CAREERS360
PRACTICE Series

CBSE Class 12

Chemistry

Question and Solution 2025

SET - 1 OBJECTIVE ANSWERS

Q. 1- (B)

Q.2-(A)

Q.3-(C)

Q.4-(A)

Q.5-(B)

Q.6-(D)

Q.7-(C)

Q.8-B)

Q.9-(C)

Q.10-(D)

Q.11-(B)

Q.12-(C)

Q.13-(B)

Q.14-(A)

Q.15-(A)

Q.16-(D)

SET -2 OBJECTIVE ANSWERS

Q. 1- (D)

Q.2-(A)

Q.3-(A)

Q.4-(B)

Q.5-(C)

Q.6-(D)

Q.7-(D)

Q.8-(C)

Q.9-(B)

Q.10-(C)

Q.11-(D)

Q.12-(B)

Q.13-(A)

Q.14-(C)

Q.15-(A)

Q.16-(B)

SET -3 OBJECTIVE ANSWERS

Q. 1- (A)

Q.2-(B)

Q.3-(A)

Q.4-(C)

Q.5-(D)

Q.6-(B)

Q.7-(B)

Q.8-(C)

Q.9-(D)

Q.10-(C)

Q.11-(C)

Q.12-(D)

Q.13-(A)

Q.14-(B)

Q.15-(D)

Q.16-(A)

SET -1 ANSWERS (SUBJECTIVE)

Q. 17 (A)For a zero-order reaction, the integrated rate equation is:

$$[A] = [A]_0 - kt$$

where:

- $[A] =$ final concentration of $\mathrm{A} = 0.075\mathrm{M}$

- $[A]_0 =$ initial concentration of $\mathrm{A} = 0.10\mathrm{M}$
- $k =$ rate constant $= 0.0030 \text{ mol L}^{-1} \text{ s}^{-1}$
- $t =$ time (to be determined)

Substituting the values:

$$0.075 = 0.10 - (0.0030 \times t)$$
$$t = \frac{0.10 - 0.075}{0.0030}$$
$$t = \frac{0.025}{0.0030} = 8.33 \text{ s}$$

Q.17(B)

The decomposition reaction of ammonia $(\mathrm{NH_3})$ follows:

$$2\mathrm{NH_3} \rightarrow \mathrm{N_2} + 3\mathrm{H_2}$$

Given:
- Zero-order reaction rate constant $k = 2.5 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$.

For zero-order reactions, the rate of disappearance of $\mathrm{NH_3}$ is:

$$\text{Rate } = k = 2.5 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$$

From stoichiometry:

$$\text{Rate of formation of } \mathrm{N_2} = \frac{1}{2} \times k = \frac{1}{2} \times \left(2.5 \times 10^{-4}\right)$$
$$= 1.25 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$$
$$\text{Rate of formation of } \mathrm{H_2} = \frac{3}{2} \times k = \frac{3}{2} \times \left(2.5 \times 10^{-4}\right)$$
$$= 3.75 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$$

Final Answers:
- Rate of production of $N_2 = 1.25 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$.
- Rate of production of $H_2 = 3.75 \times 10^{-4} \text{ mol L}^{-1} \text{ s}^{-1}$.

Q18(a) Pseudo First Order Reaction:

A **pseudo-first order reaction** is a reaction that is truly of higher order but behaves as a first-order reaction under certain conditions. This happens when the concentration of one reactant is much larger than the other, making its change negligible during the reaction.

Example: Hydrolysis of ethyl acetate in excess water:

$$\mathrm{CH3COOC2H5 + H2O \rightarrow CH3COOH + C2H5OH}$$

Since water is in large excess, the reaction follows **first-order kinetics**, even though it should be second order.

Q18(b) Half-life Period of Reaction (t1/2t_{1/2}t1/2):

The **half-life period** ($t_{1/2}$)of a reaction is the time required for the concentration of a reactant to decrease to half of its initial concentration.

For different orders:

- **Zero-order reaction:**

  $$t_{1/2} = \frac{[A]_0}{2k}$$

  First-order reaction:

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

For a **first-order reaction**, half-life is independent of concentration.

Q19(a) Transition Elements Generally Form Coloured Compounds:

Transition elements form **coloured compounds** due to the presence of **partially filled d-orbitals**. When light falls on these compounds, **d-d electronic transitions** occur, where electrons move between different d-orbitals. The energy absorbed corresponds to a particular wavelength, and the remaining light gives the compound its colour.

Example:

- \- Cu^{2+} (blue)
  \- Fe^{3+} (yellow-brown)
  \- Cr^{3+}(green)

Q19(b) Zinc is Not Regarded as a Transition Element:

Zinc (Zn) is **not** considered a transition element because:

1. **It has a completely filled d-orbital** ($3d^{10}$) in both elemental and ionic (Zn^{2+}) forms.
2. **It does not exhibit variable oxidation states** (only +2).
3. **It does not form coloured compounds** or show significant catalytic properties like other transition metals.

Hence, zinc does not meet the criteria of transition elements, which typically have **partially filled d-orbitals**.

Q20: Naming the Coordination Compounds

(a) **$[Co(NH_3)_4(H_2O)Cl]Cl_2$**
IUPAC Name: Tetraammineaquachloridocobalt(III) chloride

- **Co** is cobalt, oxidation state = **+3**
- **NH_3 (Ammine)** and **H_2O (Aqua)** are neutral ligands.
- **Cl^- (Chlorido)** is a monodentate anionic ligand.
- **Cl_2 outside** represents counter ions.

(b) **$[CrCl_2(en)_2]Cl$**
IUPAC Name: Dichloridobis(ethylenediamine)chromium(III) chloride

- **Cr** is chromium, oxidation state = **+3**
- **en (ethylenediamine)** is a **bidentate neutral ligand**.
- **Cl^- (Chlorido)** is a monodentate anionic ligand.
- **One Cl^- is outside as a counter ion.**

Q21(a): SN1 Reactivity Comparison

The **SN1 reaction** (unimolecular nucleophilic substitution) depends on **carbocation stability** after leaving group departure.

- The **first compound** is **tert-butyl chloride** (tertiary halide).
- The **second compound** is **isobutyl chloride** (primary halide).

SN1 proceeds faster for tertiary carbocations due to **better stability via hyperconjugation and +I effect of alkyl groups**.

Answer: tert-Butyl chloride undergoes SN1 reaction faster because the **tertiary carbocation formed is more stable**.

Q21(b): Increasing Order of SN2 Reactivity

The **SN2 reaction** (bimolecular nucleophilic substitution) depends on **steric hindrance**—bulkier groups slow the reaction.

Given compounds:

1. **2-Bromo-2-methylbutane** → Highly hindered (tertiary halide) → **Least reactive**
2. **1-Bromopentane** → Primary halide → **Most reactive**
3. **2-Bromopentane** → Secondary halide → **Intermediate reactivity**

Order of increasing SN2 reactivity:
2-Bromo-2-methylbutane < 2-Bromopentane < 1-Bromopentane

Q.22

Using Raoult's Law:

$$P_{\text{solution}} = P_0 \times \chi_{\text{solvent}}$$

where:
- $P_0 = 24 \mathrm{mmHg}$ (saturated vapour pressure of water),
- $\chi_{\text{solvent}} = \frac{n_{\text{solvent}}}{n_{\text{solutet}} + n_{\text{solvent}}}$.

Given:
- 5% urea solution means 5g urea in 95g water.
- Moles of urea:

$$n_{\text{urea}} = \frac{5}{60} = 0.0833 \mathrm{moles}$$

- Moles of water:

$$n_{\text{water}} = \frac{95}{18} = 5.278 \text{ moles}$$

- Mole fraction of water:

$$\chi_{\text{water}} = \frac{5.278}{5.278+0.0833} = 0.9846$$

- Saturated vapour pressure:

$$P_{\text{solution}} = 24 \times 0.9846 = 23.63 \mathrm{mmHg}$$

Final Answer: 23.63 mmHg

Q.23

Given:
- Resistance (R) $= 5 \times 10^3 \Omega$,
-Concentration (C) $= 0.05$) M ,
-Length $(\mathrm{l}) = 40\ \mathrm{cm} = 0.4\ \mathrm{m}$,
-Area $(A) = 0.8\ \mathrm{cm}^2 = 8\backslash$ times $10^\wedge\{-8\})\mathrm{m}^2$.

(a) Resistivity (ρ):

$$\rho = R \times \frac{A}{l}$$
$$= \left(5 \times 10^3\right) \times \frac{8 \times 10^{-8}}{0.4}$$
$$= 1 \times 10^{-3} \Omega\ \mathrm{m}$$

(b) Conductivity (κ):

$$\kappa = \frac{1}{\rho} = \frac{1}{1 \times 10^{-3}}$$
$$= 10^3\ \mathrm{S\ m}^{-1}$$

(c) Molar Conductivity (Λ_m):

$$\Lambda_m = \frac{\kappa \times 1000}{C}$$
$$= \frac{10^3 \times 1000}{0.05}$$
$$= 2 \times 10^7 \mathrm{Sm}^2\ \mathrm{mol}^{-1}$$

Q.24

(a) Redox Reaction of MnO_4- with $\mathrm{C_2O_4}^{2-}$ in Acidic Medium

$$2\mathrm{MnO}_4^- + 5\mathrm{C}_2\mathrm{O}_4^{2-} + 16\mathrm{H}^+ \rightarrow 2\mathrm{Mn}^{2+} + 10\mathrm{CO}_2 + 8\mathrm{H}_2\mathrm{O}$$

(b) Thermal Decomposition of KMnO_4

$$2\mathrm{KMnO}_4 \xrightarrow{\text{Heat },513\ \mathrm{K}} \mathrm{K}_2\mathrm{MnO}_4 + \mathrm{MnO}_2 + \mathrm{O}_2$$

(c) Dichromate Reaction with H_2S in Acidic Medium

$$Cr_2O_7^{2-} + 3H_2S + 8H^+ \rightarrow 2Cr^{3+} + 3S + 7H_2O$$

Q25: Hybridization & Magnetic Character Using Valence Bond Theory

(a) **$[Co(NH_3)_6]^{3+}$**

- **Cobalt (Co) atomic number = 27 → Electronic configuration: [Ar] $3d^7$ $4s^2$**.
- **Oxidation state of Co = +3 → Configuration: [Ar] $3d^6$**.
- NH_3 is a **strong field ligand**, so **low spin complex** forms.
- **Hybridization**: **d^2sp^3 (octahedral)**.
- **Magnetic property**: **Diamagnetic** (all electrons paired).

(b) **$[Ni(CO)_4]$**

- **Nickel (Ni) atomic number = 28 → Configuration: [Ar] $3d^8$ $4s^2$**.
- **Oxidation state of Ni = 0 → Configuration: [Ar] $3d^8$ $4s^2$**.
- CO is a **strong field ligand**, so **low spin complex** forms.
- **Hybridization**: **sp^3 (tetrahedral)**.
- **Magnetic property**: **Diamagnetic** (all electrons paired).

Q26(a): Definitions

(i) Enantiomers

Enantiomers are **stereoisomers** that are **non-superimposable mirror images** of each other. They have identical physical and chemical properties except:

- They rotate plane-polarized light in opposite directions.
- They react differently with chiral reagents.

Example: Lactic acid (one enantiomer rotates light clockwise, the other counterclockwise).

(ii) Racemic Mixture

A **racemic mixture** is a **1:1 mixture of two enantiomers** of a chiral compound. Since the enantiomers rotate light in opposite directions with equal magnitude, the net optical rotation is **zero** (optically inactive).

Example: (±)-Lactic acid (equal amounts of both enantiomers).

Q26(b): Why is Chlorobenzene Resistant to Nucleophilic Substitution?

Chlorobenzene is **highly resistant to nucleophilic substitution** due to the following reasons:

1. **Partial Double Bond Character (Resonance Effect)**
    - The lone pair on **Cl** participates in resonance with the benzene ring.
    - This creates **partial double bond character** in the **C–Cl bond**, making it stronger and less reactive.
2. **Sp^2 Hybridization of Carbon**
    - In chlorobenzene, the carbon attached to chlorine is **sp^2 hybridized**, making the **C–Cl bond shorter and stronger** than the **sp^3 C–Cl bond** in alkyl halides.
3. **Steric Hindrance**

    - The **benzene ring** creates steric hindrance, preventing nucleophiles from attacking easily.
4. **Lack of Carbocation Stability**
    - In **SN1 reactions**, carbocation formation is difficult because **phenyl carbocations are highly unstable**.

Hence, chlorobenzene undergoes **nucleophilic substitution only under drastic conditions**, like **high temperature and strong nucleophiles**.

Q.27 (A)

(a) Wolff-Kishner Reduction
- This reaction is used to convert carbonyl compounds (aldehydes and ketones) into alkanes.
- It involves treating the carbonyl compound with hydrazine $\left(\mathrm{NH_2NH_2}\right)$ in a strong base (KOH) and heating.

Reaction:

$$\mathrm{R-CO-R'+NH_2NH_2\xrightarrow{\text{K\textsc{oh}, heat}}R-CH_2-R'+N_2}$$

Example:

$$\mathrm{CH_3COCH_3+NH_2NH_2\xrightarrow{\text{KoH, heat}}CH_3CH_3+N_2}$$

(b) Etard Reaction
- This reaction selectively oxidizes toluene to benzaldehyde using chromyl chloride ($\mathrm{CrO_2Cl_2}$).

Reaction:

$$\mathrm{C_6H_5CH_3+CrO_2Cl_2\xrightarrow{CS_2}C_6H_5CHO+CrCl_3+HCl}$$

(c) Cannizzaro Reaction
- Aldehydes without a-hydrogen atoms undergo a self-redox reaction in the presence of a strong base (NaOH or KOH).
- One molecule is reduced to an alcohol, while the other is oxidized to a carboxylate anion.

Reaction:

$$\mathrm{2HCHO+NaOH\rightarrow CH_3OH+HCOONa}$$

Q27(B): Identifying A, B, and C in Given Reactions
(a) $\mathrm{CH_3COOH\rightarrow(SOCl_2)\rightarrow A\rightarrow(H_2,Pd_{-}BaSO_4)\rightarrow B\rightarrow(H_2\,N-NH_2)\rightarrow C}$
1. $\mathrm{CH_3COOH+SOCl_2\rightarrow CH_3COCl(A)}$
2. $\mathrm{CH_3COCl+H_2\ \left(Pd_{-BaSO_4)\rightarrow CH_3CHO(B)}\right.}$
3. $\mathrm{CH_3CHO+NH_2NH_2\rightarrow CH_3CH=N-NH_2\rightarrow CH_3CH_3(C)}$

Final Products:
- $\mathrm{A}=$ Acetyl chloride $\left(\mathrm{CH_3COCl}\right)$
- $\mathrm{B}=$ Acetaldehyde $\left(\mathrm{CH_3CHO}\right)$
- $\mathrm{C}=$ Ethane $\left(\mathrm{CH_3CH_3}\right)$

(b) $CH_3CN \rightarrow$ (DIBAL-H) $\rightarrow A \rightarrow$ (Dil. $NaOH, \Delta) \rightarrow B \rightarrow C$
1. CH_3CN+ DIBAL-H $\rightarrow CH_3CH = NH(A)$
2. $CH_3CH = NH + H_2O \rightarrow CH_3CHO(B)$
3. $CH_3CHO + NaOH \rightarrow CH_3CH_2OH(C)$

Final Products:
- $A =$ Imines $(CH_3CH = NH)$
- $B =$ Acetaldehyde (CH_3CHO)
- $C =$ Ethanol (CH_3CH_2OH)

Q28: Definitions

(a) Glycosidic Linkage

- A **glycosidic linkage** is a **covalent bond** that joins two monosaccharide units via an **oxygen bridge (-O-)**.
- Formed by a **condensation reaction** (removal of water).

Example:
α-D-Glucose + α-D-Glucose → Maltose (linked via α-1,4-glycosidic bond).

(b) Invert Sugar
- Invert sugar is an equimolar mixture of glucose and fructose formed by hydrolysis of sucrose.
- It is called "invert" because the optical rotation of the solution changes from dextrorotatory $(+66^\circ)$ to levorotatory (-39°).

Reaction:

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{HCl or Invertase}} C_6H_{12}O_6 + C_6H_{12}O_6$$

(Sucrose $\rightarrow$ Glucose + Fructose)

(c) Oligosaccharides

- Oligosaccharides are **carbohydrates composed of 2–10 monosaccharide units** linked by glycosidic bonds.
- They are hydrolyzed into **monosaccharides** in acidic or enzymatic conditions.

Examples:

- **Disaccharides:** Sucrose, Maltose, Lactose.
- **Trisaccharides:** Raffinose.

Q29(a): Define Reverse Osmosis & Name a Semipermeable Membrane (SPM) Used

Reverse osmosis (RO) is a process where **solvent molecules move from a concentrated solution to a dilute solution** across a **semipermeable membrane (SPM)** when **external pressure greater than the osmotic pressure** is applied. This process is widely used for **water purification and desalination**.

Example of SPM Used:

- **Cellulose acetate membrane**

- **Polyamide membrane**
- **Thin-film composite (TFC) membrane**

Q29(b)(i): Effect of 0.5% NaCl Solution on RBCs

The **normal saline concentration for RBCs is 0.9% NaCl** (isotonic solution).

- **0.5% NaCl is a hypotonic solution** (lower solute concentration than inside RBCs).
- **Osmosis occurs**, water enters RBCs, causing them to **swell and possibly burst** (hemolysis).

Final Answer: RBCs will swell and may burst due to water influx.

Q29(b)(ii): Higher Osmotic Pressure - 1M KCl vs. 1M Urea
Osmotic pressure (π) is given by:

$$\pi = iCRT$$

where:
- $i =$ Van't Hoff factor (number of particles in solution)
- $C =$ Concentration (Molarity)
- $R =$ Gas constant
- $T =$ Temperature

For:
- KCl: It dissociates into $\mathbf{K}^{+}$and $\mathrm{Cl}^{-} (i = 2)$, so $\pi = 2MRT$.
- Urea: It does not dissociate $(i = 1)$, so $\pi = 1MRT$.

Since i is higher for KCl, the osmotic pressure of $\mathbf{1 M KCl}$ is higher than 1 M urea.
Final Answer: 1M KCl has higher osmotic pressure than 1M urea because KCl dissociates into two ions, increasing the effective particle concentration.

Q29(c): Why Osmotic Pressure is a Colligative Property?

Colligative properties depend only on the **number of solute particles** in solution, **not on their identity**. **Osmotic pressure** depends on **solute concentration (number of particles per unit volume)** rather than their nature.

π=iCRT

Since osmotic pressure is **directly proportional** to the number of solute particles (not their type), it is classified as a **colligative property**.

Final Answer: Osmotic pressure is a colligative property because it depends only on the number of solute particles in solution, not their chemical identity.

Q30(a): Increasing Order of Basic Character with Reason

The given compounds include:

1. **p-Nitroaniline (NO_2 at para position, $-NH_2$ group)**
2. **m-Nitroaniline (NO_2 at meta position, $-NH_2$ group)**
3. **p-Toluidine (CH_3 at para position, $-NH_2$ group)**

Basicity Order Analysis:

- **Electron-donating groups (EDGs) like $-CH_3$ increase basicity** by enhancing electron density on the nitrogen of the amine group.
- **Electron-withdrawing groups (EWGs) like $-NO_2$ decrease basicity** by pulling electron density away from the nitrogen.
- **Para-position NO_2 ($-NO_2$ at p-position)** has the **strongest -M effect (mesomeric effect)**, making the amine least basic.
- **Meta-position NO_2 ($-NO_2$ at m-position)** has only an **-I effect (inductive effect)** and no resonance interaction, making it slightly more basic than the para form.
- **p-Toluidine ($-CH_3$ at p-position)** has an **+I effect**, increasing electron density on nitrogen, making it the most basic.

Final Order (Increasing Basicity):
p-Nitroaniline < m-Nitroaniline < p-Toluidine

Q30(b): Why is pK_b of Aniline More than that of Methylamine?

- **Aniline ($C_6H_5NH_2$) is less basic than methylamine (CH_3NH_2)** because of **resonance stabilization** in the benzene ring.
- The lone pair on nitrogen in aniline **participates in conjugation with the benzene ring**, reducing its availability for protonation.
- In contrast, **methylamine is an aliphatic amine** where **no resonance effect occurs**, and the **+I effect of the $-CH_3$ group** increases electron density on nitrogen, making it more basic.
- Since **stronger bases have lower pK_b values**, **aniline has a higher pK_b than methylamine**.

Final Answer:
pK_b of aniline is higher than that of methylamine because resonance in aniline reduces the availability of nitrogen's lone pair for protonation, making it less basic than methylamine.

Q(c)(i): Increasing Order of Basic Character in Aqueous Solution

Given compounds:

1. **NH_3 (Ammonia)**
2. **CH_3NH_2 (Methylamine, Primary Amine)**
3. **$(CH_3)_2NH$ (Dimethylamine, Secondary Amine)**
4. **$(CH_3)_3N$ (Trimethylamine, Tertiary Amine)**

Basicity Order Analysis in Aqueous Solution:

- **Basic strength of amines in aqueous solution depends on:**
  1. **+I (Inductive) Effect of Alkyl Groups:** Alkyl groups push electron density towards nitrogen, increasing basicity.
  2. **Solvation Effect:** More hydrogen bonding in **primary and secondary amines** makes them more stable, increasing their effective basicity in water.
  3. **Steric Hindrance:** Tertiary amines are **less basic** due to steric hindrance and poor solvation.

Trend of Basicity in Aqueous Solution:

$NH3<(CH_3)_3N<CH_3NH_2<(CH_3)_2NH$

- **Ammonia (NH_3)** is the least basic.
- **Tertiary amine ($(CH_3)_3N$)** is less basic than primary and secondary due to **poor solvation**.
- **Secondary amine ($(CH_3)_2NH$)** is the most basic due to **optimal electron donation and solvation balance**.

Final Order (Increasing Basicity):
$NH_3 < (CH_3)_3N < CH_3NH_2 < (CH_3)_2NH$

Q(c)(ii): Why is Ammonolysis of Alkyl Halides Not a Good Method to Prepare Pure Amines?

Ammonolysis of alkyl halides involves **nucleophilic substitution**, where ammonia reacts with an alkyl halide to form an amine:

$R{-}X + NH_3 \rightarrow R{-}NH_2 + HX$

Problems with Ammonolysis:

1. **Formation of a Mixture of Amines**
   - The formed amine **($R{-}NH_2$)** is itself a **strong nucleophile** and reacts further with alkyl halide, leading to **secondary (R_2NH), tertiary (R_3N), and even quaternary ammonium salts ($R_4N^+X^-$)**.
   - This makes **separating a pure amine difficult**.
2. **Low Yield of Primary Amine**
   - Since secondary and tertiary amines also form, the yield of the **desired primary amine ($R{-}NH_2$)** is low.
3. **Difficult Separation**
   - The mixture of amines requires **complex separation techniques** like **fractional distillation**, making the process inefficient.

Final Answer:
Ammonolysis of alkyl halides is not a good method for preparing pure amines because it leads to a mixture of primary, secondary, and tertiary amines, making separation difficult.

Q31(A)(a): IUPAC Name of $CH_3{-}CH{=}CH{-}CHO$

- **The longest carbon chain contains four carbon atoms.**
- **The -CHO (aldehyde) functional group takes priority.**
- **The double bond (-CH=CH-) is present at carbon 2.**

IUPAC Name: But-2-enal

Q31(A)(b): Chemical Test to Distinguish Between Propanal and Propanone

- **Propanal (Aldehyde, CH_3CH_2CHO)**
- **Propanone (Ketone, CH_3COCH_3)**

Test: Tollen's Test (Silver Mirror Test)

- **Propanal (Aldehyde) gives a positive test, forming a silver mirror.**
- **Propanone (Ketone) does not react.**

Reaction (for propanal):

$$CH_3CH_2CHO + 2[Ag(NH_3)_2]^+ + H_2O \rightarrow CH_3CH_2COOH + 2Ag + 4NH_3$$

Final Answer: Propanal gives a silver mirror with Tollen's reagent, while propanone does not.

Q31(A)(c): Conversions
(i) Toluene to Benzoic Acid (Using Jones Reagent)
- Jones reagent $(\mathrm{CrO_3 + H_2SO_4})$ is a strong oxidizing agent.
- It oxidizes toluene $(\mathrm{C_6H_5CH_3})$ to benzoic acid $(\mathrm{C_6H_5COOH})$.

Reaction:

$$\mathrm{C_6H_5CH_3 + [O] \xrightarrow{\text{Jones Reagent}} C_6H_5COOH}$$

(ii) Ethanol to Propan-2-ol

1. Convert ethanol to ethyl bromide:

$$\mathrm{C_2H_5OH + HBr \rightarrow C_2H_5Br + H_2O}$$

2. Wurtz reaction with methyl bromide:

$$\mathrm{C_2H_5Br + CH_3MgBr \xrightarrow{\text{dry ether}} (CH_3)_2CHOH}$$

Final Product: Propan-2-ol ($\mathrm{CH_3CHOHCH_3}$)

(iii) Propanal to 2-Hydroxypropanoic Acid (Lactic Acid)
- Step 1: Propanal undergoes nucleophilic addition with HCN to form cyanohydrin.

$$\mathrm{CH_3CH_2CHO + HCN \rightarrow CH_3CH(OH)CN}$$

- Step 2: Acidic hydrolysis converts the -CN group to - COOH , forming 2-hydroxypropanoic acid (Lactic Acid).

$$\mathrm{CH_3CH(OH)CN + 2H_2O + H^+ \rightarrow CH_3CH(OH)COOH}$$

Final Answer: Propanal $\rightarrow$ Cyanohydrin $\rightarrow$ Lactic Acid (2-hydroxypropanoic acid).

Q31(B): Completing the Synthesis
(a) Reaction of Cyclopentanone with Hydroxylamine
- The given cyclopentanone (five-membered ketone) reacts with hydroxylamine $(\mathrm{NH_2OH})$ in an acidic medium.
- This forms an oxime via nucleophilic addition-elimination.

Reaction:

$$\text{Cyclopentanone } + \mathrm{NH_2OH} \xrightarrow{\mathrm{H^+}} \text{Cyclopentanone oxime}$$

Final Product: Cyclopentanone oxime ($\mathrm{C_5H_5NO}$)

(b) Ozonolysis of a Cyclic Alkene
- The final product is cyclohexane-1,2-dione (six-membered diketone).
- Ozonolysis of 1,2-cyclohexene (cyclohexene with a double bond between two carbons) in the presence of $\mathrm{O_3}/\mathbf{Zn}-\mathbf{H_2}\mathrm{O}$ leads to cleavage of the double bond and formation of two carbonyl groups.

Reaction:

$$\text{1,2-Cyclohexene } + \mathrm{O}_3 \xrightarrow{\mathrm{Zn-H_2O}} \text{ Cyclohexane-1,2-dione}$$

Starting Material: 1,2-Cyclohexene

(c) Reaction of 2-Hydroxy-1,2-benzophenone with SOCl₂

- **The given compound is 2-hydroxy-1,2-benzophenone (a hydroxyl carboxyl compound).**
- **SOCl₂ (Thionyl chloride) converts the –COOH group to –COCl (acid chloride).**
- **On heating, it undergoes intramolecular cyclization, forming coumarin (lactone formation).**

Final Product: Coumarin (Benzopyrone)

(d) Reaction of Aldo-Carboxylic Acid with NaCN/HCl

- **The given compound has both an -CHO (aldehyde) and -COOH (carboxyl) group.**
- **NaCN in HCl leads to cyanohydrin formation by addition of -CN to the aldehyde (-CHO) group.**

Final Product: α-Hydroxy-α-carboxylic acid (Cyanohydrin derivative)

(e) Friedel-Crafts Acylation of Benzene
- The reaction represents the Friedel-Crafts acylation of benzene.
- Benzene reacts with acetyl chloride $(\mathrm{CH_3COCl})$ in the presence of $\mathrm{AlCl_3}$ catalyst.
- This results in the formation of acetophenone $(\mathrm{C_6H_5COCH_3})$.

Reaction:

$$\mathrm{C_6H_6} + \mathrm{CH_3COCl} \xrightarrow{\mathrm{AlCl_3}} \mathrm{C_6H_5COCH_3}$$

Final Product: Acetophenone $(\mathrm{C_6H_5COCH_3})$

Q32(A)(a): Calculation of Standard Gibbs Energy ($\Delta \mathrm{G}^{\circ}$)
Given reaction:

$$Au(s) + Ca^{2+}(1M) \rightarrow Au^{3+}(1M) + Ca(s)$$

Standard electrode potentials:

$$E^{\circ}_{Au^{3+}/\mathrm{Au}} = +1.5\ \mathrm{V}$$
$$E^{\circ}_{Ca^{2+}/\mathrm{Ca}} = -2.87\ \mathrm{V}$$

Step 1: Calculate Standard Cell Potential (E° cell)

$$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cathode}} - E^{\circ}_{\text{anode}}$$
$$E^{\circ}_{\text{cell}} = (+1.5\ \mathrm{V}) - (-2.87\ \mathrm{V})$$
$$E^{\circ}_{\text{cell}} = 4.37\ \mathrm{V}$$

Step 2: Calculate Gibbs Free Energy ($\Delta\mathbf{G}^\circ$)

$$\Delta G^\circ = -nFE^\circ_{\text{cell}}$$

where:
- $n = 3$ (electrons transferred)
- $F = 96500 \mathrm{Cmol}^{-1}$
- $E^\circ_{\text{cell}} = 4.37 \text{ V}$

$$\begin{gathered}\Delta G^\circ = -(3)(96500)(4.37) \\ \Delta G^\circ = -1.26 \times 10^6 \text{ J mol}^{-1} \\ \Delta G^\circ = -1260 \text{ kJ mol}^{-1}\end{gathered}$$

Conclusion:
Since ΔG° is negative, the reaction is spontaneous at $25^\circ \mathrm{C}$.

Q32(A)(b): Can $\mathrm{Ag_2\ S}$ Tarnish be Removed Using Aluminium?
Given half-reactions:

$$\begin{gathered}Ag_2S(s) + 2e^- \rightarrow 2Ag(s) + S^{2-}, \quad E^\circ = -0.71V \\ Al^{3+} + 3e^- \rightarrow 2Al(s), \quad E^\circ = -1.66 \text{ V}\end{gathered}$$

To remove tarnish, aluminium must act as a reducing agent, meaning its oxidation potential must be higher than silver's reduction potential.

Step 1: Calculate Cell Potential

$$\begin{gathered}E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} \\ E^\circ_{\text{cell}} = (-0.71 \text{ V}) - (-1.66 \text{ V}) \\ E^\circ_{\text{cell}} = 0.95 \text{ V}\end{gathered}$$

Since $\mathbf{E}^\circ$ is positive, the reaction is spontaneous, meaning aluminium can reduce $\mathbf{Ag_2S}$, removing tarnish.

Final Answer:
Yes, placing tarnished silverware in an aluminium pan with NaCl solution will remove the tarnish, as aluminium will reduce $\mathbf{Ag_2S}$ to $\mathbf{Ag(s)}$.

Q32(B)(a): Definitions
(i) Cell Potential
- Cell potential (E_{cell}) is the difference in electrode potentials between the cathode and anode in an electrochemical cell.
- It determines the voltage output of the cell.

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

(ii) Fuel Cell

- A fuel cell is an electrochemical cell that continuously converts chemical energy of a fuel (e.g., hydrogen) into electrical energy.
- Unlike batteries, it requires a continuous supply of reactants.

Example: Hydrogen fuel cell:

$$2\mathrm{H}_2 + \mathrm{O}_2 \rightarrow 2\mathrm{H}_2\mathrm{O} + \text{ electricity}$$

Q32(B)(b): EMF of the Given Cell

Given cell:

$$\mathrm{Zn(\,s)}\left|\mathrm{Zn}^{2+}(0.1M)\right\|\mathrm{Cd}^{2+}(0.01M)\left|\mathrm{Cd(\,s)}\right.$$

Standard electrode potentials:

$$E^{\circ}_{\mathrm{Cd}^{2+}/\mathrm{Cd}} = -0.40\ \mathrm{V}$$
$$E^{\circ}_{\mathrm{Zn}^{2+}/\mathrm{Zn}} = -0.76\ \mathrm{V}$$

Step 1: Calculate E°_{cell}

$$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cathode}} - E^{\circ}_{\text{anode}}$$
$$E^{\circ}_{\text{cell}} = (-0.40) - (-0.76)$$
$$E^{\circ}_{\text{cell}} = 0.36\ \mathrm{V}$$

Step 2: Apply Nernst Equation

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.0591}{n}\log\frac{\left[\mathrm{Cd}^{2+}\right]}{\left[\mathrm{Zn}^{2+}\right]}$$

where:
- $n = 2$ (electrons transferred),
- $\left[\mathrm{Cd}^{2+}\right] = 0.01M$,
- $\left[\mathrm{Zn}^{2+}\right] = 0.1M$.

$$E_{\text{cell}} = 0.36 - \frac{0.0591}{2}\log\left(\frac{0.01}{0.1}\right)$$
$$E_{\text{cell}} = 0.36 - \frac{0.0591}{2} \times (-1)$$
$$E_{\text{cell}} = 0.36 + 0.0296$$
$$E_{\text{cell}} = 0.39\ \mathrm{V}$$

Final Answer: EMF $= 0.39\ \mathrm{V}$ at $25^{\circ}\mathrm{C}$.

Q33(A): Identifying Compounds A, B, C, D, and E
Given molecular formula: $C_2\mathbf{H}_6O$ (ethanol or dimethyl ether).
Step 1: Oxidation of ' A ' with CrO_3
- Primary alcohols oxidize to aldehydes and then to carboxylic acids.
- Ethanol (CH_3CH_2OH) oxidizes to ethanal (acetaldehyde, $CH_3\mathbf{CHO}$).

$$CH_3CH_2OH + [O] \xrightarrow{CrO_3} CH_3CHO$$

So, $A =$ Ethanol, $B =$ Ethanal (CH_3CHO).

Step 2: Iodoform Test
- Ethanal gives a yellow precipitate with iodine and NaOH due to the methyl ketone group ($COCH_3$).

$$CH_3CHO + I_2 + NaOH \rightarrow CHI_3(\text{ yellow ppt }) + \text{ others}$$

So, $\mathbf{C} =$ Iodoform (CHI_3).

Step 3: Heating A (Ethanol) with H_2SO_4 at 413 K
- Dehydration occurs, forming ethene (C_2H_4).

$$CH_3CH_2OH \xrightarrow{\text{Conc. } H_2SO_4, 413\text{ K}} CH_2 = CH_2 + H_2O$$

So, $\mathbf{D} =$ Ethene (C_2H_4).

Step 4: Reaction of Ethene with Excess HI
- Ethene undergoes electrophilic addition of HI , forming ethyl iodide (C_2H_s).

$$CH_2 = CH_2 + 2HI \rightarrow CH_3CH_2I$$

So, $E =$ Ethyl iodide ($C_2H_sI)$.

Q33(B)(a): Writing Chemical Equations
(i) Phenol + Conc. HNO_3 (Nitration of Phenol)
- Phenol undergoes nitration, forming 2,4,6-trinitrophenol (Picric Acid).

$$C_6H_5OH + 3HNO_3 \xrightarrow{\text{conc. } H_2SO_4} C_6H_2(NO_2)_3OH + 3H_2O$$

(ii) Hydroboration-Oxidation of Propene
- Step 1: Propene reacts with B_2H_6 (diborane) via anti-Markovnikov addition.
- Step 2: Oxidation by H_2O_2/OH^-forms propan-1-ol.

$$CH_3 - CH = CH_2 + B_2H_6 \longrightarrow CH_3 - CH_2 - CH_2\ B_2H_5$$

$$CH_3 - CH_2 - CH_2\ B_2H_5 \xrightarrow{H_2O_2/OH^-} CH_3 - CH_2 - CH_2OH$$

(iii) Sodium t-Butoxide $+\mathrm{CH_3Cl}$
- SN2 reaction, where t-butoxide acts as a strong nucleophile.

$$(\mathrm{CH_3})_3\mathrm{CO^-Na^+} + \mathrm{CH_3Cl} \rightarrow (\mathrm{CH_3})_3\mathrm{COCH_3} + \mathrm{NaCl}$$

Final Product: Methyl tert-butyl ether (MTBE).

Final Product: Propan-1-ol ($\mathrm{CH_3CH_2CH_2OH}$).

Q33(B)(b): Test to Distinguish Butan-1-ol and Butan-2-ol
- Lucas Test ($\mathrm{ZnCl_2 + HCl}$):
- Butan-1-ol (Primary alcohol) $\rightarrow$ No immediate reaction.
- Butan-2-ol (Secondary alcohol) $\rightarrow$ Cloudy solution in 5 minutes.

Q33(B)(C): Increasing Order of Acid Strength
- Phenol ($\mathrm{C_6H_5OH}$): Most acidic due to resonance stabilization of the phenoxide ion.
- Water $(\mathrm{H_2O})$: More acidic than ethanol due to better hydrogen bonding.
- Ethanol ($\mathrm{CH_3CH_2OH}$): Least acidic due to the electron-donating effect of the $-\mathrm{CH_3}$ group.

Final Order (Increasing Acid Strength):
Ethanol < Water < Phenol