



SAMPLE PAPER 5

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.: straight line, $-k/2.303$

(ii)

Ans.: paramagnetic, diamagnetic

(iii)

Ans.: Lucas reagent, tertiary

(iv)

Ans.: toluene, sodium chloride

(B)

(i)

Ans.: (b) 19.3

Explanation:

$$W_{\text{metal}} = \frac{E \times i \times t}{96500} = \frac{E \times 3 \times 50 \times 60}{96500}$$

$$\therefore E = \frac{96500 \times w}{3 \times 50 \times 60} = \frac{96500 \times 1.8}{3 \times 50 \times 60} = 19.3$$

(ii)

Ans.: (b) $\frac{-12}{5}\Delta_0 + 3P$

Explanation:

$$\text{CFSE} = (-0.4x + 0.6y)\Delta_0 + zP$$

where x = number of electrons occupying t_{2g} orbital

y = number of electrons occupying e_g orbital z = number of pairs of electrons

For low spin d^6 complex electronic configuration = $t_{2g}^6 e_g^0$ or $t_{2g}^{2,2,2} e_g^0$, $x = 6, y = 0, z = 3$

$$\text{CFSE} = (-0.4 \times 6 + 0 \times 0.6)\Delta_0 + 3P = \frac{-12}{5}\Delta_0 + 3P$$

(iii)

Ans.: (b) +2 state compounds of copper are formed by exothermic reactions

Explanation:

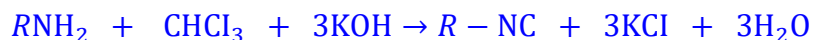
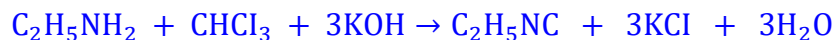
The Stability of $\text{Cu}^{2+}(\text{aq})$ rather than $\text{Cu}^+(\text{aq})$ is due to much more negative $\Delta_{\text{hyd}}H^0$ of $\text{Cu}^{2+}(\text{aq})$ than Cu^+ , which more than compensates for 2nd ionization enthalpy of Cu.

(iv)

Ans.: (a) $\text{C}_2\text{H}_5\text{CN}$

Explanation:

This is carbylamine reaction which is used to distinguish 1° amines from other amines. The reaction is given by 1° amines only.



1° amine chloroform isocyanide
(bad smelling)

(v)

Ans.: (c) The Henry's law constant (K_H) equals the partial pressure.

(vi)

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

(vii)

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

(C)

Ans.:

(i) Vapour pressure of water (p_A°) = 17.5 mm of HgLowering of vapour pressure ($p_A^\circ - p_A$) = 0.061

Relative lowering of vapour pressure

$$= \frac{p_A^\circ - p_A}{p_A^\circ} = \frac{0.061}{17.5} = 0.00348$$

(ii) p = Vapour pressure of solvent - lowering in vapour pressure

$$= 17.5 - 0.061$$

$$= 17.439 \text{ mm of Hg}$$

$$\begin{aligned} \frac{p_A^\circ - p_A}{p_A^\circ} &= x_B = \frac{w_B \times M_A}{M_B \times w_A} \\ \frac{17.5 - p_A}{17.5} &= \frac{25 \times 18}{450 \times 180} = 5.56 \times 10^{-3} \\ 17.5 - p_A &= 17.5 \times 5.56 \times 10^{-3} \\ 17.5 - p_A &= 0.0973 \\ p &= 17.40 \text{ mmHg} \end{aligned}$$

$$\begin{aligned} \text{(iii)} \quad M_B &= \frac{w_B M_A}{w_A \left(\frac{p_A^\circ - p_A}{p_A^\circ} \right)} \\ w_B &= 5 \text{ g}, M_A = 18 \text{ g}, w_A = 108 \text{ g} \\ M_B &= \frac{5 \times 18}{108 \times 0.00348} = 240 \end{aligned}$$

SECTION B – 20 MARKS

Question 2

Ans.: (i) Chlorobenzene doesn't undergo Williamson's ether synthesis due to the partial double bond character of the C—Cl bond, making it less reactive in nucleophilic substitution. Instead, aromatic ethers are formed using sodium phenoxide, which is more nucleophilic due to resonance stabilization.

(ii) Anhydrous calcium chloride cannot be used for drying ethyl alcohol because it forms an addition compound with the alcohol.



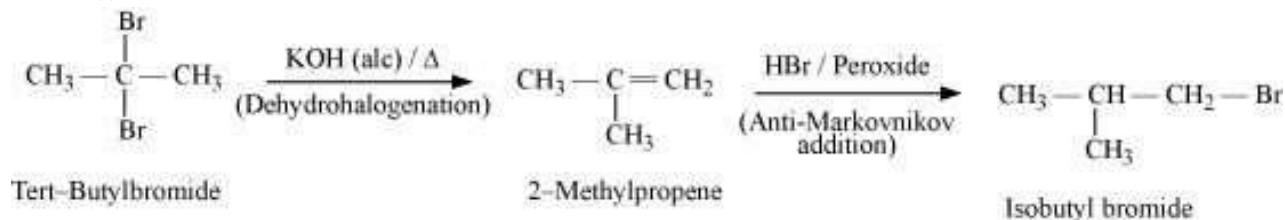
Question 3

Ans.: (i) This is due to lanthanide contraction. As the size of lanthanide ions decreases from La^{3+} to Lu^{3+} , the covalent character of the hydroxides increases and hence the basic strength decreases.

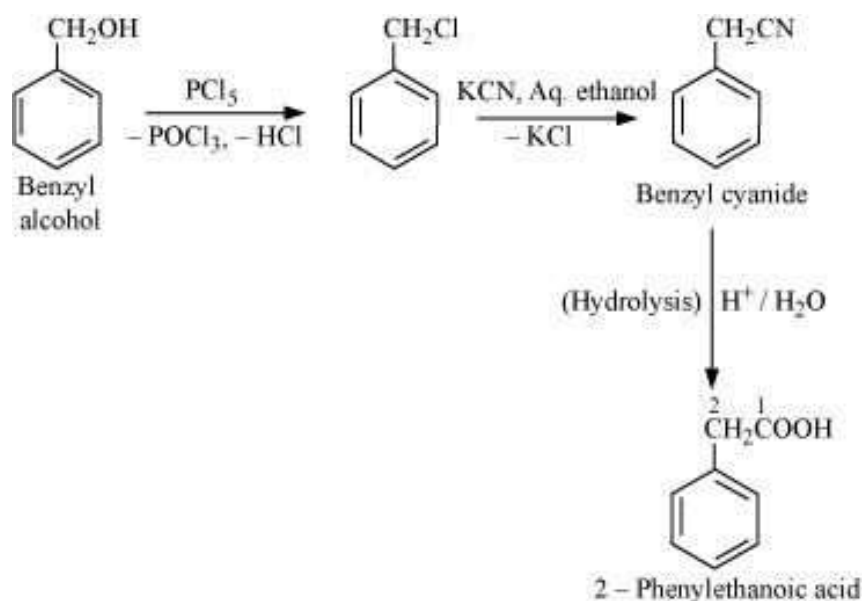
(ii) Cu^{2+} is colored due to d-d transitions in its incompletely filled 3d orbitals ($3d^9$), imparting color to copper (II) salts, while Cd^{2+} is colorless with completely filled 4d orbitals ($4d^{10}$), lacking the necessary electronic transitions for visible spectrum absorption.

Question 4

Ans.: (i)



(ii)



Question 5

Ans.: (i) Interstitial compounds are those which are formed when small atoms like H, N or C are trapped inside the crystal lattices of metals. They are usually nonstoichiometric and are neither typically ionic or covalent.

(ii) Transition metals and many of their compounds show paramagnetic behaviour due to presence of one or more unpaired electrons in d subshell.

Question 6

Ans:

(i) Retention

(ii) Racemisation

Question 7

Ans.:

$$E_{\text{cell}}^{\circ} = 0.76 \text{ volt}$$

Applying Nernst equation

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0591}{2} \log \frac{[\text{Zn}^{2+}] - [\text{P}_{\text{H}_2}]}{[\text{H}^+]^2}$$

$$0.26 = 0.76 - \frac{0.0591}{2} \log \frac{(0.1) - (1)}{[\text{H}^+]^2}$$

$$\log \frac{0.1}{[\text{H}^+]^2} = \frac{2 \times 0.50}{0.0591}$$

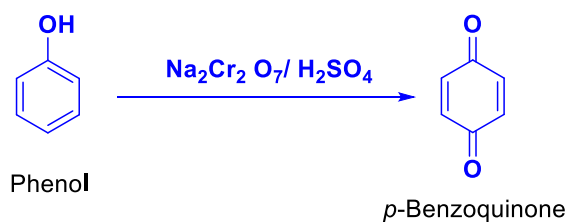
$$\text{or } \log 0.1 - \log [\text{H}^+]^2 = 17$$

$$\text{or } 2\text{pH} = 17 - \log 0.1$$

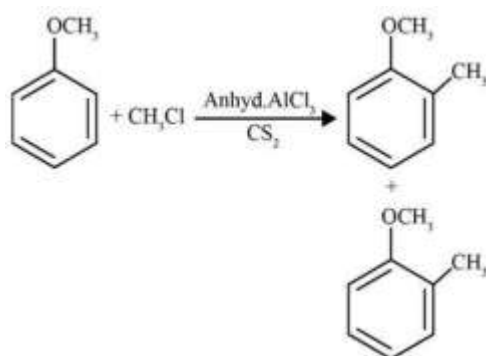
$$\text{pH} = \frac{18}{2} = 9$$

Question 8

Ans.: (i) (a) *p*-Benzoquinone is formed.



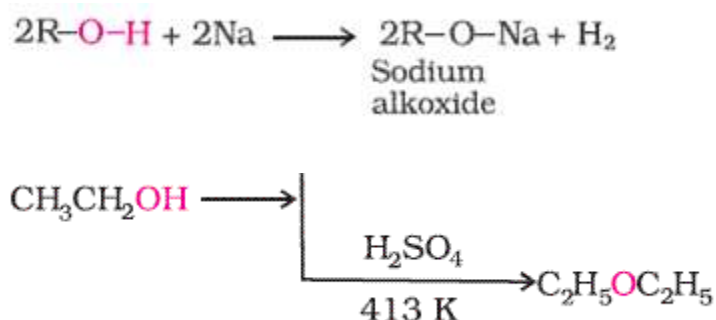
(b) Methyl group is introduced at ortho and para positions.



OR

Ans.: (ii)

Compound A is ethanol, compound B is sodium ethoxide and compound C is ethoxy ethane.



Question 9

Ans.:

(a) Increase in temperature decrease the solubility of oxygen in water. As a results, amount of dissolved oxygen decreases. It becomes more difficult to breathe as oxygen is less. Hence, the aquatic species are not comfortable in warm water.

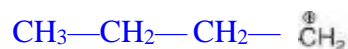
(b) At high altitudes, the partial pressure of oxygen is less than at the ground level. As a result, there is a low concentration of oxygen in the blood and tissues of the people living at high altitudes. Thus, they feel weak and are unable to think properly.

Question 10

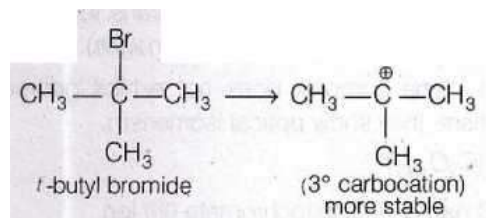
Ans.: (a) In $\text{S}_{\text{N}}1$ reaction, reactivity depends upon the stability of intermediate carbocation formed.



n-butyl bromide



(1° carbocation) less stable



Carbocation formed by tert-butyl bromide being tertiary is more stable than primary, hence t-butyl bromide undergoes $\text{S}_{\text{N}}1$ reaction faster.

(b) As I^- ion is a better leaving group than Br^- ion, therefore iodides are more reactive than bromides. Therefore, $\text{CH}_3-\text{CH}_2-\text{I}$ is more reactive than $\text{CH}_3-\text{CH}_2-\text{Br}$ towards $\text{S}_{\text{N}}2$ reaction and thereby, $\text{CH}_3-\text{CH}_2-\text{I}$ would undergo $\text{S}_{\text{N}}2$ reaction faster than $\text{CH}_3-\text{CH}_2-\text{Br}$.

Question 11



SECTION C – 21 MARKS

Question 12

Ans.: Suppose order with respect to NO is m and order with respect to Cl_2 is n ,

Then the rate will be:

$$\text{Rate} = k [\text{A}]^m [\text{B}]^n$$

$$2.0 \times 10^{-3} = [1.0]^x [1.0]^y$$

$$\text{For experiment (ii)} \quad 4.0 \times 10^{-3} = [2.0]^x [1.0]^y \dots (2)$$

$$\text{For experiment (iii)} \quad 8.0 \times 10^{-3} = [4.0]^x [1.0]^y$$

$$\text{For experiment (iv)} \quad 2.0 \times 10^{-3} = [1.0]^x [2.0]^y$$

$$\text{For experiment (v)} \quad 2.0 \times 10^{-3} = [1.0]^x [4.0]^y$$

Determination of x . In order to get the value of x , divide equation (2) by (1)

$$\frac{4.0 \times 10^{-3}}{2.0 \times 10^{-3}} = \frac{[2.0]^x [1.0]^y}{[1.0]^x [1.0]^y}, (2)^1 = (2)^x \text{ or } x = 1$$

Determination of y . In order to get the value of y , divide equation (4) by (1)

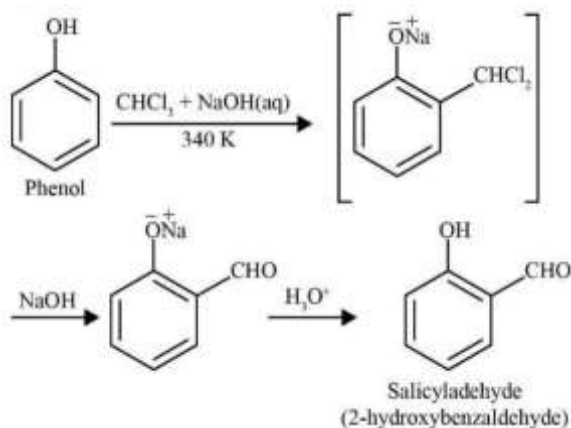
$$\frac{2.0 \times 10^{-3}}{2.0 \times 10^{-3}} = \frac{[1.0]^x [2.0]^y}{[1.0]^x [1.0]^y}, (1)^1 = [2.0]^y \text{ or } y = 0$$

(i) Overall order of the reaction = $1 + 0 = 1$

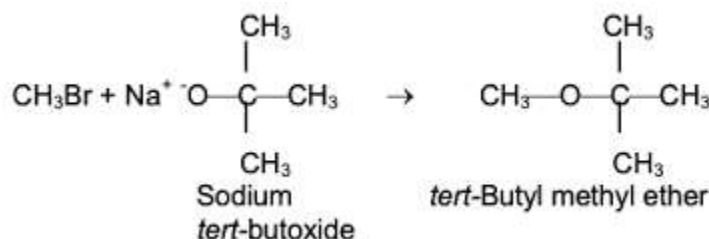
(ii) Rate Law equation, $\text{Rate} = k[\text{A}]^1 [\text{B}]^0 = k[\text{A}]$

Question 13

Ans.: (i) Reimer - Tiemann reaction



(ii) Williamson ether synthesis:



Question 14

Ans.:

(i) Monosaccharides: Ribose, 2-deoxyribose, galactose and fructose.

Disaccharides: Maltose and lactose.

(ii) Denaturation of proteins is a process in which physical and biological properties of protein without changing the chemical composition of protein. In an egg denaturation of protein is the coagulation of albumin present in the white of an egg. When egg is boiled in water, the globular proteins present in it changes to a rubber like insoluble mass which absorbs all water present in the egg.

(iii) Amino acids exist as zwitterions ($\text{H}_3\text{N}^+ - \text{CHR} - \text{COO}^-$) with strong dipole-dipole attractions, giving them higher melting points than haloacids. Their salt-like character leads to increased water interaction, resulting in higher solubility compared to haloacids lacking this feature.

Question 15

Ans.: Here, $n = 2$ because phenol forms dimer on association.

$$W_2 = 20 \text{ g}, W_1 = 1 \text{ kg} = 1000 \text{ g},$$

$$\Delta T_f = 0.69 \text{ K}, K_f = 5.1 \text{ K m}^{-1}$$

$$\Delta T_f = \frac{K_f \times W_2 \times 1000}{M_2 \times W_1}$$

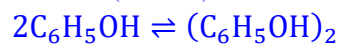
$$M_2 = \frac{K_f \times W_2 \times 1000}{\Delta T_f \times W_1} = \frac{5.1 \times 20 \times 1000}{0.69 \times 1000} = 7.82$$

$$M_{2(\text{calculated})} = 147.82$$

$$M_2 (\text{calculated})$$

$$\text{C}_6\text{H}_5\text{OH} = 6 \times 12 + 6 \times 1 + 16 = 94 \text{ g mol}^{-1}$$

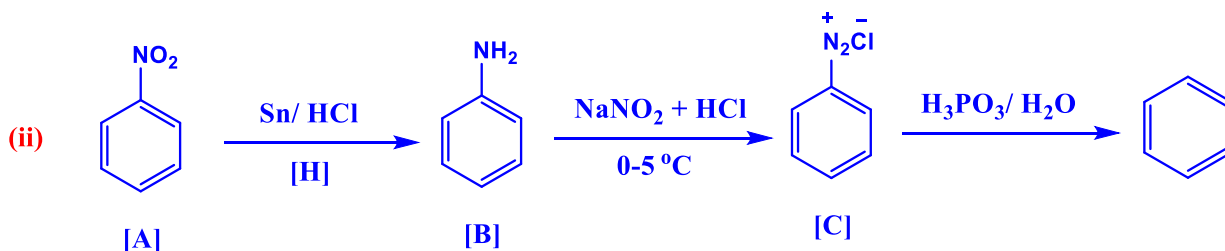
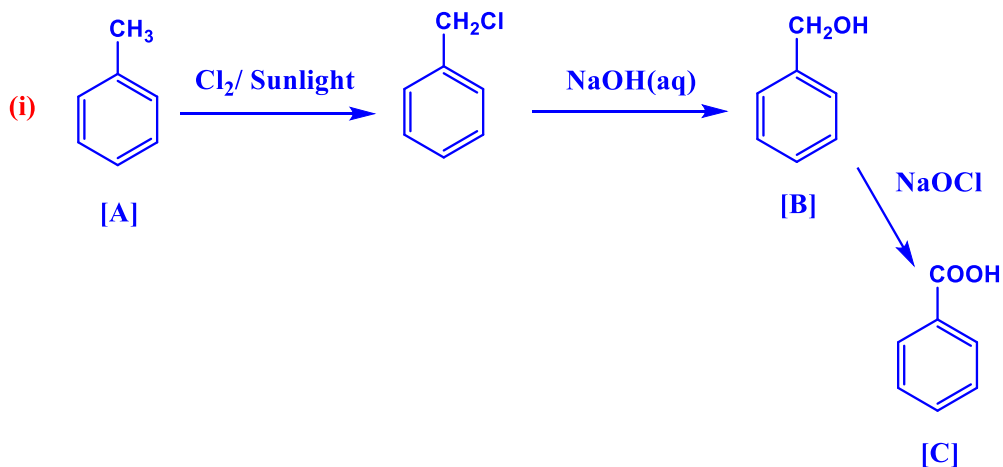
$$i = \frac{M_2 \text{ (calculated)}}{M_2 \text{ (observed)}} = \frac{94}{147.82} = 0.635$$



$$\alpha = \frac{i - 1}{\left(\frac{1}{n} - 1\right)} = \frac{0.635 - 1}{\left(\frac{1}{2} - 1\right)} = \frac{0.365}{0.5} = 0.73$$

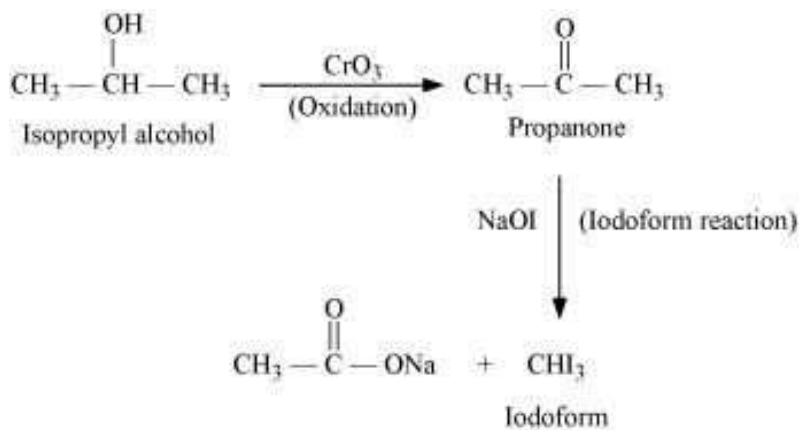
Question 16

Ans.:

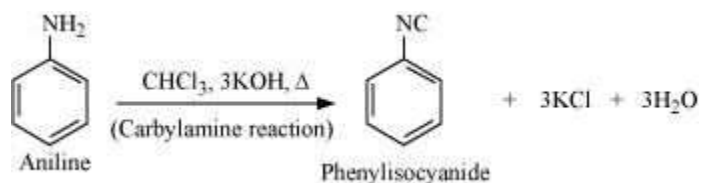


Question 17

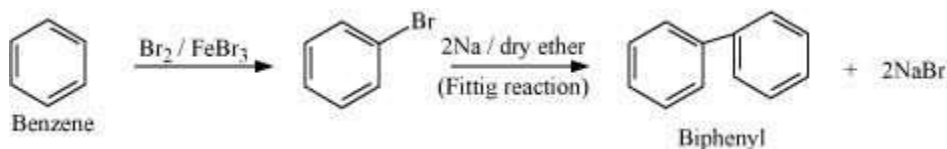
Ans.: (a)



(b)



(c)



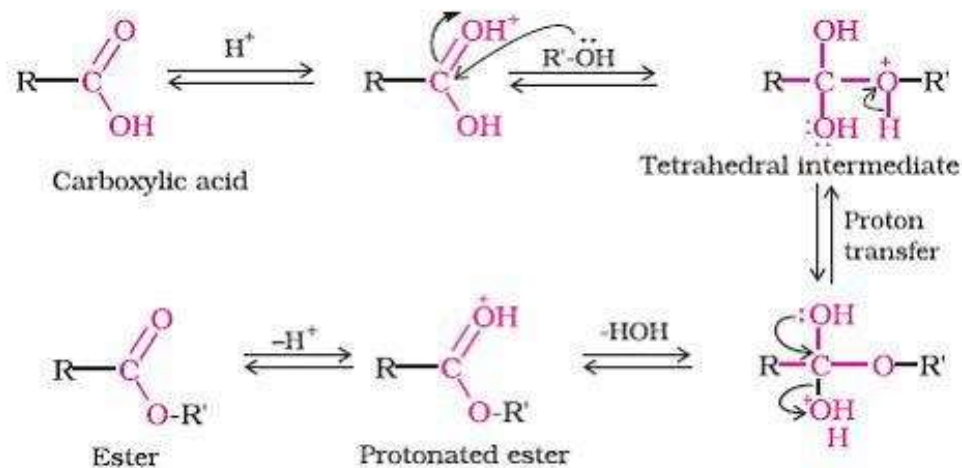
OR

Ans.: (ii)

Carboxylic acids are esterified with Alcohols or Phenols, in presence of mineral acid or HCl gas as catalyst.



Mechanism of the reaction:



Question 18**Ans.: (i)**

For 1st order reaction

$$k = \frac{2.303}{t} \log \frac{[A]_0}{[A]}$$

$$\text{If } [A]_0 = a, [A] = a - \frac{a \times 20}{100} = 0.80a$$

$$t = 10 \text{ min}$$

$$k = \frac{2.303}{10} \log \frac{a}{0.80a} = \frac{2.303}{10} \times 0.0969$$
$$= 0.0223$$

$$\text{If } [A]_0 = a, [A] = a - \frac{a \times 75}{100} = 0.25a$$

$$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]}$$
$$= \frac{2.303}{0.0223} \log \frac{a}{0.25a}$$
$$= \frac{2.303}{0.0223} \times 0.6021$$
$$= 62.18 \text{ min}$$

(ii) Let n be the order of reactant of the given reaction.

$$\frac{dx}{dt} = k[A]^n$$

$$\frac{dx'}{dt} = k[4A]^n$$

$$\frac{dx'/dt}{dx/dt} = \left(\frac{4}{1}\right)^n$$

$$2 = \left(\frac{4}{1}\right)^n$$

$$n = \frac{1}{2}$$

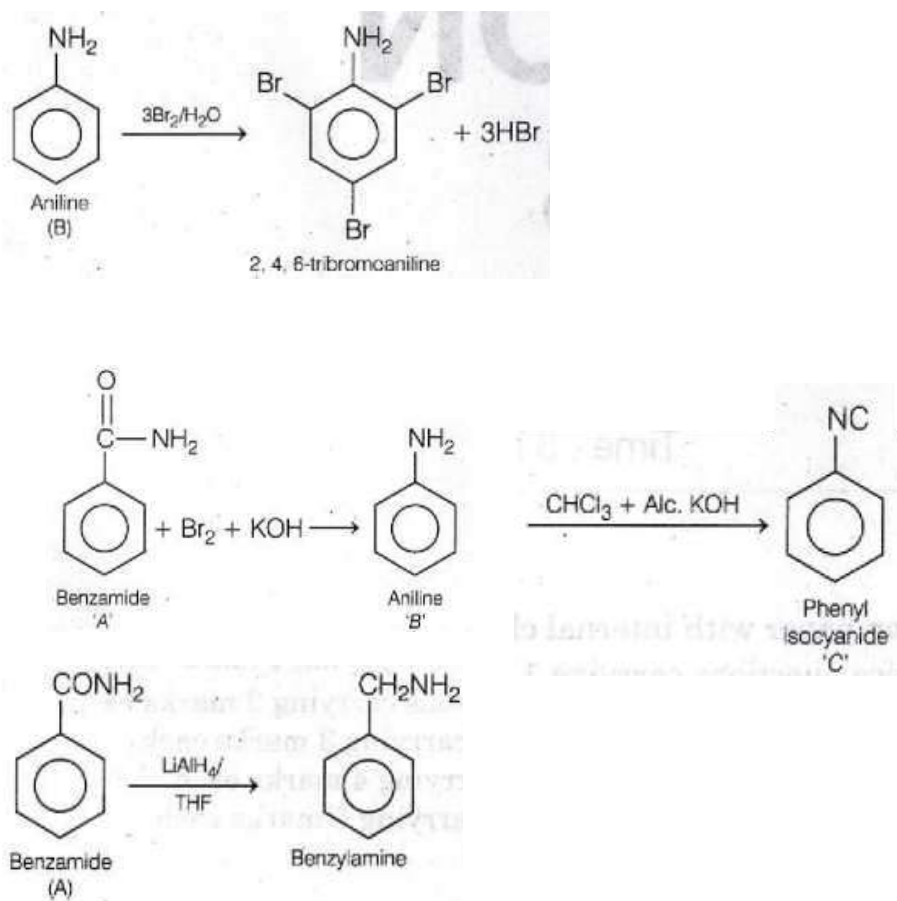
SECTION D – 15 MARKS

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

- (a) The α -hydrogen in aldehydes and ketones is acidic and can undergo deprotonation, facilitating the formation of an enolate ion, which is a key intermediate in aldol condensation reactions.
- (b) In chloroacetic acid Cl atom has -I effect which decreases the electron density of O-H bond in carboxylic group while in case of acetic acid CH_3 group has +I effect which increases the electron density of O-H bond. Therefore, chloroacetic acid is more acidic than acetic acid.
- (c) It is due to weak molecular association in aldehydes and ketones arising out of the dipole-dipole interactions.

Ans.: (ii)

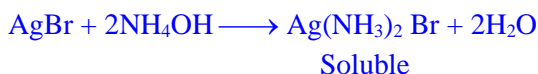
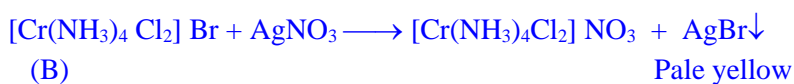
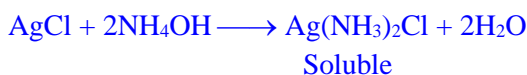
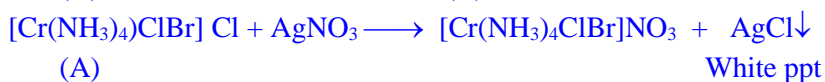
Since compound 'A' on heating with Br_2 and KOH forms a compound 'B' which further reacts with CHCl_3 and alc. KOH producing a foul smelling compound 'C'. Thus, compound 'C' is an aromatic isocyanide and compound 'B' is aniline with formula $\text{C}_6\text{H}_5\text{NH}_2$ and compound 'A' must be benzamide. Reactions involved are:



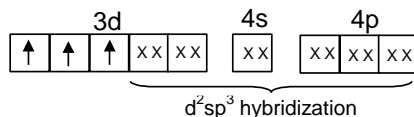
(D)

Question 20**Ans.: (i)**

Complex, $\text{Cr}(\text{NH}_3)_4\text{Cl}_2\text{Br}$, has two isomers. Since, coordination number of Cr is six, the two forms may be represented in the following way



The state of hybridisation of chromium in both the complexes is d^2sp^3 . Chromium is in trivalent state (Cr^{3+}).



As three unpaired electrons are present, the magnetic moment = $\sqrt{n(n+2)}$ B.M. = $\sqrt{3 \times 5}$ B.M. = **3.87 B.M.**

(ii) As the moles of AgCl precipitated is 2 and no Br^- is detected on reaction with excess of HCl, so the compound would be $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$.

Question 21

Ans.: (i) E° value of silver is lower than that of gold, hence silver displaces gold which gets deposited on the silver object.

E° value of copper is lower than that of silver, hence silver cannot displace copper from its solution.

(ii) (a) Electrons flow from Zn to Ag plate.

(b) Zn as anode and Ag acts as cathode

(c) Cell will stop functioning

(d) Concentration of Zn^{2+} ions will increase and that of Ag^+ ions will decrease.

(e) No change

OR

Ans.: (ii) (a) $\Lambda_m = \frac{1000k}{c}$

$$\begin{aligned}\Lambda_m &= \frac{1.65 \times 10^{-4} \text{ S cm}^{-1} \times 1000 \text{ cm}^3 \text{ L}^{-1}}{0.01 \text{ mol L}^{-1}} \\ &= 16.5 \text{ S cm}^2 \text{ mol}^{-1}\end{aligned}$$

(b) $\Lambda_m = \frac{1000 \times K}{M} \text{ Scm}^2 \text{ mol}^{-1}$

$$\Lambda_m = \frac{1000 \times 5.25 \times 10^{-5}}{2.5 \times 10^{-4}} \text{ S cm}^2 \text{ mol}^{-1}$$

$$\Lambda_m^\circ \text{HCOOH} = \lambda^\circ \text{HCOO}^- + \lambda^\circ \text{H}^+$$

$$= (50.5 + 349.5) \text{ Scm}^2 \text{ mol}^{-1}$$

$$= 400 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\alpha = \Lambda_m / \Lambda_m^\circ$$

$$\alpha = 210/400 = 0.525$$

(c) Both will have same value of specific conductance.

***** The End *****