(OH)CN$

d) $C_6H_5CH(OH)COC_6H_5$

(c) **Assertion (A):** Aromatic aldehydes and formaldehyde undergo Cannizzaro reaction. **[1]**
Reason (R): Aromatic aldehydes are almost as reactive as formaldehyde.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

(d) **Assertion (A):** The rate law may not depend on the concentration of every reactant. **[1]**
Reason (R): With increase in temperature, the rate of reaction increases.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

(e) The solubility of a gas varies directly with pressure of the gas, is based upon: **[1]**

a) Henry' law

b) None of these

c) Nernst's Distribution Law

d) Raoult's law

(f) Which of the following does not influence the rate of reaction? **[1]**

a) Temperature of the reaction

b) Nature of the reactants

c) Molecularity of the reaction

d) Concentration of the reactants

(g) Among the following oxides, the least acidic is: **[1]**

a) AS_4O_{10}

b) P_4O_6

c) P_4O_{10}

d) AS_4O_6

3. For the reaction A + B $\rightleftharpoons$ Product, following data was obtained. **[3]**

Experiment number	Initial concentration of [A] (mol L^{-1})	Initial concentration of [B] (mol L^{-1})	Initial rate (mol L^{-1} min^{-1})

1	0.15	0.15	9.6×10^{-2}
2	0.30	0.15	3.84×10^{-1}
3	0.15	0.30	1.92×10^{-1}
4	0.30	0.30	7.68×10^{-1}

Calculate the following.

  i. The overall order of the reaction.

  ii. The rate law equation.

  iii. The value of rate constant.

Section B

4. If the slope of graph of log K vs $\frac{1}{T}$ is -5841. How can you graphically find the activation energy? **[2]**

5. For the reaction $A + B \longrightarrow C + D$, the initial rate for different reactions and initial concentration of reactants are given below. **[2]**

S.No.	Initial conc.		Initial rate
	[A] mol L^{-1}	[B] mol L^{-1}	(mol L^{-1} s^{-1})
1.	1.0	1.0	2×10^{-3}
2.	2.0	1.0	4×10^{-3}
3.	4.0	1.0	8×10^{-3}
4.	1.0	2.0	2×10^{-3}
5.	1.0	4.0	2×10^{-3}

  i. What is the overall order of reaction?

  ii. Write the rate law equation.

6. The osmotic pressure of blood at 37°C is 8.21 atm. How much glucose in grams should be used per litre of aqueous solution for an intravenous injection so that it is isotonic with blood? (Molecular wt. of glucose = 180 g/mol) **[2]**

7. John was making noodles in boiling water. When he added common salt (NaCl) to boiling water, the water stopped boiling for a short while. If John had added 15.0 g of NaCl to 250.0 g of water, calculate the boiling point of solution assuming that NaCl dissociates completely in water. (K_b for water = 0.512 K kg mol^{-1}, molecular mass of NaCl = 58.44 g mol^{-1}). **[2]**

8. The freezing point of a solution containing 0.3 g of acetic acid in 30 g of benzene is lowered by 0.45 K. Calculate the van't Hoff factor. (Atomic weight of C = 12, H = 1, O = 16, K_f for benzene = 5.12 K kg mol^{-1}) **[2]**

9. Name the type of isomerism shown by the following pairs of coordination compounds. **[2]**

  i. $[Co(NH_3)_5NO_2]Cl_2$ and $[Co(NH_3)_5ONO]Cl_2$

  ii. $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$ and $[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$

10. With reference to the coordination complex ion $[Fe(H_2O)_6]^{2+}$ answer the following. (Atomic **[2]**

number of Fe = 26)

   i. Give the IUPAC name of the complex ion.

   ii. What is the oxidation number of the central metal atom?

  iii. How many unpaired electrons are there in the complex ion?

  iv. State the type of hybridisation of the complex ion.

11.   Account for the following: **[2]**

   i. Salts of cuprous (Cu^+) ion are colourless whereas the salts of cupric (Cu^{2+})ion are coloured.

   ii. Zinc is not regarded as a transition element. (at. no. of Zn = 30)

<div align="center">OR</div>

Complete and balance the following chemical equations.

   i. $KMnO_4 + H_2SO_4 + FeSO_4 \rightarrow$ ..... + ... + ... + ...

   ii. $K_2Cr_2O_7 + KI + H_2SO_4 \rightarrow$ ..... + ... + ... + ...

12.   i. Write a chemical test to distnguish between ethanol and phenol. **[2]**

   ii. Give a chemical reaction to convert acetaldehyde into secondary propyl alcohol.

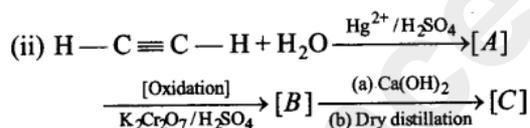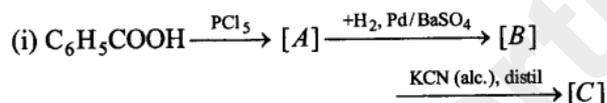13.   How will you convert the following? (Give balanced equation). **[2]**

   i. Methyl chloride to acetic acid

   ii. Acetic acid to methane

<div align="center">**Section C**</div>

14.   Identify the compounds [A], [B] and [C]. **[3]**

(i) $C_6H_5COOH \xrightarrow{PCl_5} [A] \xrightarrow{+H_2, Pd/BaSO_4} [B] \xrightarrow{KCN\ (alc.),\ distil} [C]$

(ii) $H-C\equiv C-H + H_2O \xrightarrow{Hg^{2+}/H_2SO_4} [A] \xrightarrow[K_2Cr_2O_7/H_2SO_4]{[Oxidation]} [B] \xrightarrow[\text{(b) Dry distillation}]{\text{(a) Ca(OH)}_2} [C]$

15.   Give one good chemical test to distinguish between the following pairs of organic compounds: **[3]**

   i. Benzaldehyde and acetone.

   ii. Methylamine and dimethylamine

16.   i. Name the types of isomerism shown by the following pairs of compounds: **[3]**

     a. $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$

     b. $[Co(en)_2Cl_2]^+$ and $[Co(en)_2Cl_2]^+$

   ii. For the coordination complex ion $[Co(NH_3)_6]^{3+}$

     a. Give the IUPAC name of the complex ion.

     b. What is the oxidation number of cobalt in the complex ion?

     c. State the type of hybridisation of the complex ion.

     d. State the magnetic behaviour of the complexion.

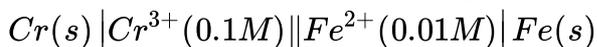17.   Calculate the degree of dissociation (α) of acetic acid, if its molar conductivity (Λ_m) is **[3]** $39.05\ S\ cm^2\ mol^{-1}$.

(Given: $\lambda^\circ_{(H^+)} = 349.6\ S\ cm^2\ mol^{-1}$ and $\lambda^\circ_{(CH_3COO^-)} = 40.95\ S\ cm^2\ mol^{-1}$)

<div align="center">OR</div>

Calculate the emf and ΔG for the given cell at $25^\circ C$.

$$Cr(s)\big|Cr^{3+}(0.1M)\|Fe^{2+}(0.01M)\big|Fe(s)$$

Given, $E^\circ_{Cr^{3+}/Cr} = -0.74\,V, E^\circ_{Fe^{2+}/Fe} = -0.44\,V$

$$\left(1\,F = 96500C, R = 8.314JK^{-1}\,mol^{-1}\right)$$

18. Explain why: **[3]**

   i. Glucose is soluble in water but cyclohexane is not.

   ii. Aldehyde group is absent in the pentaacetate of D-glucose.

   iii. Glucose when heated with red P and HI gives n-hexane.

19. The rate constant for a first order reaction becomes six times when the temperature is increased from 350 K to 410 K. Calculate activation energy (E_a) for the reaction. **[3]**

20. The decomposition of A into products has a value of k as $4.5 \times 10^3\,s^{-1}$ at $10^\circ C$ and energy of activation 60 kJ mol^{-1}. At what temperature would k be $1.5 \times 10^{+4}\,s^{-1}$? **[3]**

Section D

21. i. Write the product(s) of the following reactions. **[5]**

     a. $CH_3COCH_3 + H_2NOH \longrightarrow$

     b. $2C_6H_5CHO + $ Conc. $NaOH \longrightarrow$

     c. $CH_3COOH \xrightarrow{Cl_2/P}$

   ii. Give one chemical test each to distinguish between the following pairs of compounds.

     a. Benzaldehyde and benzoic acid

     b. Propanal and propanone

22. An alcohol $A\,(C_4H_{10}O)$ on oxidation with acidified $K_2Cr_2O_7$ gives a carboxylic acid $B\,(C_4H_8O_2)$. Treatment of C with warm aq. H_2SO_4 gives $D\,(C_4H_{10}O)$, an isomer of A. The compound D is resistant to oxidation. Identify compound A, B, C and D. Write all reactions. **[5]**

23. i. The elevation in boiling point when 0.30 g of acetic acid is dissolved in 100 g of benzene is 0.0633°C. Calculate the molecular weight of acetic acid from this data. What conclusion can you draw about the molecular state of the solute in the solution? (Given K_b, for benzene = 253 K kg mol^{-1}, at. wt. of C = 12, H = 1, 0 = 16). **[5]**

   ii. Determine the osmotic pressure of a solution prepared by dissolving 0.025 g of K$_2$SO$_4$ in 2 litres of water at 25°C, assuming that K$_2$SO$_4$ is completely dissociated. (R = 0.0821 L atm K^{-1} mol^{-1}, mol. wt. of K$_2$SO$_4$ = 174g mol^{-1}).

OR

   i. Define the following terms:

     a. Molarity

     b. Molal elevation constant (K$_b$)

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

Solution

Section A

1. Fill in the blanks by choosing the appropriate word(s) from those given in the brackets:

   (a) i. The electrode where oxidation takes place is called the **anode**, while the electrode where reduction takes place is the **cathode**.

       ii. The variation of cell potential with the concentration of ions is given by the **Nernst** equation.

      iii. The relationship between the emf of a cell and the **Gibbs free energy** change can be expressed as:
   $\Delta G = -nFE$.

      iv. **Fuel cell** is a type of galvanic cell where chemical energy is directly converted into electrical energy using a continuous supply of reactants.

2. Select and write the correct alternative from the choices given below.
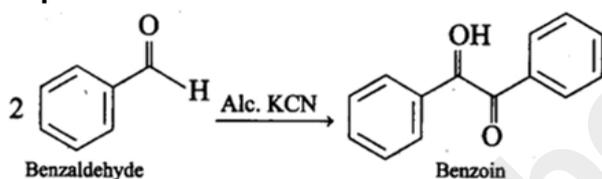
   (a) **(a)** A-B interaction are stronger than those between A-A or B-B.
   Explanation:
   A-B interaction are stronger than those between A-A or B-B.

   (b) **(d)** $C_6H_5CH(OH)COC_6H_5$
   Explanation:

   (c) **(c)** A is true but R is false.
   Explanation:
   A is true but R is false.

   (d) **(b)** Both A and R are true but R is not the correct explanation of A.
   Explanation:
   Both A and R are true but R is not the correct explanation of A.

   (e) **(a)** Henry' law
   Explanation:
   Henry' law

   (f) **(c)** Molecularity of the reaction
   Explanation:
   Molecularity of the reaction

   (g) **(d)** AS_4O_6
   Explanation:
   AS_4O_6

3. Let, the order w.r.t A and B be α and β respectively.
   Rate law expression may be written as
   $\text{Rate} = k[A]^{\alpha}[B]^{\beta}$

   $\therefore 9.6 \times 10^{-2} = k[0.15]^{\alpha}[0.15]^{\beta}$ ...(i)

   or $3.84 \times 10^{-1} = k[03]^{\alpha}[0.15]^{\beta}$ ...(ii)

   or $1.92 \times 10^{-1} = k[0.15]^{\alpha}[03]^{\beta}$ ...(iii)

   or $7.68 \times 10^{-1} = k[03]^{\alpha}[03]^{\beta}$ ...(iv)

   Dividing Eqs. (i) by (ii), we get

   $\dfrac{9.6 \times 10^{-2}}{3.84 \times 10^{-1}} = \dfrac{k[0.15]^{\alpha}[0.15]^{\beta}}{k[0.3]^{\alpha}[0.15]^{\beta}}$

$\therefore \left[\frac{1}{4}\right] = \left[\frac{1}{2}\right]^{\alpha} \Rightarrow \left[\frac{1}{2}\right]^{2} = \left[\frac{1}{2}\right]^{\alpha}$

$\therefore \alpha = 2$

Dividing Eqs. (i) by (iii), we get

$\frac{9.6 \times 10^{-2}}{1.92 \times 10^{-1}} = \frac{k[0.15]^{\alpha}[0.15]^{\beta}}{k[0.15]^{\alpha}[0.3]^{\beta}}$

$\Rightarrow \left[\frac{1}{2}\right]^{1} = \left[\frac{1}{2}\right]^{\beta} \Rightarrow \beta = 1$

   i. The overall order of the reaction is 3.

   ii. Rate law expression.

$\quad$ Rate $= k[A]^{2}[B]^{1}$

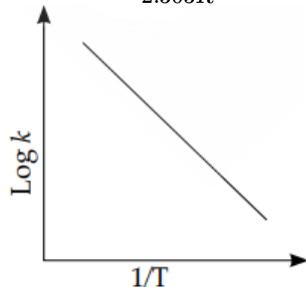   iii. From expression (i) rate constant can be calculated as

$9.6 \times 10^{-2} = k[0.15]^{2}[0.15]^{1}$

$k = \frac{9.6 \times 10^{-2} \text{ mol L}^{-1} \text{ min}^{-1}}{[0.15]^{3} \left(\text{ mol L}^{-1}\right)^{3}}$

$= 28.44 \text{ mol}^{-2} \text{ L}^{2} \text{ min}^{-1}$

Section B

4. Slope $= -\frac{E_a}{2.303R}$

$E_a = -2.303 \times \text{ slope } \times R$

$= -2.303 \times -5841 \times 8.314$

=111838.4 J mol^{-1}

= 111.8 kJ mol^{-1}

5. Rate $= k[A]^{a}[B]^{b}$

where, a = order of A and b = order of B

By dividing rate (2) by rate (1), we get

$\frac{(\text{ Rate })_{2}}{(\text{ Rate })_{1}} = \frac{[A]_{2}^{a}[B]_{2}^{b}}{[A]_{1}^{a}[B]_{1}^{b}}$

$\frac{4 \times 10^{-3}}{2 \times 10^{-3}} = \frac{(2)^{a}(1)^{b}}{(1)^{a}(1)^{b}}$

$2 = (2)^{a} \Rightarrow a = 1$

$\therefore$ Order of A = 1

Similarly, on dividing rate (1) and rate (4), we get

$\frac{(\text{ Rate })_{4}}{(\text{ Rate })_{1}} = \frac{[A]_{4}^{a}[B]_{4}^{b}}{[A]_{1}^{a}[B]_{1}^{b}}$

$\frac{2 \times 10^{-3}}{2 \times 10^{-3}} = \frac{(1)^{a}(2)^{b}}{(1)^{a}(1)^{b}}$

(1) = (1)^{a}

$\Rightarrow$ a = 0

$\therefore$ Order of B = 0

   i. Therefore, overall order of reaction

$\quad$ = 1 + 0 = 1,

   ii. and rate law is r = k[A].

6. Given, π_{blood} = 8.21 atm, V = 1 L, T = 37 + 273 = 310 K

   Blood and glucose are isotonic,

   So, both will have same osmotic pressure,

   We know, π = CRT

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

   $\pi V = nRT$

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

   $n = \frac{8.21 \times 1.0}{0.0821 \times 310} = \frac{10}{31}$

   Weight of glucose = n × molecular weight

   $= \frac{10}{31} \times 180$ = 58.064 g

7. Mass of NaCl = 15 g

   Weight of the solvent = 250 g

   Boiling point of water = T_0 = 373 K

   Boiling point of solution = T

   K_b = 0.512K kg/mol

   $\Delta T = K_b \times$ molality

   $= 0.512 \times \frac{\text{mass of } NaCl}{\text{molar mass of } NaCl \times}$

   weight of the solvent 1 kg

   $\Delta T = 0.512 \times \frac{15\ g \times 1000}{58.5\ g/mol \times 250} = 0.53\ K$

   $\Delta T = 0.523\ K$

   $= T - T_0 = T - 373\ K$

   $\Rightarrow$ T = 373.53 K

8. Given, amount of acetic acid (w) = 03 g,

   amount of benzene (W) = 30 g,

   depression in freezing point

   $\Delta T_f = 0.45\ \text{K}$

   K_f = 5.12 Kkg mol^{-1}

   We know that, $\Delta T_f = iK_fm$

   (where, m is molality and i represents van't Hoff factor)

   Molality, $m = \frac{w \times 1000}{M' \times W} = \frac{0.3 \times 1000}{60 \times 30}$

   $= 0.166 \approx 0.17$

   [as molar mass of acetic acid (CH$_3$COOH)

   $M' = 2 \times 12 + 4 \times 1 + 2 \times 16 = 60\ \text{g mol}^{-1}$]

   Now, $i = \frac{\Delta T_f}{K_f \times m} = \frac{0.45}{5.12 \times 0.17} = 0.517$

9. i. In both compounds, ambident ligand NO$_2$ is present. In [Co(NH$_3$)$_5$NO$_2$] Cl$_2$, NO$_2$ is coordinated through N and in [CO(NH$_3$)$_5$ONO]Cl$_2$, NO$_2$ is coordinated through O.

    Hence, they show linkage isomerism.
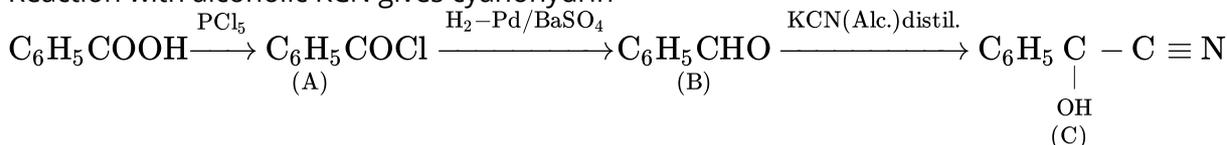
    ii. These isomers differ from each other in number of water molecules coordinated to central metal atom, i.e. (Cr). So, they show hydrate isomerism.
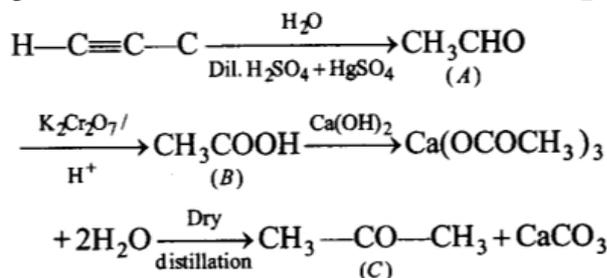
10. i. Hexaaquairon (II) ion.

    ii. Oxidation number is +2.

    iii. In [Fe (H$_2$O)$_6$]$^{2+}$, four unpaired electrons are present as H$_2$O is a weak field ligand. [Fe(H$_2$O)$_6$]$^{2+}$, Fe is in +2 oxidation state

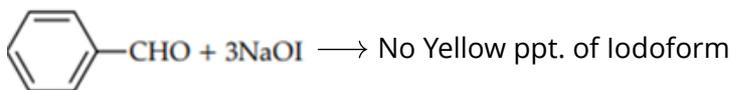$$Fe^{2+}(3d^6, 4s^0) = \boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow} \quad 3d$$

$$[Fe(H_2O)_6]^{2+} = \boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow} \underbrace{\boxed{} \boxed{}\boxed{}\boxed{}\boxed{} \boxed{}\boxed{}\boxed{}}_{sp^3d^2}$$

iv. sp^3d^2-hybridisation

11. i. Cuprous ion (Cu^+) has the electronic configuration of $[Ar]3d^{10}4s^0$ which is fully-filled. Cupric ion (Cu^{2+}) has electronic configuration $[Ar]3d^9 4s^0$ so it can undergoes d-d transition.
Hence, the cuprous ion is colourless and the cupric ion has a colour.

ii. As, zinc atom has completely filled d-orbitals ($3d^{10}$) in its ground state as well as oxidised state, therefore it is not regarded as transition element.

OR

i. The given reaction takes place in acidic mediumin which the ferroussalt is converted to ferric salt.

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4\, 3H_2O + 5O$$
$$[2FeSO_4 + H_2SO_4 + O \longrightarrow Fe_2(SO_4)_3 + H_2O] \times 5$$
$$\overline{2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O}$$

ii. In acidic medium $Cr_2O_7^{2-}$ is converted to Cr^{3+} and I⁻ is converted to I_2.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$$
$$6I^- \longrightarrow 3I_2 + 6e^-$$
$$\overline{Cr_2O_7^{2-} + 14H^+ + 6I^- \longrightarrow 2Cr^{3+} + 7H_2O + 3I_2}$$

12. i. Iodoform test can be used distinguish between ethanol and phenol.

- $\underset{\text{Ethanol}}{CH_3CH_2OH} + 4NaOl \longrightarrow \underset{\substack{\text{Iodoform}\\ \text{(Yellow ppt.)}}}{CHI_3} + HCOONa + NaI + H_2O + 2NaOH$

- $\underset{\text{Phenol}}{C_6H_5OH} + NaOH \longrightarrow$ No yellow ppt.

ii. Conversion of acetaldehyde to secondary propyl alcohol.

$$\underset{\text{(Acetaldehyde)}}{CH_3 - \overset{\overset{\displaystyle H}{|}}{C} = O} + CH_3MgBr \longrightarrow$$

$$CH_3 - \underset{\underset{\displaystyle CH_3}{|}}{\overset{\overset{\displaystyle H}{|}}{C}} - OMgBr \xrightarrow[\text{Hydrolysis}]{H_2O/H^+}$$

$$\underset{\text{(Secondary propyl alcohol)}}{CH_3 - \underset{\underset{\displaystyle CH_3}{|}}{\overset{\overset{\displaystyle H}{|}}{C}} - OH} + Mg \Big\langle\begin{array}{l} OH \\ Br\end{array}$$

13. i. $\underset{\text{Methylchloride}}{CH_3 - Cl} \xrightarrow{Mg/Ether} CH_3MgCl \xrightarrow[\text{(b) Water}]{\text{(a) } CO_2} \underset{\text{Acetic acid}}{CH_3COOH}$

ii. $\underset{\text{Acetic acid}}{CH_3COOH} \xrightarrow{NaOH} CH_3COO^-Na^+ \xrightarrow[\Delta]{NaOH/CaO} \underset{\text{Methane}}{CH_4}$

Section C

14. i. Benzoic acid reacts with PCl_5 to form benzyl chloride and reduction with H_2-Pd/BaSO$_4$ gives benzaldehyde.

Reaction with alcoholic KCN gives cyanohydrin

$$C_6H_5COOH \xrightarrow{PCl_5} \underset{(A)}{C_6H_5COCl} \xrightarrow{H_2-Pd/BaSO_4} \underset{(B)}{C_6H_5CHO} \xrightarrow{KCN(Alc.)distil.} \underset{\underset{\underset{(C)}{OH}}{|}}{C_6H_5 \overset{}{C} - C \equiv N}$$
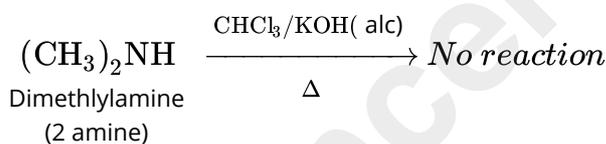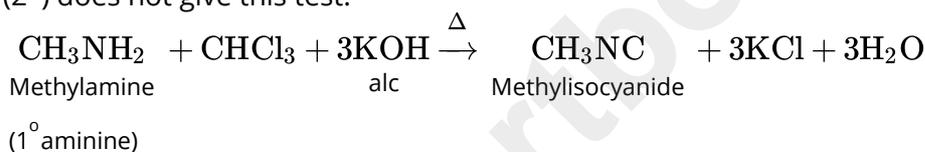
ii. Hydration of ethyne with $H_2O HgSO_4/H_2SO_4$ gives acetaldehyde. Moreover, oxidation of acetaldehyde gives ethanoic acid. It is reacted with $Ca(OH)_2$ and the product is distilled dry and form acetone.

$$H-C \equiv C-C \xrightarrow[Dil. H_2SO_4 + HgSO_4]{H_2O} \underset{(A)}{CH_3CHO}$$

$$\xrightarrow[H^+]{K_2Cr_2O_7/} \underset{(B)}{CH_3COOH} \xrightarrow{Ca(OH)_2} Ca(OCOCH_3)_3$$

$$+2H_2O \xrightarrow[distillation]{Dry} \underset{(C)}{CH_3-CO-CH_3} + CaCO_3$$

15. i. The distinction between benzaldehyde and acetone: Iodoform test: Acetone on treatment with $NaOH/I_2$ (NaOI) gives yellow ppt. of Iodoform but benzaldehyde does not.

$$\underset{Acetone}{CH_3COCH_3} + 3NaOI \longrightarrow \underset{Iodoform}{CHI_3} + CH_3COONa + 2NaOH$$

$$\text{⌬}-CHO + 3NaOI \longrightarrow \text{No Yellow ppt. of Iodoform}$$

ii. The distinction between methylamine and dimethylamine. Carbylamine test: Methylamine (1^0 amine) when heated with alc. KOH and $CHCl_3$ gives the offensive smell of methylisocyanide. Dimethylamine

(2^0) does not give this test.

$$\underset{\underset{(1^o \text{ aminine})}{Methylamine}}{CH_3NH_2} + CHCl_3 + 3KOH \underset{alc}{\overset{\Delta}{\longrightarrow}} \underset{Methylisocyanide}{CH_3NC} + 3KCl + 3H_2O$$

$$\underset{\underset{(2 \text{ amine})}{Dimethlylamine}}{(CH_3)_2NH} \xrightarrow[\Delta]{CHCl_3/KOH(\text{ alc})} No \ reaction$$

16. i. a. Coordination isomerism.
   b. Ligand isomerism.
   ii. a. Hexaamminecobalt(III) ion.
   b. +3
   c. d^2sp^3 hybridisation
   d. diamagnetic

17. Given, $\Lambda_m = 39.05 \ S \ cm^2 \ mol^{-1}$

We know that,

Degree of dissociation$(\alpha) = \frac{\Lambda_m}{\Lambda_m^\circ}$

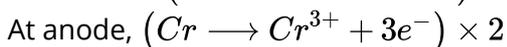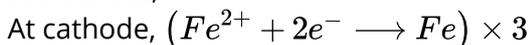$\lambda_{CH_3COOH}^\circ = \lambda_{CH_3COO^-}^\circ + \lambda_{H^+}^\circ$

$\Lambda_{CH_3COOH}^\circ = 40.95 + 349.6 = 390.55 \ S \ cm^2 \ mol^{-1}$

Now, $\alpha = \frac{39.05}{390.55} = 0.099$

OR

Given, $E_{Cr^{3+}/\dot{Cr}}^\circ = -0.74 \ V, E_{Fe^{2+}/Fe}^\circ = -0.44 \ V$

For the cell,

At cathode, $(Fe^{2+} + 2e^- \longrightarrow Fe) \times 3$

At anode, $(Cr \longrightarrow Cr^{3+} + 3e^-) \times 2$

Hence, n = 6

According to Nernst equation,

$$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{n} \log_{10} \frac{[\text{Product}]}{[\text{Reactant}]}$$

$$= E^{\circ}_{cell} - \frac{0.0591}{6} \log \frac{[Cr^{3+}]^2}{[Fe^{2+}]^3}$$

$$E^{\circ}_{cell} = E_{cathode} - E_{anode}$$

= -0.44 - (-0.74) = 0.30 V

Given, $[Cr^{3+}] = 0.1 M$ and $[Fe^{2+}] = 0.01 M$

$$E_{cell} = 0.30 - \frac{0.0591}{6} \log \frac{[0.1]^2}{[0.1]^3} = 0.2902\ V$$

Also, we know, $\Delta G = -nFE_{cell}$

$$= -6 \times 96500 \times 0.2902$$

= -168025.8 J = -168.03 kJ

18. i. Glucose has five -OH groups which form hydrogen bond with water. Due to this extensive intermolecular hydrogen bonding, glucose is soluble in water.
Cyclohexane is a non-polar molecule with no -OH group, hence it does not dissolve in polar solvent water.

  ii. Pentaacetate of D-Glucose does not contain any free aldehyde group as it is a cyclic structure of glucose. Glucose on acetylation forms pentaacetate of D-glucose.

  iii. As it contains straight chain of six carbon atoms.

19. Let $k_1 = k$ and $k_2 = 6k$

Given, $T_1 = 350$ K, $T_2 = 410$ K

$$\log \frac{k_2}{k_1} = \frac{E_a}{2303R} \left[\frac{T_2 - T_1}{T_1 \cdot T_2} \right]$$

$$\log \frac{6k}{k} = \frac{E_a}{2.303 \times 8314} \left[\frac{410 - 350}{410 \times 350} \right]$$

$$\frac{0.77 \times 2.303 \times 8.314 \times 410 \times 350}{60} = E_a$$

$E_a = 35.2$ kJ mol^{-1} = 3563433 J mol^{-1}

20. Given, $T_1 = 10^{\circ}$C + 273 = 283 K

$$k_{T_1} = 4.5 \times 10^3\ s^{-1}$$

$$E_a = 60\ kJ\ mol^{-1} = 50 \times 10^3\ J\ mol^{-1}$$

$$T_2 = ?$$

$$k_{T_2} = 1.5 \times 10^{-4}\ s^{-1}$$

We know that

$$\log \frac{k_{T_2}}{k_{T_1}} = \frac{E_a}{2.303R} \left[\frac{T_2 - T_1}{T_1 \times T_2} \right]$$

On putting values

$$\log \frac{1.5 \times 10^{+4}}{4.5 \times 10^3} = \frac{60 \times 10^3\ J\ mol^{-1}}{2.303 \times 8.314} \left(\frac{T_2 - 283}{283\ T_2} \right)$$

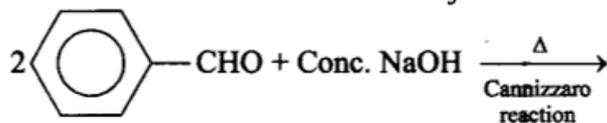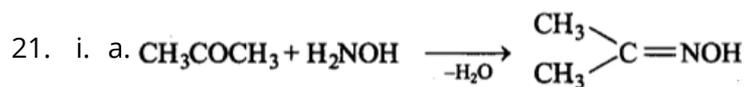$$0.523 = 3133.63 \left(\frac{T_2 - 283}{283\ T_2} \right)$$

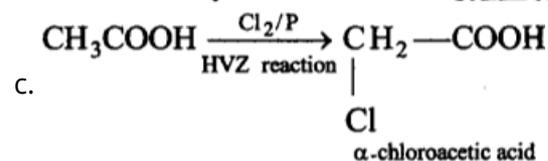$$\frac{T_2 - 283}{283\ T_2} = 1.67 \times 10^{-4}$$

$$T_2 - 283 = 0.0472\ T_2$$
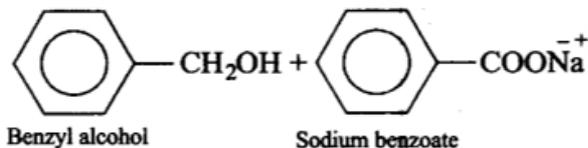
$$0.953 T_2 = 283$$

$$T_2 = 297,\ \text{or}$$

$$T_2 = 24^{\circ}C$$

Section D

21. i. a. $CH_3COCH_3 + H_2NOH \xrightarrow{-H_2O} \begin{array}{c} CH_3 \\ CH_3 \end{array} C=NOH$

   b.

   Benzyl alcohol   Sodium benzoate

   c. $CH_3COOH \xrightarrow[\text{HVZ reaction}]{Cl_2/P} \underset{\underset{Cl}{|}}{CH_2}-COOH$
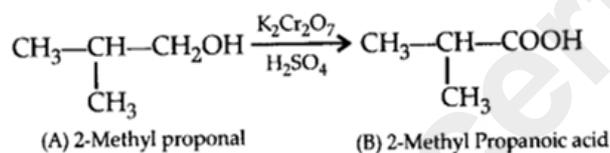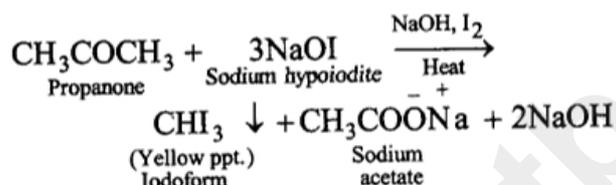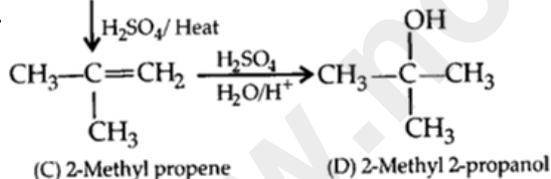
   α-chloroacetic acid

   ii. a. **Benzaldehyde and benzoic acid** NaHCO$_3$ **test** is used to distinguish between the two molecules. Benzoic acid being an acid reacts with NaHCO$_3$ solution to produce brisk effervescence due to evolution of CO$_2$ while benzaldehyde does not give this test.

   $$C_6H_5COOH + NaHCO_3 \longrightarrow C_6H_5CO\overset{- \ +}{O}Na + CO_2\uparrow + H_2O$$
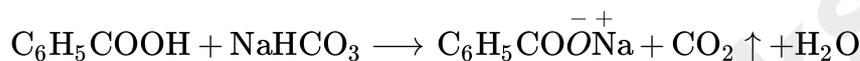
   b. **Propanal and propanone Propanone** responds to iodoform test whereas propanal (CH$_3$CH$_2$CHO) due to the absence of CH$_3$CO- group does not.

22.

   (A) 2-Methyl propanal   (B) 2-Methyl Propanoic acid

   (C) 2-Methyl propene   (D) 2-Methyl 2-propanol

23. i. Given, weight of solute $(w_B) = 0.30\ g$ weight of solvent $(W_A) = 100\ g$.

   $\Delta T_b = 0.0633°C \Rightarrow 0.0633\ K$.

   $K_b = 2.53\ K\ kg\ mol^{-1}$

   $M_B = \frac{K_b \times w_B \times 1000}{W_A \times \Delta T_b} = \frac{2.53 \times 1000 \times 0.30}{100 \times 0.0633}$

   = 119.9 g/mol

   $i = \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}} \Rightarrow \frac{60}{119.90} = 0.5$
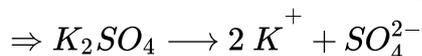
   $\therefore i < 1$

   As i is less than 1, thus association will take place.

   ii. Given, mass of $K_2SO_4 (W) = 25mg = 0.025\ g$;

   volume (V) = 2 L, T = 298 K

   The reaction of dissociation of K_2SO_4.

   $\Rightarrow K_2SO_4 \longrightarrow 2\ K^+ + SO_4^{2-}$

   Number of ions produced $i = 2 + 1 = 3$

   as $\pi = i\frac{n}{V}RT = i\frac{W}{MV}RT$

where, $R = 0.082 \ L \ atm \ K^{-1} \ mol^{-1}$, molar mass of $K_2SO_4 = 174 \ g/mol$

By substituting the value we get

$T_1 = \frac{3 \times 0.025}{174 \times 2} \times 0.0821 \times 298 = 5.27 \times 10^{-3} \ atm$

OR

i. i. Molarity: Molarity of a substance in a solution is equal to the number of moles of the substance present inone litre of the solution.

i.e., Molarity $= \dfrac{\text{No. of moles of substance}}{\text{Volume of solution in } L}$

ii. Molal elevation constant: It is also called ebullioscopic constant. It is equal to the change in boiling point of one molar solution.

$\Delta T_b = K_b \cdot m$

So, when, Molarity = 1, $\Delta T_b = K_b$

ii. Given; Mass of urea, W_B = 15 g

Molar mass of urea, M_B = 60 g

The solution of urea in water is isotonic to that of glucose solution.

So, $\pi_{\text{urea}} = \pi_{\text{Glucose}}$

$C_{\text{urea}} \ RT = C_{\text{Glucose}} \ RT$

$\dfrac{n_{\text{urea}}}{VT} = \dfrac{n_{\text{Glucose}}}{RT}$

$\dfrac{W}{M_B} = \dfrac{W_{\text{Glucose}}}{M_w}$

So, $W_{\text{Glucose}} = \dfrac{15 \times 180}{60}$

= 45 g

So, 45 g of glucose is present in 1 L of solution.