CHEMISTRY PAPER 1
(THEORY)
ANSWER KEY

SECTION A - 14 MARKS

Question 1

(A) **[4×1]**

(i) decreases, increases

(ii) two, zero

(iii) 2,4,6 – tribromophenol, electrophilic

(iv) alc. KCN, alc. AgCN

(B) **[7×1]**

(i) (c) or 9

(ii) (b) or Only (P) and (S) are correct.

(iii) (a) or aniline

(iv) (d) or inversion

(v) (b) or CH_3-CO-CH_3

(vi) (d) or Both Assertion and Reason are false

(vii) (a) or Both Assertion and Reason are true and Reason is the correct explanation for Assertion

(C) **[3×1]**

(i) The conductivity of a solution is the conductance of ions present in a unit volume of the solution. With dilution, the number of ions per unit volume decreases. Hence, conductivity decreases with dilution. The molar conductance (Λ_m) is the product of conductivity (κ) and the volume of the solution containing 1 mole of the electrolyte.

$\Lambda_m = \kappa \times V_m$

Hence, Λ_m increases on dilution.

(ii) Given; $\Lambda^o_m = 150.0$ S cm^2 mol^{-1}, $\Lambda^c_m = 141.0$ S cm^2 mol^{-1}

Molarity of KCl = 0.01 M

Degree of dissociation (α) = $\frac{\Lambda^c_m}{\Lambda^o_m}$ or $\alpha = \frac{141.0}{150.0}$

$\alpha = 0.94$ or 94%

(iii) Calculation of molar conductivity of solution.

$\Lambda_m = \frac{\kappa \times 1000}{\text{Molarity}}$ or

$\Lambda_m = \frac{1.65 \times 10^{-4} \times 1000}{0.01}$

$= 16.5$ S cm^2 mol^{-1}

SECTION B – 20 MARKS

Question 2 **[2]**

$t_{1/2}$ = 120 min, a = 100, (a-x) = (100-90) = 10

$k = \frac{0.693}{t_{1/2}} = 0.005775\ min^{-1}$

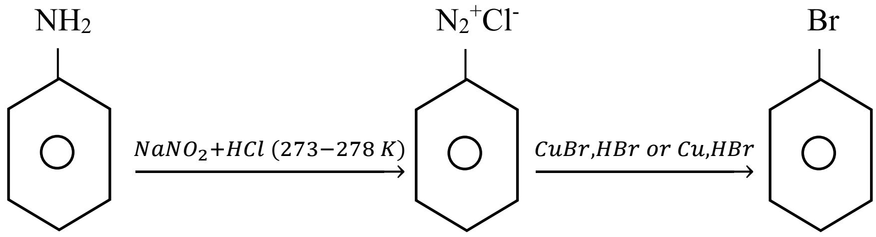
$t = \frac{2.303}{\kappa} \log \frac{a}{(a-x)}$ or

$t = \frac{2.303}{0.005775} \log \frac{100}{10}$

$t = \frac{2.303}{\kappa}$ x 1 = 398.79 minutes

Question 3 **[2]**

(i) Aniline to bromobenzene



Aniline bromobenzene

(ii) Ethyl chloride to propanoic acid

$$CH_3CH_2Cl \xrightarrow{alc.KCN} CH_3CH_2CN \xrightarrow{H^+;\ H_2O\ (Hydrolysis)} CH_3CH_2COOH$$

Ethylchloride Propanoic acid

Question 4 **[2]**

(i) hexaammine cobalt (III) sulphate

Ans: $[Co(NH_3)_6]SO_4$

(ii) tetraaquadichloridochromium (III) nitrate

Ans: $[Cr(H_2O)_4Cl_2]NO_3$

Question 5 **[2]**

Given; wt. of solute = 2.0g, wt. of solvent = 25g

ΔT_f = 1.62 K, k_f = 4.7 K kg mol^{-1}

M_{normal} = 122 g mol^{-1}

$m_{obs} = \frac{1000 \times k_f.w}{\Delta T_f \times w}$

$= \frac{1000 \times 4.7 \times 2}{1.62 \times 25}$

$= 241.98 \text{ g mol}^{-1}$

$i = \frac{\text{Normal mol. wt}}{\text{observed mol. wt}} = \frac{122.0}{241.98}$ or

$= 0.504$

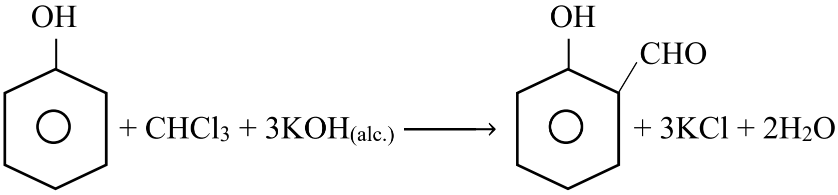
Degree of dissociation (α) $= \frac{1 - i}{1 - \frac{1}{h}} = \frac{1 - 0.504}{1 - \frac{1}{2}} = \frac{0.496}{\frac{1}{2}}$

(α) = 0.496 x 2

= 0.992 = 99.2%

Question 6 **[2]**

(i) Phenol to salicylaldehyde



(ii) Formaldehyde to ethanol

$CH_3MgBr + H-\underset{H}{C}=O \longrightarrow H-\underset{H}{\overset{CH_3}{C}}-OMgBr \xrightarrow{+HOH} H-\underset{H}{\overset{CH_3}{C}}-OH + Mg\begin{matrix}Br\\OH\end{matrix}$

ethanol

Question 7 **[2]**

Molar conductivity at infinite dilution (Λ^o_m) for MgI_2 may be calculated as:

$\Lambda^o_m (MgI_2) = \Lambda^o_m(CH_3COO)_2Mg + 2\Lambda^o_m(NaI) - 2\Lambda^o_m(CH_3COONa)$

$= 187.8 + 2 \times 126.9 - 2\ (91.0)$

$= 259.6 \text{ S cm}^2 \text{ mol}^{-1}$

Question 8 **[2]**

(i) Mn^{2+} show maximum paramagnetic character because it has maximum number of unpaired electrons.

(ii) All the electrons in d-subshell are paired. Hence the metallic bonds present in Zn, Cd and Hg are weak. Therefore, they have low melting and boiling points.

Question 9 **[2]**

(i)

$$CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-H + 4[H] \xrightarrow{\text{Zn-Hg (HCl conc.)}} \underset{\text{Ethane}}{CH_3CH_3} + H_2O$$

(or any other correct example)

Clemmensen reduction

OR

(ii) (a) Acetic acid to acetaldehyde

$$CH_3COOH \xrightarrow{+SOCl_2} CH_3COCl \xrightarrow{H_2, Pd/BaSO_4} CH_3CHO$$

(b) Formaldehyde to urotropine

$$6HCHO + 4NH_3 \longrightarrow \underset{\text{urotropine}}{(CH_2)_6N_4} + 6H_2O$$

Question 10 **[2]**

Given; $T_1 = 298K$, $T_2 = 308K$, $K_2/K_1 = 2$

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

$$\log\frac{K_2}{K_1} = \frac{E_a}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \text{ or}$$

$$\log 2 = \frac{E_a}{2.303 \times 8.314}\left[\frac{1}{298} - \frac{1}{308}\right]$$

$$0.3010 = \frac{E_a}{19.147}\left[\frac{10}{298 \times 308}\right] \text{ or}$$

$$E_a = \frac{0.3010 \times 19.147 \times 298 \times 308}{10}$$

$E_a = 52898\ J\ mol^{-1}$

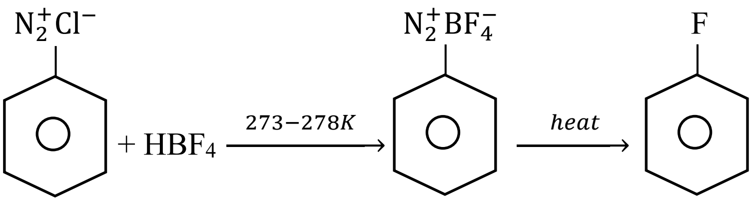
$E_a = 52.898\ kJ\ mol^{-1}$

Question 11 **[2]**

(i) Hofmann's degradation reaction

$$CH_3CONH_2 + Br_2 + 4KOH \longrightarrow CH_3NH_2 + K_2CO_3 + 2KBr + 2H_2O$$

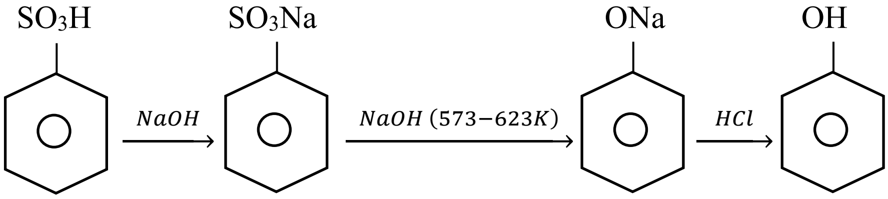
(ii) Balz-Scheimann reaction



SECTION C – 21 MARKS

Question 12 **[3]**

(i) Phenol from benzene sulphonic acid



(ii) Ethyl alcohol from ethylamine

$C_2H_5NH_2 + HNO_2 \longrightarrow C_2H_5OH + N_2 + H_2O$

(iii) Diethyl ether from ethyl alcohol

$2C_2H_5OH \xrightarrow{H_2SO_4\ conc.\ (413\ K)} C_2H_5\text{-O-}\ C_2H_5 + H_2O$

(or any other correct method)

Question 13 **[3]**

(i) (a) $K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 7H_2O$

(b) $2KMnO_4 + 10KI + 8H_2SO_4 \longrightarrow 6K_2SO_4 + 2MnSO_4 + 8H_2O + 5I_2$

(ii) $K_2Cr_2O_7 + 2KOH \longrightarrow 2K_2CrO_4 + H_2O$

orange yellow

$2K_2CrO_4 + H_2SO_4 \longrightarrow K_2Cr_2O_7 + K_2SO_4 + H_2O$

yellow orange

Or

The $Cr_2O_7^{2-}$ (dichromate ion) and CrO_4^{2-} (chromate ion) exist in equilibrium at pH = 4.

When alkali is added, the pH value will increase and $K_2Cr_2O_7$ solution will change from orange to yellow.

When acid is added, the pH value will decrease and the solution will change from yellow to orange.

Question 14 **[3]**

(i) $CH_3 – CH_2 – O – CH_2 – CH_3$

(ii) $CH_3CH_2 – N \equiv C$

(iii) $CH_3CH_2 – CH_2 – I$

Question 15 **[3]**

(i) Vitamin A

(ii) Glucose and Galactose

(iii) Salt solution is hypertonic solution as compared to grapes hence, exosmosis takes place and the grapes tend to shrink.

Question 16 **[3]**

(i) (a) Upon dilution the specific conductivity will decrease, and molar conductivity will increase.

(b) The following reaction takes place:

$Cu + 2Ag^{+}_{(aq.)} \longrightarrow Cu^{2+}_{(aq.)} + 2Ag$

$E^{o}_{cell} = E^{o}_{cathode} + E^{o}_{anode}$

$= + 0.80 - (+ 0.34)$

$E^{o}_{cell} = + 0.46$

Copper spoon will dissolve in 1M $AgNO_3$ solution therefore it is not safe to stir 1M $AgNO_3$ solution with copper spoon.

(c) Metal 'A' will liberate H_2 gas from dil. HCl solution.

Metal having lower reduction potential will liberate H_2 gas from dil. HCl solution.

OR

(ii) (a) Given:

$Zn_{(s)} + Zn^{2+}_{(0.0004M)} \| Cd^{2+}_{(0.2M)} / Cd_{(s)}$

$E^{o}_{Zn^{2+}/Zn} = - 0.763V$, $E^{o}_{Cd^{2+}/Cd} = - 0.403V$

Cell reaction: $Zn_{(s)} + Cd^{2+}_{(aq.)} \longrightarrow Zn^{2+}_{(aq.)} + Cd_{(s)}$

$E^{o}_{cell} = E^{o}_{cathode} - E^{o}_{anode}$

$= -0.403V - (-0.763V)$

$= 0.36V$

$E_{cell} = E^{o}_{cell} - \frac{0.059}{2} \log \frac{[Zn^{2+}]}{[Cd^{2+}]}$

$= 0.36 - \frac{0.059}{2} \log \frac{[0.0004]}{[0.2]}$

$= 0.36 - \frac{0.059}{2} \log 2 \times 10^{-3}$

$= 0.36 - \frac{0.059}{2} (-2.6990)$

$= 0.36 + 0.08 = 0.44V$

$E_{cell} = + 0.44V$

$\Delta G = - nFE$ or

$= - 2 \times 96500 \times 0.44$

$\Delta G = - 84920$ J or $- 84.92$ kJ

(b) $Cr^{3+} + 3e^{-} \longrightarrow Cr$

52g of chromium requires current = 3 x 96,500 coulombs

or 1g of chromium requires current = $\frac{3 \times 96500 \times 1}{52}$

Q = 5567.3 coulombs

$Q = I \times t$ or $t = \frac{Q}{I}$

Time required in seconds = $\frac{Q}{I} = \frac{5567.3}{1.25}$

= 4453.8 seconds

Question 17 **[3]**

(i) Zero order reaction

(ii) Pseudo first order reaction:

$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$

$CH_3COOC_2H_5 + H_2O \longrightarrow CH_3COOH + C_2H_5OH$

(iii) The rate of reaction decreases.

Question 18 **[3]**

(i) (A) = $C_6H_5NH_2$

(B) = $C_6H_5N_2^{+}Cl^{-}$

(C) = C_6H_5Cl

(ii) (A) = $CH_3CH_2NH_2$

(B) = CH_3CH_2OH

(C) = CH_3CH_2Cl

SECTION D – 15 MARKS

Question 19 **[5]**

(i)

(a)

$$CH_3-\underset{\underset{\displaystyle CH_3}{|}}{C}=O + CH_3MgBr \longrightarrow CH_3-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}}-OMgBr \xrightarrow{+HOH} CH_3-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}}-OH + Mg\begin{matrix}\diagup Br\\ \diagdown OH\end{matrix}$$

(b) $2HCHO + NaOH_{(conc.)} \longrightarrow HCOONa + CH_3OH$

(c) $CH_3COOH + SOCl_2 \longrightarrow CH_3COCl \xrightarrow{H_2+Pd/BaSO_4} CH_3CHO$

(acetic acid) (acetaldehyde)

(ii) [A] = C_6H_5COOH or benzoic acid

[B] = C_6H_5COCl or benzoyl chloride

[C] = $C_6H_5CONH_2$ or benzamide

[D] = $C_6H_5NH_2$ or aniline

Question 20 **[5]**

(i) Given; w = 0.63g, V = 300 cm^3 or 0.3 litre

R = 0.0821 lit.atm K^{-1} mol^{-1}, T = 300K

$\pi = 1.29 \times 10^{-3}$ atm

$$\pi V = \frac{w}{m}RT$$

$$1.29 \times 10^{-3} \times 0.3 = \frac{0.63}{m} \times 0.0821 \times 300 \text{ or}$$

$$m = \frac{0.63 \times 0.0821 \times 300}{1.29 \times 10^{-3} \times 0.3}$$

m = 40,095.35 g mol^{-1}

(ii) Given; W = 5.5kg = 5500g, $\Delta T_f = 10\ ^oC$

$K_f = 1.86$ K kg mol^{-1}, m = 62.0 g mol^{-1}

w = ?

$$w = \frac{m \times \Delta T_f \times W}{1000 \times K_f} \text{ or}$$

$$w = \frac{62 \times 10 \times 5500}{1000 \times 1.86}$$

w = 1833g = 1.833kg

(iii) In pure water, the egg will swell or increase in size due to endosmosis whereas in saturated sodium chloride solution, the egg will shrink due to exosmosis.

(iv) $K_2SO_4 \longrightarrow 2K^+ + SO_4^{2-}$

The value of vant Hoff factor i = 3 (if K_2SO_4 is completely ionized).

Question 21 **[5]**

(i)

(a) $[Co(NH_3)_6]Cl_3 \longrightarrow [Co(NH_3)_6]^{3+} + 3Cl^-$

$3AgNO_3 + 3Cl^- \longrightarrow 3AgCl + NO_3^-$

Structural formula of compound is $[Co(NH_3)_6]Cl_3$

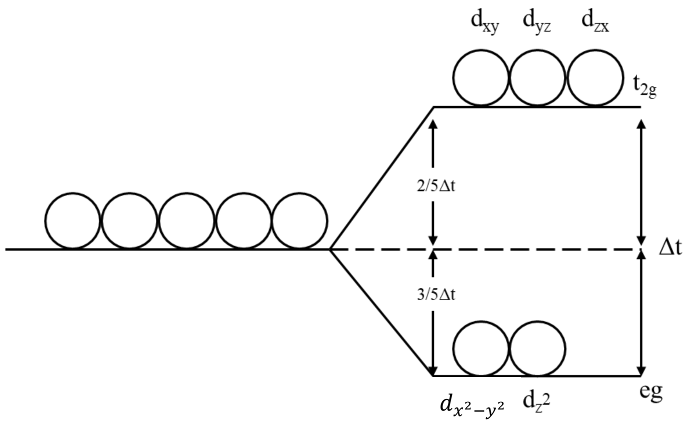
(b) For $[Fe(H_2O)_6]^{3+}$, $t_{2g}^3\ eg^2$

No. of unpaired electrons = 5

for $[Fe(CN)_6]^{3-}$, $t_{2g}^5\ eg^0$

No. of unpaired electrons = 1

(c)



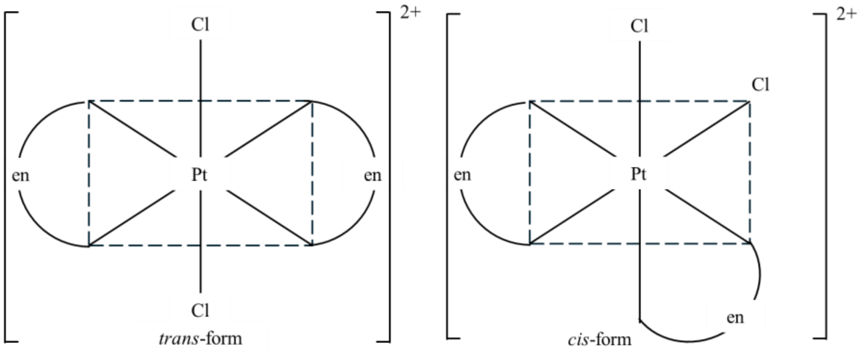
Splitting of d-orbitals Tetrahedral field

(d) (1) Linkage isomer of $[CoCl(en)_2NO_2]Cl_2$
Ans: $[CoCl(en)_2ONO]Cl_2$
(2) Ionisation isomer of $[CoBr(NH_3)_5]SO_4$
Ans: $[Co(NH_3)_5SO_4]Br$

OR

(ii) (a) For the complex compound $[Fe(en)_2Cl_2]Cl$:
(1) Oxidation state = +3
(2) Hybridisation = d^2sp^3
(3) Magnetic behaviour = paramagnetic
(4) Geometry = octahedral

(b) Geometrical isomers of $[Pt(en)_2Cl_2]^{2+}$ ion



(c) Electronic configuration for d^4 ion if $\Delta_o > P$ (strong field ligand)

$d^4 = t_{2g}^4 \, eg^o$