Section A

Q. 1
i) (d) AB₂
ii) (d) AlCl₃
iii) (d) 968 x 10⁻³ J
iv) (d) 5 m² mol⁻¹⁻¹
v) (a) 1800 s
vi) (b) Bispyramidal
vii) (a) Sc³⁺
viii) (b) EDTA
ix) (d) NaCl
x) (c) 1 and 5

Q. 2
i) Density of solids does not alter the density of the solid
ii) statement
iii) Applications of integrate rate equation:
Rate of chemical reaction could be calculated.
Rate constant could be easily estimated.
iv) Isopropyl benzene / cumene
v) Denaturation is uncoils the protein by heating the protein with alcohol, conc. inorganic acids or by
Vii) Carboxylic detergents quaternary ammonium salts of amines with chlorides, acetates or bromides.

\[
\begin{align*}
\text{Salicylic acid} & \quad \text{Aspirin} \\
\text{Acetic anhydride} & \quad \text{OCOCH}_3 \\
\text{COOH} & \quad \text{COOH}
\end{align*}
\]

Section B

\[ W_{\text{max}} = -2.303 \text{ NRT} \log \frac{V_2}{V_1} \]

\[ n = 2 \text{ mol} \quad R = 8.314 \text{ JK}^{-1}\text{mol}^{-1} \quad T = 300K \]

\[ V_1 = 10 \text{ L} \quad V_2 = 100 \text{ L} \]

\[ W_{\text{max}} = -2.303 \times 2 \times (2 \text{ mol}) \times 8.314 \text{ (JK}^{-1}\text{mol}^{-1}) \times 300 \text{ (K)} \times \log_{10} \frac{100 \text{ (L)}}{10 \text{ (L)}} \]

\[ = -2.303 \times 2 \times 8.314 \times 300 \times \log_{10} 10 \]

\[ = -2.303 \times 2 \times 8.314 \times 300 \times 1 \]

\[ = -11488 \text{ KJ} \]

The amount of work done is \(-11488 \text{ KJ}\)
\[ E^{\circ}_{\text{cell}} = E^{\circ}_{\text{Fe}} - E^{\circ}_{\text{Cd}} \]

\[ = -0.441 - (0.403) \]

\[ = -0.038 \text{ V} \]

(3m)

cell reaction: \( \text{Cd} + \text{Fe}^{2+} (0.6) \rightarrow \text{Cd}^{2+} (0.01 \text{ M}) + \text{Fe} \) (1/2 m)

\[ E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.0592}{2} \log \frac{\text{[Cd}^{2+}\]}{\text{[Fe}^{2+}\]} \]

\[ = -0.038 - \frac{0.0592}{2} \log 10^{-3} \]

(1/2 m)

\[ = -0.038 + 0.0821 \]

\[ E_{\text{cell}} = 0.0441 \text{ V} \] (1 m)

Q. 5
i) Definition of pyrometallurgy

- 1 m

ii) Definition of hydrometallurgy

- 1 m

Q. 6

Nitrogen belong to group 15 element possess half filled p- subshell in its valence shell which is more symmetrical & more stable.

Due to extra stability of half filled configuration more energy is required to remove electron from the valence shell of nitrogen.

- 1 m

Q. 7 Action of \( \text{K}_2\text{Cr}_2\text{O}_7 \) on

a) \( \text{SO}_2 \)

When \( \text{SO}_2 \) gas is passed into acidified \( \text{K}_2\text{Cr}_2\text{O}_7 \) solution it is oxidised to sulphuric acid & potassium dichromate to chromic sulphate orange colour of the solution turns green.

\[ \text{K}_2\text{Cr}_2\text{O}_7 + 3\text{SO}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + \text{Cr}_2(\text{SO}_4)_3 + \text{H}_2\text{O} \]

- 1 m

b) With \( \text{KI} \)

\[ \text{K}_2\text{Cr}_2\text{O}_7 + 6\text{KI} + 7\text{H}_2\text{SO}_4 \rightarrow 9\text{K}_2\text{SO}_4 + \text{Cr}_2(\text{SO}_4)_3 + 7\text{H}_2\text{O} + 3\text{I}_2 \]

Iodinate Iodine solution brown,

- 1 m
Q. 8

a) \( \text{CH}_3\text{CH}_2\text{OH} + \text{HI} \xrightarrow{\Delta} \text{CH}_3\text{CH}_2\text{I} + \text{H}_2\text{O} \) (1m)

Ethyl iodide (Iodoethane)

b) \( \text{CH}_3\text{CH}_2\text{OH} + \text{PI}_3 \xrightarrow{\bar{P}} \text{I}_2 \xrightarrow{\cdot} \text{CH}_3\text{CH}_2\text{I} + \text{H}_2\text{PO}_3 \) (1m)

Ethanol Iodoethane

D) \( \text{CH} = \text{CH} + \text{H}_2 \xrightarrow{\Delta} \text{CH}_3\text{CH}_2\text{I} \)

Ethene Iodoethane

Q. 9

Step i: Methoxyethane is protonated to give dimethyl oxonium ion as oxygen of ether is basic.

\[ \text{CH}_3\text{O}^-\text{CH}_2 + \text{H}^- \xrightarrow{\Delta} \text{H}_2\text{O} \text{CH}_2 + \text{I}^- \] (1m)

Step ii: Iodide ion, a good nucleophile, attack & departure of alk alcohol molecule take place simultaneously.

\[ \text{I}^- \text{CH}_2\text{O} \xrightarrow{\Delta} \text{CH}_2 + \text{I}^- \text{CH}_2 \text{O} \] (1m)

Q. 10

In presence of dilute base NaOH, KOH or Na_2CO_3, two molecule of an aldehyde or ketone having α-hydrogen add together to give β-hydroxyaldehyde (aldol). (1m)

In this reaction product is formed by the nucleophile addition of one molecule of aldehyde to second molecule in such way that the α-carbon of first molecule gets attached to the carbonyl of second molecule.
Q. 11
(a) No. of substituents: with increasing No. of electron withdrawing substituents increase the acidity (IM) of carboxylic acid.

\[ \text{CH}_3\text{COOH} > \text{CH}_2\text{COOH} > \text{CH}_3\text{CH}_2\text{COOH} > \text{CH}_3\text{COOH} \]

(b) Position of substituents:
Substituent on \( \alpha \)-carbon atom are most effective in increasing the strength of acid (IM).

\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} > \text{CH}_3\text{CHCH}_2\text{COOH} > \text{CH}_3\text{C}_6\text{H}_5\text{COOH} \]

Q. 12 polymers are classified based on molecular forces as:

(i) Elastomers: Polymers show elasticity. They are soft & stretchy & used in making rubber. E.g. neoprene. (II M)

(ii) Fibres: Strong intermolecular forces in fibres of polymers due to H-bonding. They possess high tensile strength. E.g. nylon, terylene

(iii) Thermoplastic polymers: These polymers become soft on heating & cooling
become hard. These can be recycled & remould (e.g. polythene, pvc)

iv) Thermosetting polymers:

These do not become soft on heating under pressure hence cannot be recycled & remoulded.

e.g. Bakelite.

(1/2 m)

Q. 13 e-caprolactum is heated at 533 K in an inert atmosphere it is polymerise to give nylon-6.

\[
\begin{align*}
\text{e-caprolactum} \rightarrow \text{repeating unit nylon-6}
\end{align*}
\]

Q. 14 Antibiotics are classified as bactericidal & bacteriostatic.

Bactericidal antibiotics kill the bacteria.

e.g. Ofloxacin, penicillin.

Bacteriostatic antibiotic inhibits growth of bacteria.

e.g. Tetracycline, erythromycin etc.

(1m)

Section - C

Q. 15 \[\Delta T_f = T^* - T\] (1/2 m)

\[\Delta T_f \propto m\]

m is molality of solution. (1/2 m)

\[\Delta T_f = k_f \cdot m\]

Let \(w_2\) gram of solute with molar mass \(m_2\) dissolve in \(w_1\) gram of solvent, \(m\) is given by

\[m = \frac{w_2}{M_2 \times w_1}\] (1/2 m)

\[\Delta T_f = \frac{k_f \cdot w_2}{M_2 \times w_1}\] (1/2 m)
Q. 15 Molality is the best flawless way of expressing concentration of solution as it is temperature independent quantity.

Q. 16 Hydrogen chloride gas is oxidised by atmospheric oxygen in the presence of CuCl₂ at 723 K

\[ \text{CuCl₂} \rightarrow 2 \text{Cl}_2 + 2 \text{H}_2\text{O} \]

Uses of Krypton

i) Krypton – 85 used in high efficiency miners’ cap lamps

ii) Krypton is used in filling discharge tubes & electric bulbs.

Q. 17 Structure of MnO₄⁻ (Permanganate ion)

\[
\text{Structure of } \text{CrO}_4^{2-} \text{ (Chromate ion)}
\]

\[ \text{Ti}(8s) = [Ar] 3d^2, 4s^2 \]

Ti show +2 (3d²), +3 (3d¹), +4 (3d⁴)

Oxidation state.

Ti⁺⁺ more stable due to 3d⁰ configuration.
Q. 18
(i) \( K \left[ \text{Au(CN)}_4 \right]^- \)  
\( (1 \text{m}) \)

(ii) \( \left[ \text{CrCl(H}_2\text{O})_5 \right]^- \text{Cl}_2 \)  
\( (1 \text{m}) \)

(iii) \( K_3 \left[ \text{Al(C}_2\text{O}_4 \right)_3] \)  
\( (1 \text{m}) \)

Q. 19
Given:
\( \Delta T_f = 0.680K \), \( c = 0.2 \text{ m}, \ V = 1 \text{ kg} = 1 \text{ L} \)
\( \Delta T_f = \frac{T_f - T_m}{m} \)
\( = 1.86 \text{ K kg mol}^{-1} \times 0.2 \text{ mol kg}^{-1} \)
\( = 0.372 \text{ K} \)  
\( (1/2 \text{ m}) \)

\( i = \frac{(\Delta T_f) \text{ (observed)}}{(\Delta T_f) \text{ (theoretical)}} \)
\( = \frac{0.680}{0.372} \)
\( = 1.83 \)  
\( (1 \text{ m}) \)

\( \lambda \text{ (Theoretical)} = cRT \)
\( = \frac{nRT}{V} \)
\( = 0.2 \text{ mol} \times 0.0821 \text{ atm mol}^{-1} \text{ K}^{-1} \times 298 \text{ K} \)
\( = 4.477 \text{ atm} \)

\( i = 1.83 = \frac{\lambda \text{ observed}}{\lambda \text{ Theoretical}} \)

\( \lambda \text{ observed} = 1.83 \times 4.477 \)
\( = 8.19 \text{ atm} \)  
\( (1 \text{ m}) \)

Q. 20
a) calamine \( \text{ZnO}_3 \)  
\( (1/2 \text{ m}) \)

b) Haematite \( \text{Fe}_2\text{O}_3 \)  
\( (1/2 \text{ m}) \)

c) Magnetite \( \text{Fe}_3\text{O}_4 \)  
\( (1/2 \text{ m}) \)

d) corundum \( \text{Al}_2\text{O}_3 \)  
\( (1/2 \text{ m}) \)
Q. 20 The Ellingham diagram is the plot of free energy change \( \Delta G \) against temperature for the reaction of metal & other element with one mole of oxygen at 1 atmosphere (1m)

Q. 21 Action of nitrous acid on

(a) Primary nitroalkane reacts with nitrous acid to form blue coloured nitroso-nitroalkanes (acid form) which dissolve in NaOH to give red solutions. (1m)

\[
\begin{align*}
R-C-N\equiv O + OH^{-} &\rightarrow R-C-N=O + H_2O \\
\text{(blue solution)}
\end{align*}
\]

(b) Secondary nitroalkanes reacts with nitrous acid to form blue coloured nitroso-nitroalkanes which no more contain \( \alpha \)-hydrogen atom hence are insoluble in NaOH. (1m)

\[
\begin{align*}
R-C-N\equiv O + NO_2^- &\rightarrow R-C-N=O + H_2O \\
\text{(blue solution)}
\end{align*}
\]

(c) Tertiary nitroalkanes do not react with nitrous acid here due to absence of \( \alpha \)-hydrogen atom. (1m)
Q. 22

\[ \text{Aniline} \rightarrow \text{p-nitrobenzenediazonium chloride} \rightarrow \text{Chlorobenzene} \]

\[ 2 \text{Cl}^- + 3 \text{Na} \rightarrow \text{Chlorobenzene} \rightarrow \text{Diphenyl} \]

When equal molar quantities of dextro & laevo isomers are mixed, the mixture is found to be optically inactive due to the external compensation known as racemic mixture (IM).

Q. 83

Primary alcohol like propan-1-ol which on reaction with Lucas reagent very slowly on heating give 1-chloro propane.

\[ \text{CH}_3-\text{CH}2-\text{CH}_2-\text{OH} + \text{HCl} \xrightarrow{\text{anhydrous} \text{ZnCl}_2} \text{CH}_3-\text{CH}2-\text{CH}_2-\text{Cl} + \text{H}_2\text{O} \] (IM)

propan-2-01

propan-2-01 react with Lucas reagent, separation of layer observed after few minutes.

\[ \text{CH}_3-\text{CH}-\text{CH}_2 + \text{HCl} \xrightarrow{\text{anhydrous} \text{ZnCl}_2} \text{CH}_3-\text{CH}-\text{CH}_2 + \text{H}_2\text{O} \] (IM)

2-methylpropan-2-01 react instantaneously with HCl at room temperature form turbidity immediately due to formation of 2-chloro-2-methylpropane.

\[ \text{CH}_3-\text{CH}_2-\text{OH} + \text{HCl} \xrightarrow{\text{RT}} \text{CH}_3-\text{CH}2-\text{Cl} + \text{H}_2\text{O} \] (IM)

2-methylpropan-2-01 2-chloro-2-methyl propane
In direct nitration of aniline due to strongly acidic medium aniline is converted into anilinium ion which is meta directing group, hence considerable amount of m-nitroaniline is also obtained.

Q. 26 Structure of $\alpha$-D-(+)-Glucopyranose

\[
\text{Structure of } \alpha-D-(+)-\text{Glucopyranose}
\]

\[\text{a)} \quad \text{b)} \quad \text{Structure Cellobiose}\]

$\text{P- D- Glucopyranose} \quad \text{P- D- Glucopyranose}$
Q. 26 (a) Structure of Nucleotide

\[ \text{Structure of Nucleotide} \]

\[ \text{(1 M)} \]

Q. 27

Edge length of unit cell \((a) = 408.7 \text{ pm} = 408.7 \times 10^{-12} \text{ m} \]

\[ = 408.7 \times 10^{-10} \text{ cm} \]

Volume of unit cell \((a^3) = (408.7 \times 10^{-10})^3 \]

\[ = 68.27 \times 10^{-24} \text{ cm}^3 \]

Silver has Fcc unit cell hence unit cell contain total 4 atoms \(\text{(1 A.M.)}\)

Mass of one silver atom = \(\frac{\text{molar mass of silver}}{\text{Avogadro number}}\)

\[ = \frac{108 \text{ g mol}^{-1}}{6.022 \times 10^{23} \text{ mol}^{-1}} \]

\[ = 17.93 \times 10^{-23} \text{ g} \]

\(\text{(1/9 M)}\)

Mass of unit cell of silver = \(4 \times 17.93 \times 10^{-23} \text{ g} \]

\[ = 71.72 \times 10^{-23} \text{ g} \]

\(\text{(1/8 M)}\)

Density of silver = \(\frac{\text{mass of unit cell}}{\text{volume of unit cell}}\)

\[ = \frac{71.72 \times 10^{-23}}{68.27 \times 10^{-24}} \]

\[ = 10.51 \text{ g cm}^{-3} \]

\(\text{(1 M)}\)

i) As doped with Si \(\Rightarrow n\) type \(\text{(1/5 M)}\)

ii) Ge doped with In \(\Rightarrow p\) type \(\text{(1/8 M)}\)
6.8 Relationship between $\Delta H$ & $\Delta U$ for chemical reactions

$\Delta H$ & $\Delta U$ are related at constant pressure

$$\Delta H = \Delta U + P\Delta V$$

Reactions involving gases $\Delta V$ cannot be neglected.

$$\Delta H = \Delta U + P\Delta V$$

$$= \Delta U + P(V_2 - V_1)$$

$$= \Delta U + PV_2 - PV_1$$

$$PV_1 = n_1RT \text{ and } PV_2 = n_2RT$$

$$\Delta H = \Delta U + n_2RT - n_1RT$$

$$\Delta H = \Delta U + RT(n_2 - n_1)$$

$$\Delta H = \Delta U + RT \Delta n$$

$\Delta n = \text{No. of moles of gaseous product} - \text{No. of moles of gaseous reactant}$

9) $\text{Na}(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g) \quad \Delta S = -\text{ve} \quad 1/8m$

The entropy decrease because disorder decreases due to decrease in no. of particles from 4 to 2.

10) $\text{CO}_2(g) \rightarrow \text{CO}(s) \quad \Delta S = -\text{ve} \quad 1/6m$

The entropy of system decrease because more disorder gas phase converted into less disorder solid state.
Cell reaction in lead storage battery during discharge

**Reaction at anode:**
\[
Pb(s) \rightarrow Pb^{2+} (aq.) + 2e^{-} \\
(Pb^{2+} (aq.) + SO_{4}^{2-} (aq.) \rightarrow PbSO_{4})
\]
\[
Pb(s) + SO_{4}^{2-} (aq.) \rightarrow PbSO_{4} (s) + 2e^{-} \quad (\frac{1}{3} \text{ m})
\]

**Reaction at cathode**
\[
PbO_{2} (s) + 4H^{+} (aq.) + 2e^{-} \rightarrow Pb^{2+} (aq.) + 2H_{2}O (l)
\]
\[
(Pb^{2+} (aq.) + SO_{4}^{2-} (aq.) \rightarrow PbSO_{4} (s))
\]
\[
PbO_{2} (s) + 4H^{+} (aq.) + SO_{4}^{2-} (aq.) + 2e^{-} \rightarrow PbSO_{4} (s) + 2H_{2}O (l) \quad (\frac{1}{3} \text{ m})
\]

**Net cell reaction**
\[
Pb(s) + SO_{4}^{2-} (aq.) \rightarrow PbSO_{4} (s) + 2e^{-}
\]
\[
PbO_{2} (s) + 4H^{+} (aq.) + SO_{4}^{2-} (aq.) + 2e^{-} \rightarrow PbSO_{4} (s) + 2H_{2}O (l)
\]
\[
Pb(s) + PbO_{2} (s) + 4H^{+} (aq.) + 2SO_{4}^{2-} (aq.) \rightarrow 2PbSO_{4} (s) + 2H_{2}O (l)
\]
\[
(1 \text{ m})
\]

**OY**
\[
Pb(s) + PbO_{2} (s) + 2H_{2}SO_{4} (aq.) \rightarrow 2PbSO_{4} (s) + 2H_{2}O (l) \quad (2 \text{ m})
\]

**Statement of Kohlrausch law**
(1 m)

**Any two disadvantages standard Hydrogen Electrode** (1 m)

Q.20 Graphical method to determine Ea

According Arrhenius
\[
ln K = ln A - \frac{E_a}{RT}
\]
\[
log_{10} K = - \frac{E_a}{2.303RT} + log_{10} A \quad (\frac{1}{3} \text{ m})
\]
The rate constants of reaction are determined at various temperatures.

\[ \log K \text{ is plotted against reciprocal of temperature (1/\theta)} \]

\[ \text{slope} = -\frac{E_a}{2.303 R} \quad (\text{1/\theta}) \]

\[ E_a = -\text{slope} \times 2.303 R \quad (\text{1/\theta}) \]

Q.30 (a) \[ \text{A} + \text{B} \rightarrow \text{product} \]

rate \propto [\text{A}][\text{B}]

If the conc. of \([\text{A}]\) increase three times, it becomes \(3[\text{A}]\)

The new rate is \(\text{rate}_2 = K \cdot 3[\text{A}][\text{B}]\)

\(\text{i.e. the rate of reaction is increased by three times.} \quad -1\text{M}\)

b) The concentration of \([\text{A}]\) is halved & concentration of \([\text{B}]\) is doubled

The new rate law

\[ \text{rate}_3 = K \cdot \frac{1}{2} [\text{A}] \times 2 [\text{B}] \]

\[ \text{rate}_3 = \text{rate}_1 \]

Therefore when concentration \([\text{A}]\) is halved & concentration \([\text{B}]\) is doubled, rate of reaction is remain same. \quad -1\text{M}
Q.31 Structure of SO₂

The molecule of SO₂ has bent structure with O-S-O bond angle of 119°.
Sulphur is sp² hybridized and lone pair of electrons of sulphur reduces the angle from 120° to 119°.

\[ \begin{align*}
S(16) & : 1s^2, 2s^2, 2p^6, 3s^2, 3p^4, 2d^1 \\
G & : 1s^2, 2s^2, 2p^6, 3s^2, 3p^4, 2d^1
\end{align*} \]

Excited state
Hybridized state

\[ \begin{align*}
4s & \quad 4p \\
3p & \quad 3d
\end{align*} \]

SP² hybridization

Two σ bond between S & O atom are formed by SP² - P overlap while one π bond arises from PX - PX overlap & others from PX - dx².

Structure of SO₂ molecule.

The main point of difference between N₂ & other element of Group 15:

i) At ordinary temperature N₂ is gas while other elements of group 15 are solids.

ii) Nitrogen exists as diatomic molecule (N₂) while other elements exist as tetratomic molecule (As₄, P₄, Sb₄).

iii) Nitrogen does not form pentahalides while all other elements form pentahalides.
9.3.10 Nitrogen shows wide range of oxidation state from -3 to +5. The other elements of the group shows only limited number of oxidation state.

(y2 m)