



## SAMPLE PAPER 4

### CHEMISTRY PAPER 1 (THEORY)

**Maximum Marks: 70**

**Time Allowed: Three Hours**

*(Candidates are allowed **additional 15 minutes** for **only** reading the paper.*

*They must **NOT** start writing during this time.)*

*This paper is divided into four sections – A, B, C and D.*

*Answer **all** questions.*

*Section – A consists of **one** question **having sub-parts** of **one** mark each.*

*Section – B consists of **ten** questions of **two** marks each.*

*Section – C consists of **seven** questions of **three** marks each, and*

*Section – D consists of **three** questions of **five** marks each.*

***Internal choices have been provided in one question each in Section B,***

***Section C and Section D.***

*All working, including rough work, should be done on the same sheet as, and adjacent to the rest of the answer.*

*The intended marks for questions or parts of questions are given in brackets [ ].*

*Balanced equations must be given wherever possible and diagrams where they are helpful.*

*When solving numerical problems, all essential working must be shown.*

*In working out problems, use the following data:*

*Gas constant  $R = 1.987 \text{ cal deg}^{-1} \text{ mol}^{-1} = 8.314 \text{ JK}^{-1} \text{ mol}^{-1} = 0.0821 \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1}$*

*$1 \text{ L atm} = 1 \text{ dm}^3 \text{ atm} = 101.3 \text{ J}$ ,  $1 \text{ Faraday} = 96500 \text{ coulombs}$ ,  $\text{Avogadro's number} = 6.023 \times 10^{23}$*

### SECTION A – 14 MARKS

#### Question 1

(A)

(i)

Ans.: Two, zero

(ii)

Ans.: octahedral,  $sp^3d^2$

(iii)

Ans.: greater, slower

(iv)

Ans.:  $sp^2$ , shorter

**(B)****(i)****Ans.: (d) 2****Explanation:**

$$r = k[A]^n \quad \dots(i)$$

When concentration is doubled,

$$4r = k(2A)^n \quad \dots(ii)$$

Divide Eq. (ii) by (i)

$$4 = 2^n$$

$$n = 2$$

**(ii)****Ans.: (b)  $[Fe(H_2O)_6]^{3+}$** **Explanation:** $H_2O$  is a weak field ligand, hence  $\Delta_0 < \text{pairing energy}$ .

$$CFSE = (-0.4x + 0.6y)\Delta_0$$

where, x and y are no. of electrons occupying  $t_{2g}$  and  $e_g$  orbitals respectivelyFor  $[Fe(H_2O)_6]^{3+}$  complex ion,

$$Fe^{3+} (3d^5) = t_{2g}^3 e_g^2 = -0.4 \times 3 + 0.6 \times 2 = 0.0 \text{ or } 0Dq$$

**(iii)****Ans.: (a) Complete d-subshell****Explanation:**

The elements having incomplete d-orbital can show variable oxidation state (because the electrons move the two levels of d itself)

 $\therefore$  Zn has completely filled d-orbital. $\therefore$  It does not show variable oxidation state. It always shows +2 oxidation state.**(iv)****Ans.: (c) Amide to amine****Explanation:**

Hofmann's bromamide reaction is used to convert amide to amine.



amide

amine

**(v)****Ans.: (b) 0.31 mol/L****Explanation:**

$$\pi = CRT : C = \frac{\pi}{RT} = \frac{7.8}{0.0821 \times 310} = 0.31 \text{ mol/L}$$

(vi)

Ans.: (d) Assertion is false but Reason is true.

(vii)

Ans.: (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

(C)

Ans.:

(i)  $m = \frac{0.052}{180} \times \frac{1000}{80.2} = 0.0036$

(ii)  $\Delta T_f = K_f \times m = 1.86 \times 0.0036 = 0.067 \text{ K}$

(iii) Moles of glucose =  $\frac{0.052}{180} = 0.00028$

Moles of water =  $\frac{80.2}{18} = 4.455$

Mole fraction of glucose =  $\frac{0.00028}{4.455 + 0.00028} = 6.28 \times 10^{-5}$

## SECTION B – 20 MARKS

### Question 2

Ans.: (i)  $(\text{CH}_3)_3\text{C}-\text{OH} < (\text{CH}_3)_2\text{CH}-\text{OH} < \text{CH}_3\text{CH}_2\text{OH}$

More the number of methyl groups (electrons releasing) lesser will be the acidity. Hence the reactivity towards sodium metal will be tertiary alcohol < secondary alcohol < primary alcohol.

(ii) The ortho isomer of nitrophenol has the lowest boiling point and is least soluble in water due to stronger intramolecular hydrogen bonding, resulting in less effective intermolecular interactions and weaker attractions between molecules.

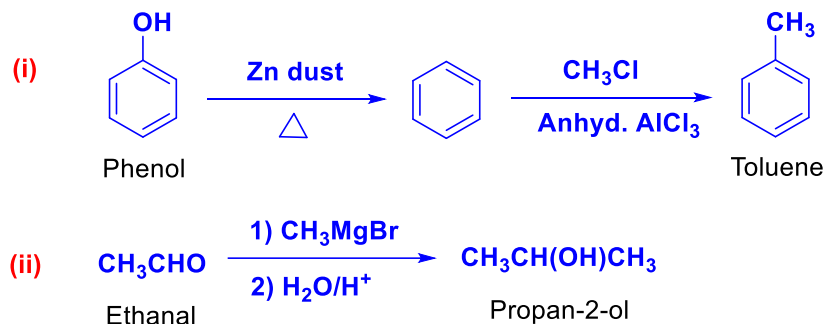
### Question 3

Ans.: (i) Manganese (Mn) and technetium (Tc) have stable half-filled *d*-orbitals, causing electrons to be held tightly by the nucleus, resulting in lesser delocalization and weaker metallic bonds compared to the preceding elements.

(ii) Zr and Hf have almost identical atomic radii due to lanthanoid contraction, influenced by the occupation of *4f* orbitals in the lanthanide series, leading to a decreased effective nuclear charge and a contraction in atomic size that extends to the following transition metals.

### Question 4

Ans.:



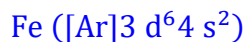
### Question 5

Ans.: (i)  $\text{Zn}^{2+}$  ions are colorless due to the absence of unpaired electrons in its  $d$ -orbitals, while  $\text{Ni}^{2+}$  ions are green in color owing to the presence of unpaired electrons that undergo  $d$ - $d$  transitions.

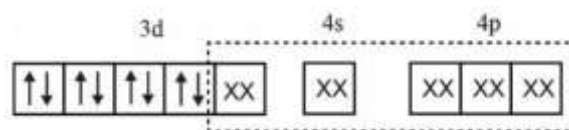
(ii)  $\text{Mn}^{2+}$

### Question 6

Ans.:



CO is a strong field ligand, so pairing of electron takes place.



$dsp^3$  hybridisation

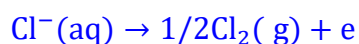
xx = Electron pair from ligand CO

Hybridisation  $\rightarrow dsp^3$

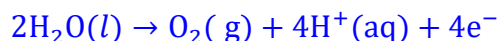
Magnetic character  $\rightarrow$  Diamagnetic

### Question 7

Ans.: At the anode the following oxidation reactions are possible:



$E_{\text{cell}}^0 = 1.36 \text{ V}$



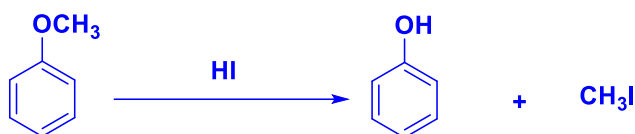
$E_{\text{cell}}^0 = 1.23 \text{ V}$

The reaction at anode with lower value of  $E^\circ$  is preferred and therefore, water should get oxidised in preference to  $\text{Cl}^-(\text{aq})$ . However, on account of over potential of oxygen, oxidation of  $\text{Cl}^-$  is preferred.

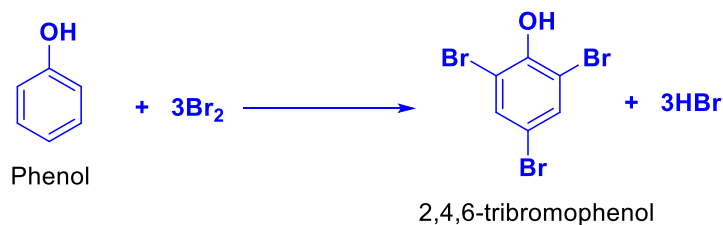
### Question 8

Ans.: (i)

(a) Anisole on reaction with HI produces only phenol and methyl iodide.



(b) When phenol is treated with bromine water, white precipitate of 2,4,6-tribromophenol is obtained.



**OR**

(ii)

Ans.: Since C gives an addition reaction with  $\text{Br}_2$  and  $\text{H}_2$  and so it is an unsaturated hydrocarbon. It gives an alcohol with a phosphoric acid and water i.e.,  $\text{CH}_3\text{CH}_2\text{OH}$ . So, C is ethene. Thus, A is ethanol which on oxidation with alkaline  $\text{KMnO}_4$  gives ethanoic acid. So, we can conclude that A is ethanol, B is ethanoic acid and C is ethene.

### Question 9

Ans.: Molality of sucrose solution (m)

$$= \frac{w_2 \times 1000}{M \times w_1} = \frac{4 \times 1000}{342 \times 96} = 0.121 \text{ m}$$

$$\Delta T_f \text{ for sucrose solution} = 273.15 - 271.15 = 2$$

$$K_f = \frac{\Delta T_f}{m} = \frac{2}{0.121} = 16.52 \text{ K/m}$$

$$\text{Molality of glucose solution} = \frac{5 \times 1000}{180 \times 95} = 0.292$$

$$\Delta T_f = K_f \times m = 16.52 \times 0.292 = 4.82 \text{ K}$$

Freezing point of glucose solution

$$= 273.15 - 4.82 = 268.33 \text{ K}$$

**Question 10**

**Ans.: (i)** Because the positive charge on carbonyl carbon of  $\text{CH}_3\text{CHO}$  decreases to a lesser extent due to one electron releasing (+I effect)  $\text{CH}_3$  group as compared to  $\text{CH}_3\text{COCH}_3$  (two electron releasing  $\text{CH}_3$  group) and hence more reactive.

**(ii)** Because carboxylate ion (conjugate base) is more resonance stabilized than phenoxide ion.

**Question 11**

**Ans.:**

**(i)** This is due to lanthanide contraction. As the change in atomic radii is very small so they possess almost similar chemical properties.

**(ii)**  $\text{Cr}^{2+}$  is a strong reducing agent with a  $d^4$  configuration. Upon acting as a reducing agent, it is oxidized to  $\text{Cr}^{3+}$  ( $d^3$ ), which forms a more stable configuration due to the presence of a half-filled set of  $d$ -orbitals. On the other hand,  $\text{Mn}^{3+}$  ( $d^4$ ), acting as an oxidizing agent, gets reduced to  $\text{Mn}^{2+}$  ( $d^5$ ), achieving a highly stable configuration with exactly half-filled  $d$ -orbitals.

**SECTION C – 21 MARKS****Question 12**

**Ans.:**

**(i)** Average rate of reaction

$$= \frac{\Delta[\text{ester}]}{\Delta \text{time}}$$

$$= \frac{0.17 - 0.31}{60 - 30} = -4.67 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$$

$$(ii) \quad K = \frac{2.303}{t} \log \frac{a}{(a-x)}$$

Where  $a$  is initial conc. of ester ( $t = 0$ ) and  $x$  is the concentration of ester at time  $t$ .

$$K_1 = \frac{2.303}{30} \log \frac{0.55}{0.31} = 1.91 \times 10^{-2}$$

$$K_2 = \frac{2.303}{60} \log \frac{0.55}{0.17} = 1.96 \times 10^{-2}$$

$$K_3 = \frac{2.303}{90} \log \frac{0.55}{0.085} = 2.01 \times 10^{-2}$$

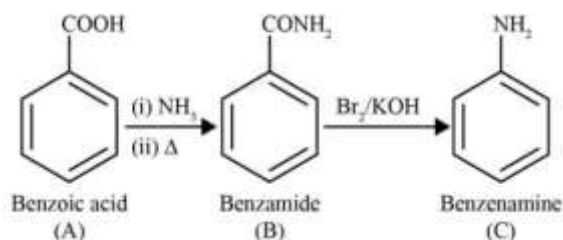
$$K = \frac{K_1 + K_2 + K_3}{3}$$

$$= \frac{1.91 \times 10^{-2} + 1.96 \times 10^{-2} + 2.01 \times 10^{-2}}{3}$$

$$= 1.96 \times 10^{-2}$$

**Question 13**

**Ans.: (i)** Formula of the compound 'C' indicates it to be an amine. Since it is obtained by the reaction of  $\text{Br}_2$  and  $\text{KOH}$  with the compound 'B' so compound 'B' can be an amide. It is also indicated because 'B' is obtained from compound 'A' by reaction with ammonia followed by heating. So compound 'A' could be an aromatic acid. Formula of compound 'C' shows it to be aniline, then 'B' is benzamide and compound 'A' is benzoic acid. The sequence of reactions can be written as follows:



**(ii)** *N*-Ethyl-*N*-methylethanamine.

**Question 14**

**Ans.:**

**(i)** Sugars with a free aldehyde and a ketone group are known as reducing sugars. All monosaccharides (both aldoses and ketoses) and disaccharides except sucrose are reducing sugars.

**(ii)** Essential amino acids are amino acids that the human body cannot produce on its own, and thus must be obtained through the diet. Non-essential amino acids, on the other hand, can be synthesized by the body and are not strictly required in the diet.

Examples of essential amino acids:

1. Leucine
2. Valine

Examples of non-essential amino acids:

1. Glycine
2. Alanine

**Question 15****Ans.: (i)**

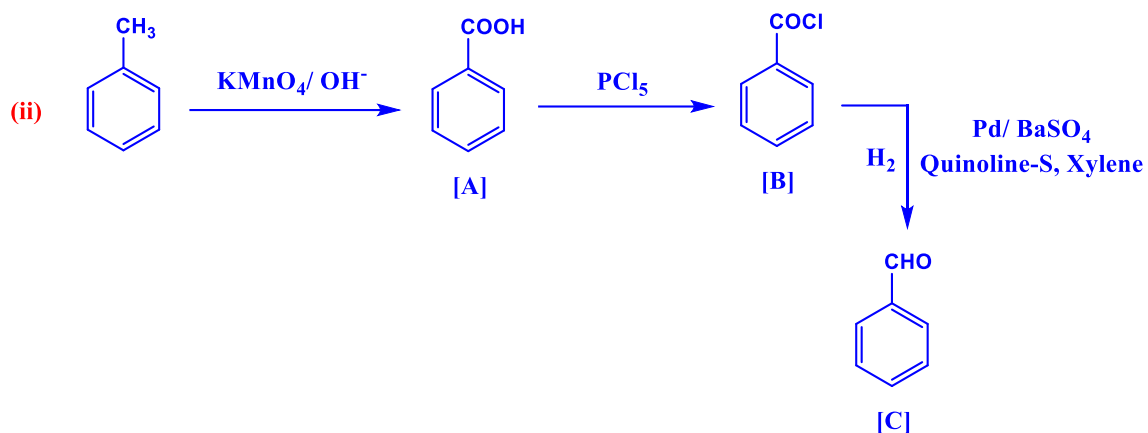
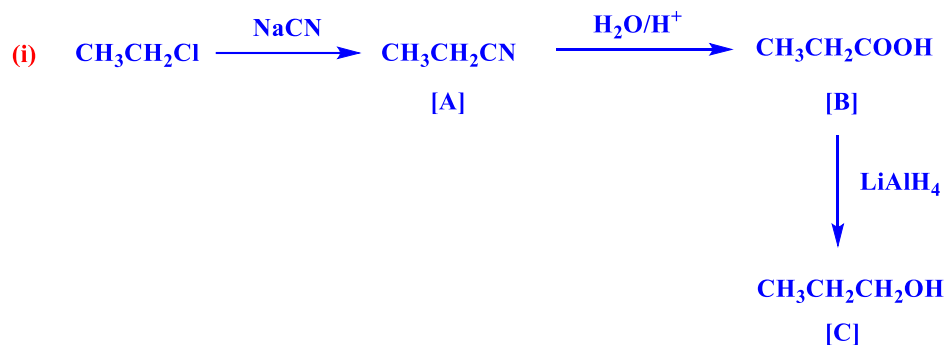
Ideal solution	Non-ideal solution
1. The interactions between the components are similar to those in the pure components.	The interaction between the components are different from those of the pure components.
2. There is no enthalpy change on mixing. ( $\Delta_{\text{mixing}}H = 0$ )	There is enthalpy change on mixing. ( $\Delta_{\text{mixing}}H \neq 0$ )
3. There is no volume change on mixing. ( $\Delta_{\text{mixing}}V = 0$ )	There is volume change on mixing. ( $\Delta_{\text{mixing}}V \neq 0$ )
4. Each compound obeys Raoult's law at all temperatures and concentrations.	Their components do not obey Raoult's law. They show positive and negative deviations from Raoult's law.
i.e., $p_A = p_A^\circ \times x_A$ and $p_B = p_B^\circ \times x_B$	i.e., $p_A \neq p_A^\circ \times x_A$ and $p_B \neq p_B^\circ \times x_B$

**(ii)** The solution shows positive deviation from ideal behaviour.**(iii)** According to Raoult's law,  $p_A = p_A^\circ x_A$ Vapour pressure of pure ethyl alcohol ( $p_A^\circ$ ) = 40 mm of HgMole fraction of ethyl alcohol ( $x_A$ ) = 0.80Vapour pressure of ethyl alcohol in solution ( $p_A$ ) =  $40 \times 0.80 = 32$  mm of Hg,



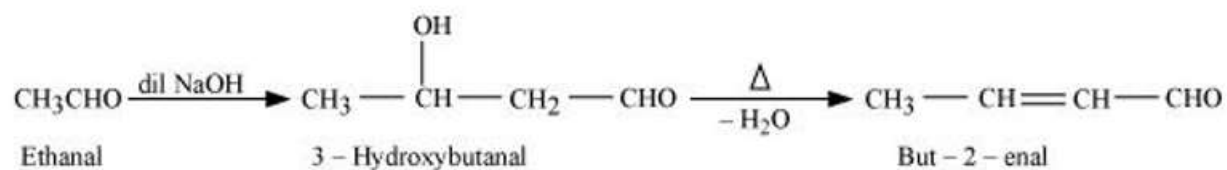
### Question 16

Ans.:

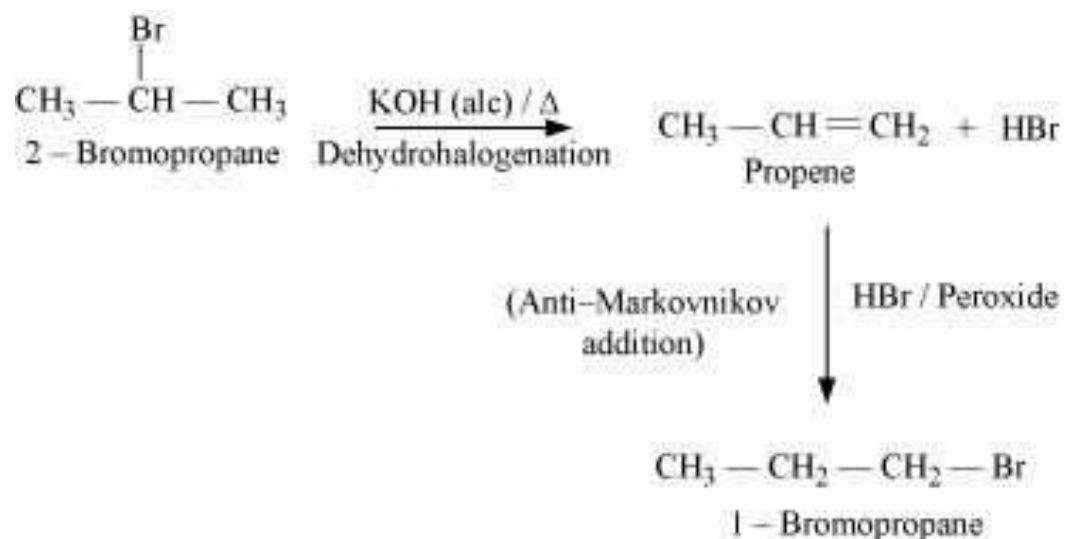


### Question 17

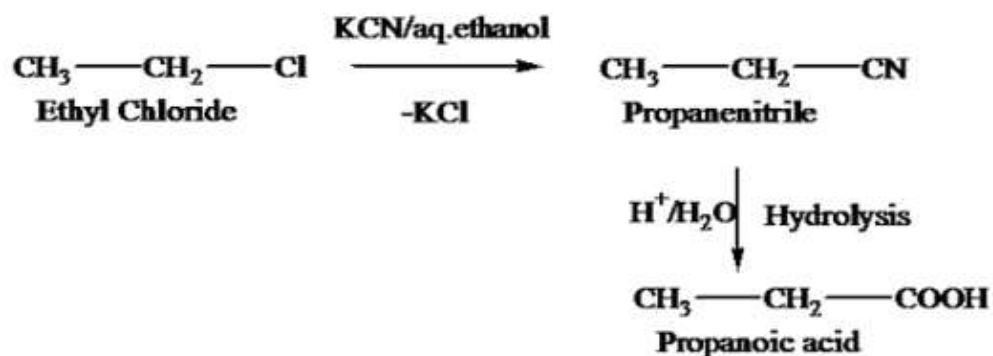
Ans.: (i) (a)



(b)



(c)





$$\Rightarrow t_{1/2} = \frac{2.303}{k} \log 2$$

$$\Rightarrow t_{1/2} = \frac{2.303}{k} \times 0.3010$$

$$\Rightarrow t_{1/2} = \frac{0.693}{k}$$

The above equation shows that half-life first order reaction is independent of the initial concentration of the reactant.

(ii) For a first order reaction

$$t = \frac{2.303}{k} \log \frac{a}{a-x}$$

$$\begin{aligned} t_{99\%} &= \frac{2.303}{k} \log \frac{100}{1} \\ &= \frac{2.303}{k} \log 100 \\ &= \frac{2.303 \times 2}{k} \\ &= \frac{4.606}{k} \end{aligned}$$

$$\text{and } t_{90\%} = \frac{2.303}{k} \log \frac{100}{10}$$

$$= \frac{2.303}{k} \log 10 = \frac{2.303}{k}$$

$$\begin{aligned} \frac{t_{99\%}}{t_{90\%}} &= 2 \\ t_{99\%} &= 2 \times t_{90\%} \end{aligned}$$

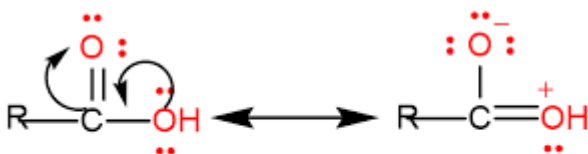
## SECTION D – 15 MARKS

**Question 19****Ans.: (i)**

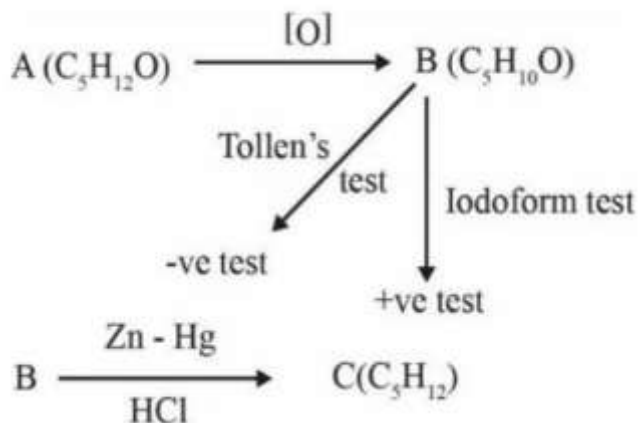
(a) Benzoic acid is somewhat stronger acid than acetic acid. The carboxyl group of benzoic acid is attached to an  $sp^2$ -hybridized carbon which is more electronegative and electron-withdrawing than the  $sp^3$ -hybridized carbon attached to acetic acid.

(b) Boiling points of aldehydes are lower than those of alcohols of similar molecular masses due to absence of intermolecular hydrogen bonding. This bonding makes the alcohol more stable at certain level of temperatures.

(c) Carboxylic acids do not give reactions of carbonyl group because the lone pairs on oxygen attach to hydrogen in the  $-COOH$  group are involved in resonance which makes the carbon less electrophilic.



Resonance structures of carboxylic acids

**Ans.: (ii)**

Since B gives a negative Tollen's test but positive Iodoform test, it is methyl ketone, i.e.,  $CH_3COCH_2CH_2CH_3$ . Also, it is formed by oxidation of A.

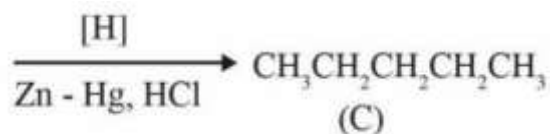
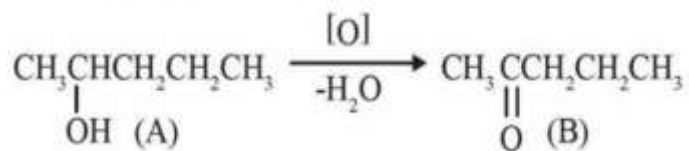
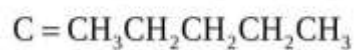
Therefore, A is secondary alcohol i.e.,



on reduction B gives pentane with  $Zn - Hg/HCl$ .

Therefore, C is  $CH_3CH_2CH_2CH_2CH_3$

Therefore,



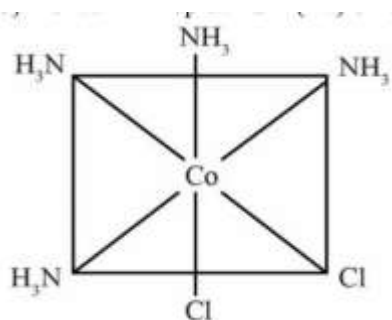
### Question 20

Ans.: (i)

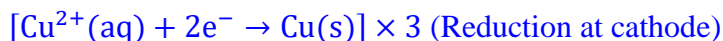
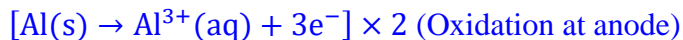
Double salt	Complex
They dissociate into simple ions when dissolved in water	They do not dissociate into simple ions completely when dissolved in water.
e.g., $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ .	e.g., $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$

(ii) (a) Potassium trioxalatoferrate (III)

(b) Hexaammineplatinum (IV) chloride.



cis - isomer of  $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$

**Question 21****Ans.: (i) (a)**

$$\therefore n = 6$$

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0591}{6} \log \frac{[\text{Al}^{3+}]^2}{[\text{Cu}^{2+}]^3}$$

$$E_{\text{cell}}^{\circ} = E_{\text{cell}} + \frac{0.0591}{6} \log \frac{[\text{Al}^{3+}]^2}{[\text{Cu}^{2+}]^3}$$

$$= 1.98 + \frac{0.0591}{6} \log \frac{(0.01)^2}{(0.01)^3}$$

$$= 1.98 + \frac{0.0591}{6} \log 10^2$$

$$= 1.98 + \frac{0.0591}{6} 2 \log 10$$

$$= 1.98 + \frac{0.0591}{6} \times 2 [\because \log 10 = 1]$$

$$= 1.98 + 0.0197 = 1.9997 \text{ V}$$

**(b)** As corrosion is a phenomenon of oxidation of iron considering the oxidation potentials of all the elements is essential. Element with more negative reduction potential than Fe can undergo reduction faster than iron preventing corrosion in iron.

Reduction potential of Fe = -0.44 V

Reduction potential of A = -2.37 V

Reduction potential of B = -0.14 V

As A has more negative reduction potential, A is more prone to undergo reduction and can act as a sacrificial coating on the surface of iron. This sacrificial protection helps prevent the corrosion of iron, as element A will oxidize preferentially, protecting the iron from undergoing oxidation (corrosion).

**OR****Ans.: (ii)****(a)**

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

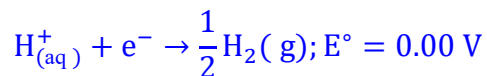
$$= (-0.44) - (-0.74)\text{V} = 0.30 \text{ V}$$

$$E = E^{\circ} - \frac{0.0591}{n} \log \frac{[\text{Products}]}{[\text{Reactants}]}$$

$$= 0.30 - \frac{0.0591}{6} \log \frac{[\text{Cr}^{3+}]}{[\text{Fe}^{2+}]}$$

$$= 0.30 - \frac{0.0591}{6} \log \frac{[0.01]^2}{[0.1]^3}$$

$$= 0.30 - \left( \frac{-0.059}{6} \right) = 0.3098 \text{ V}$$



On the basis of their standard reduction potential ( $E^{\circ}$ ) values, cathode reaction is given by the one with higher  $E^{\circ}$  values.

Thus  $\text{Ag}_{(\text{aq})}^{+} + \text{e}^{-} \rightarrow \text{Ag}(\text{s})$  reaction will be more feasible at cathode.

\*\*\*\*\* The End \*\*\*\*\*