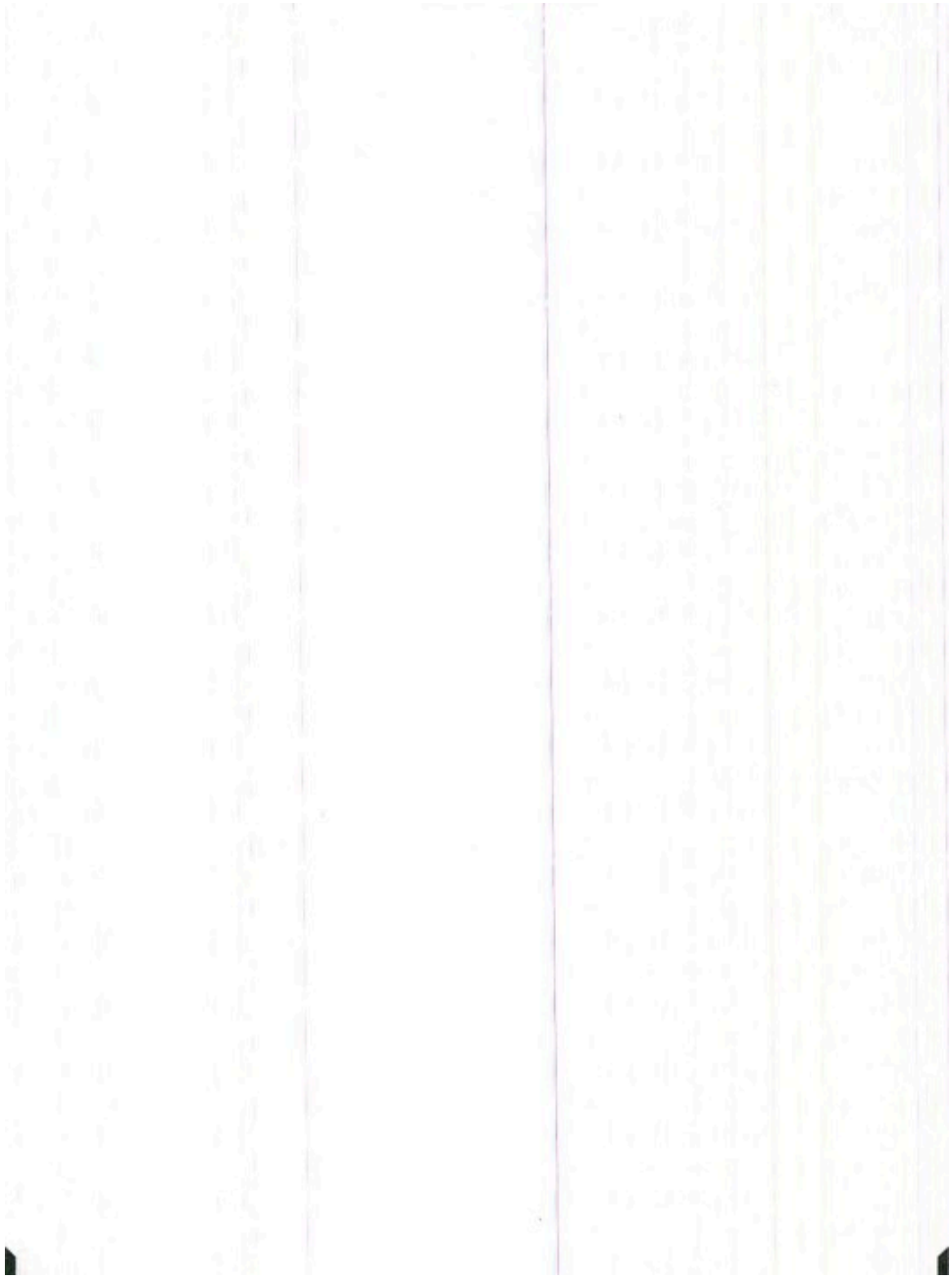
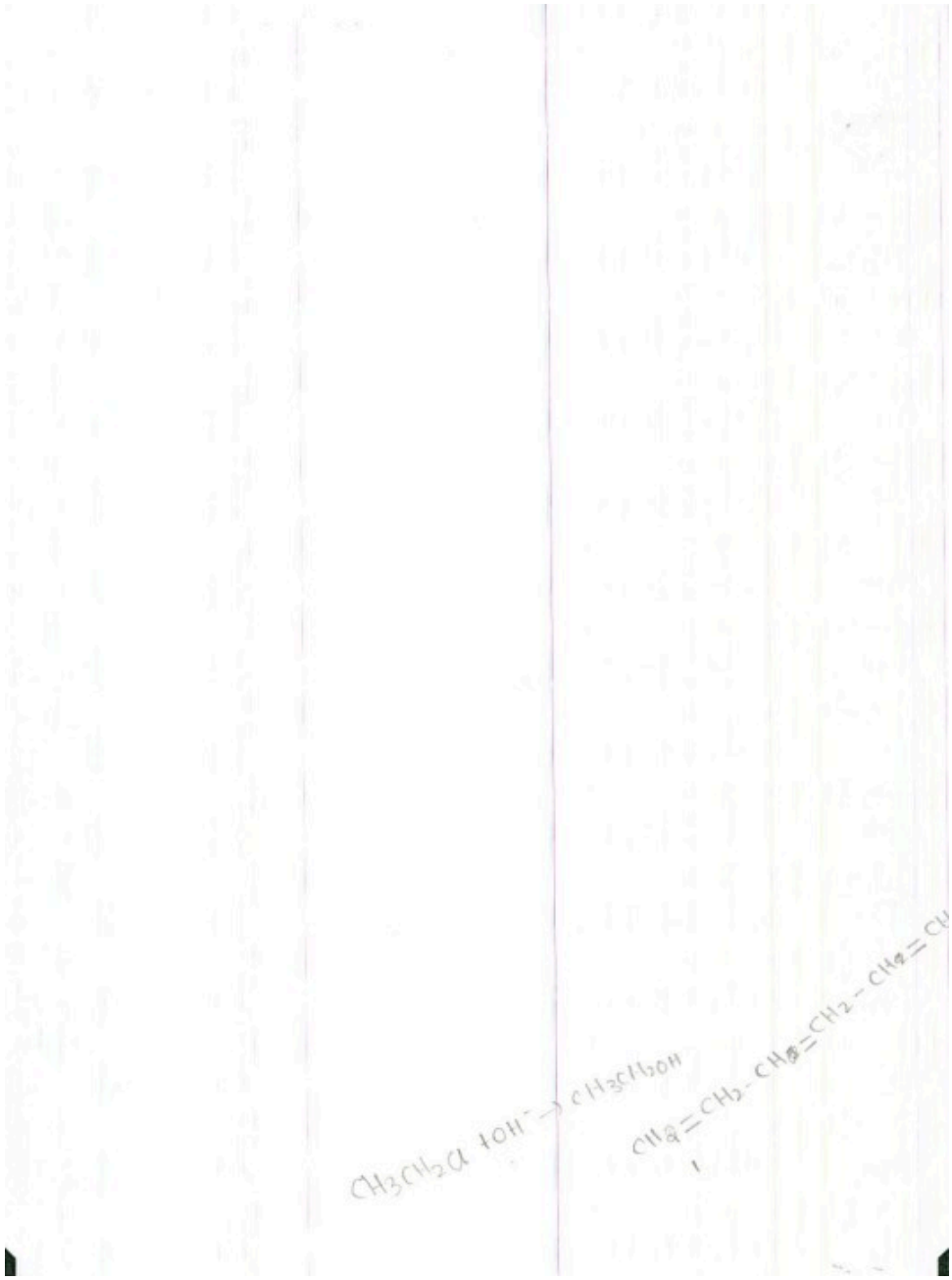





$CH_3CH_2Cl + OH^- \rightarrow CH_3CH_2OH$
$CH_2=CH_2-CH_2=CH_2-CH_2=CH$

(Section B)

Q. No. 2 Part (i) $Fe + Pb^{+2} \rightarrow Fe^{2+} + Pb$

At cathode: $Pb^{+2} + 2\bar{e} \rightarrow Pb$ (reduction half-cell)

At anode: $2Fe^{-} \rightarrow Fe^{2+} + 2\bar{e}$ (oxidation half-cell)

$E°cell = E°cathode - E°anode$

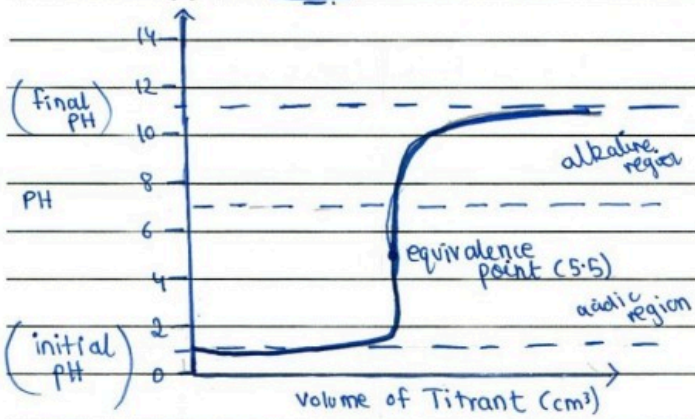
$= -0.13 - (-0.44V)$

$= 0.31V$

As E°cell is positive thus reaction is feasible.

Electrons move from anode to cathode.

Q. No. 2 Part (ii) Titration Curve:



→ This is a strong acid and weak base titration curve.

→ Initial pH is around 1-2 with HCl in flask and final pH is around 10-12 due to weak base.

→ Equivalence point is not neutral but occurs at 5.5.

(Section B)

Q. No. 2 Part (iii) pH of Buffer:

Given: $[CH_3COOH] = 1\ mol$ $[CH_3COONa] = 1\ mol$ $Ka = 1.8 \times 10^{-5}$

To find: pH = ?

Solution:

$$pH = pKa + \log \frac{[salt]}{[acid]}$$

$$pH = -\log(Ka) + \log \frac{[salt]}{[acid]} \qquad \therefore pKa = -\log(Ka)$$

$$pH = -\log(1.8 \times 10^{-5}) + \log \frac{[1.0]}{[1.0]}$$

pH of buffer = 4.74 – Ans.

Q. No. 2 Part (iv) Predicting shape, bond angle and coordination no.

$[Ag(NH_3)_2]^+$

This is diammine silver (I) ion.

Shape: It has a linear shape.

Bond Angles: It has 2 mondentate ligands lying at 180° to each other.

Coordination number: The no. of bonds it has formed with ligands is 2.

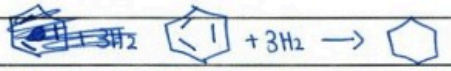
(Section B)

Q. No. 2 Part (v) Colorless Transition Elements:

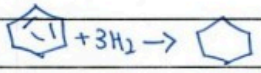
- Transition elements with d^{10} electronic configuration are usually colorless because they are highly stable and do not lose ~~protons~~ electrons.
- Colored compounds undergo d-d transition by electrons moving to higher state absorbing wavelength and emitting complimentary color. Such compounds are only formed by elements with incomplete filled 3d-sub shells as they do have an electron for d-d transition.
- For example Zn^{+2} has configuration $(3d^{10})$ and is highly Stable. It does not lose electron, therefore it does not undergo d-d- transition, thus forming a colorless compound.

Q. No. 2 Part (vi) Comparison of Enthalapies of Hydrogenation:

Benzene:



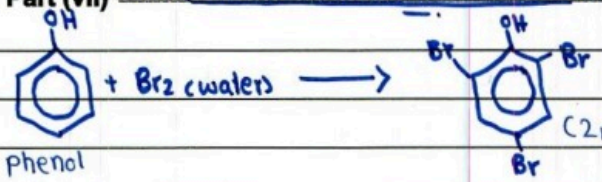
1,3,5 cyclohexatriene:



- Enthalapy of hydrogenation does depend on degree of unsaturation
- 1,3,5 cyclohexatriene is believed to be benzene. But results contradic this because one-double bond release -120KJ/mol of energy and so 1,3,5 cyclohexatriene with 3-double bonds releases. 3x -120KJ/mol = -360KJ/mol of energy. But the actual enthalapy of hydrogenation of benzene is 208 KJ/mol.
- This difference of 152 KJ/mol is called resonance energy of benzene which is used to explain extreme stability of benzene due to delocalised π-electron cloud.

(Section B)

Q. No. 2 Part (vii) Phenol on treatment with bromine water:



phenol

(2,4,6 tribromophenol)
white ppt.

→ Brown color of bromine water discharges.
→ White ppt. of 2,4,6 tribromophenol are produced.

- Unlike benzene, this reaction occurs at room temperature due to **hydroxyl** group attached to benzene ring. It is **ring activating** substituent which increases **electron density** at **2,4,6** positions making the benzene ring of phenol more **reactive.**
- Thus reaction occurs at room temperature without catalysts or harsh conditions, as benze ring is more reactive to electrophiles.

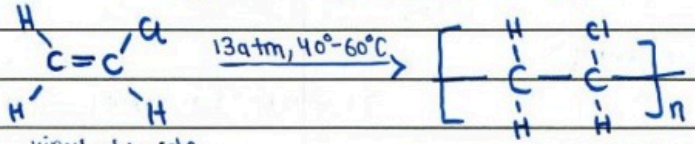
Q. No. 2 Part (viii) Comparison of Acidities:

Order: $CH_2Cl\text{-}COOH$ > CH_3COOH
(more acidic) (less acidic)

- In $CH_2ClCOOH$, the electron withdrawing group attached to carbon atom next to carbonyl group makes it more acidic. This group **withdraws** electrons from **oxygen** of **carboxylate ion.** Thus **electron density** around oxygen atom making it less likely to ~~attract~~ interact with H^+ atom thus acidic strength increases.
- In CH_3COOH, the electron donating alkyl group provides oxygen atom electron pairs. This increases the **electron density** around oxygen atom as well as **negative charge** of oxygen atom. This makes the C–O bond of –COOH more stronger hence acidic strength decreases. as –COOH group is **more acidic** now.

(Section B)

Q. No. 2 Part (ix) Polymerisation of polyvinyl chloride:



Type of polymerisation: Addition polymerisation

Vinyl chloride is obtained by treatment of HCl with acetylene.

$$HC \equiv CH + HCl \xrightarrow{HgCl_2} CH_2 = CH - Cl$$

vinyl chloride

Q. No. 2 Part (x) Addition vs. Condensation Polymerisation:

Addition Polymerisation	Condensation Polymerisation
• It occurs without lost of any molecule.	• It occurs with elimination of small molecule like HCl, H_2O, etc.
• The empirical formula of polymer is same as that of monomer.	• The empirical formula of polymer is different from that of monomer.
• Its monomers don't usually containe functional group.	• Its monomers usually contain two functional groups.
• It is not divided into further types.	• It is divided into further two types. 1-Polyamide 2-Polyester
Example: PVC, polyethylene	Example: Nylon 6,6, Kevlar.

(Section B)

Q. No. 2 Part (xi) Classification of Lipids:

- **Simple Lipids:** They are composed of only fatty acids and glycerols. For example.

Triglyceride. The act as main-energy store for many organisms.

- **Phospholipids:** They are important part of cell membranes with hydrophobic tail and hydrophilic head. For example:

Glycolipid: They are involved in cell recognition and attachment.

- **Derivative lipids:** They are composed of simple and conjugated lipids. For example:

Prostaglandins: These act as local hormones involved in inflammation.

Q. No. 2 Part (xii) No. of Carbon Atoms:

To predict no. of carbon atoms in molecule:

M+1 peak = 5.5 % M^+ peak = 100 %.

$$\text{No. of C atoms} = \frac{100 \times \text{abundance of M+1 peak}}{1.1 \times \text{abundance of M+ peak}}$$

$$= \frac{100 \times 5.5}{1.1 \times 100}$$

No. of C atoms = 5

Therefore molecule has 5 carbon atoms.

(Section B)

Q. No. 2 Part (xiii) Terms related to Chromatography:

a. Stationary phase: The stationary phase in chromatography does not move while mobile phase flows over it. Stationary phase is mostly enclosed in a tube and mobile phase runs over it. In column chromatography, the stationary phase is enclosed in a column through which mobile phase runs. Stationary phase may be liquid or solid coated on a solid.

b. Solvent Front: The level to which solute reaches up the paper is called solvent front.
There is dynamic equilibrium between stationary & mobile phase as components continously move between them.

Q. No. 2 Part (xiv) Pesticides:

These are chemicals employed to control or kill insects, fungi and pests which cause harm to plants or interfere with crop yield.

Negative Impacts:

- Pesticides are neurotoxic and carcinogenic. They can cause harmful health affects for farmers, co-workers and consumers.
- Pesticide can be harmful to aquatic organisms. water runoff containing pesticides causes water contamination harming aquatic organisms.

(Section C)

Q. No. 3 (Page 1) Mass of Copper:

Given: Current = 3A Time = 45 min = 2700s

(i) First we calculate the total charge passed:

Charge = Current x Time

$= 3 \times 2700$

Charge $= 8100\,C$

we need charge in Farad,

$1F = 96500C$

$8100\,C = \frac{8100}{96500}\,F$

Charge = 0.0839 F

(ii) At cathode, reduction of copper occurs:

$Cu^{+2} + 2\bar{e} \rightarrow Cu$

As we know that 1 mole of $\bar{e}$ = 1 F so,

2F : 1 mol of Cu

0.0839F : x mol of Cu

$2x = 0.0839$

$x = \frac{0.0839}{2}$

$x = 0.042$ mol of Cu

(Section C)

Q. No. 3 (Page 2) (iii) Mass of copper deposited:

mass = moles x molar mass

= 0.042 x 63.5

= 2.66g.

So total **2.66g** of copper is deposited at cathode.

(Section C)

Q. No. 3 (Page 3)

(Section C)

Q. No. 4 (Page 1) Basic Strength of Amines

- The strength of weaker bases is measured on bases of pKb values. Smaller the pKb value greater the basic strength.

- Strength of bases also depends on the stability of conjugate ion formed after gaining proton.

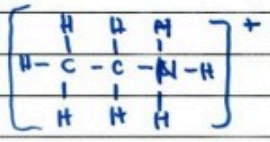
Phenyl amine	$pK_b = 9.36$
Ethyl amine	$pK_b = 3.27$
Ammonia	$pK_b = 4.75$

- Above data implies that ethyl amine is a stronger base than ammonia which is stronger base than phenyl amine.

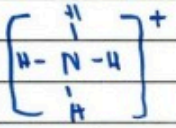
- Strength of bases depends on 2 factors:

1. The ease with which lone pair captures H^+.
2. The stability of ion formed after proton gain.

Structures of Ammonia and Ethyl amine:



Conjugate ion of ethyl amine



Conjugate ion of ammonia

(Section C)

Q. No. 4 (Page 2) • **Phenylamine** is an **aromatic** primary amine. The negative charge on nitrogen atom of amine group is involved in resonance and delocalisation in benzene ring

→ Hence, the lone pair of electron is not available to capture H^+.

→ Thus the intensity of negative charge around nitrogen atom is very less making it weak base.

• **Ethylamine** is the strongest base. The ethyl group is electron donating, increasing electron density of nitrogen atom.

→ Ethyl group makes the nitrogen atom's lone pair more electron rich making it more reactive to H^+.

→ The ethyl ammonium ion formed is more stable than ammonium ion formed by ammonia.

→ Thus ethyl group reduces the positive charge on the ion.

Both these factors make ammonia less basic than ethylamine.

Order of their basic strengths is:

Ethylamine > Ammonia > Phenylamine

(Section C)

Q. No. 4 (Page 3) Phenyl amine > Ammonia > Ethyl amine

This order represents the increasing acidity of conjugate acids of the above bases.
The conjugate acid of phenyl amine is most acidic while that of ethyl amine is least acidic.

(Section C)

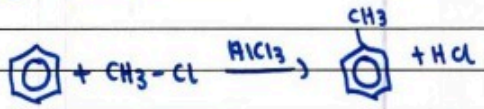
Q. No. 5 (Page 1) Friedel Crafts - Alkylation

→ Friedel - Crafts alkylation is the introduction of alkyl group in benzene ring as it is heated with alkyl halides.

→ Here in alkylation using CH_3Cl, introduces methyl group to benzene ring in presence of $AlCl_3$.

→ Benzene is heated with methyl chloride in presence of Lewis acid $AlCl_3$ as catalyst to form product called methyl - benzene.

General Reaction:

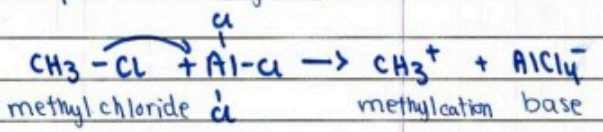


Mechanism:

It involves three steps:

a. Generation of Electrophile:

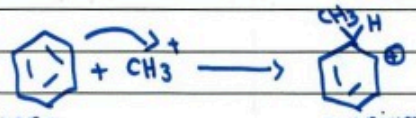
In this step methyl chloride donates an electron pair to $AlCl_3$ leading to formation of electrophile: methyl cation.



(Section C)

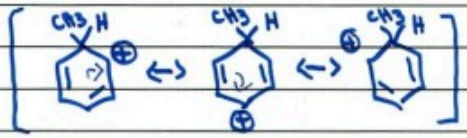
Q. No. 5 (Page 2) **b. Formation of Arenium ion:**

In this step the π-electrons of benzene ring attack on electrophile generating intermediate called arenium ion. The aromatic ring of benzene is partially broken in this ~~reaction~~ step.



benzene arenium ion.

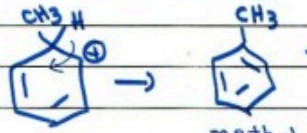
This arenium ion undergoes resonance:



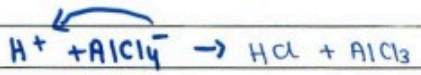
resonance-stabilised structures.

c. Regeneration of Catalyst:

In this step, base abstracts a proton from H leading to formation of methyl benzene. The aromatic ring is build again.



methyl benzene



base

(Section C)

Q. No. 5 (Page 3)

(Section C)

Q. No. 6 (Page 1) Ease of Hydrolysis:

The order of ease of hydrolysis is given as:

Acyl chloride > Alkyl chloride > Aryl chloride

- **Acyl chlorides:**

→ In acyl chlorides the hydrolysis occurs with most ease.

→ This is because in acyl chloride the carbonyl carbon group (C=O) is attached to two electronegative element Cl and O. Both of these pull electrons away from carbon atom making it highly electron deficient.

→ Thus nucleophile easily attacks on electron deficient carbon atom and hydrolysis occurs with ease.



- **Alkyl chlorides:**

→ Hydrolysis does not occur readily in alkyl chlorides.

→ This is because the carbonyl carbon (C=O) is attached to only one electronegative atom pulling electrons away. Thus this carbon is less electron deficient than carbon in acyl chloride.

→ Hence a nucleophile stronger than water is required for reaction.



A

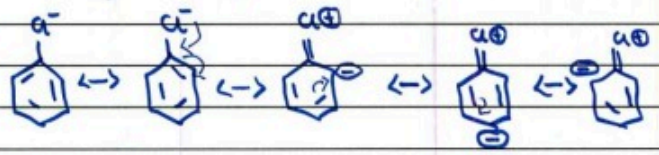
(Section C)

Q. No. 6 (Page 2) • Aryl Chlorides:

→ Hydrolysis does not occur in aryl chloride.

→ This is because the chlorine atom contains lone pairs which are involved in resonance and delocalised in the benzene ring. So they are not available for reaction.

→ The delocalisation also causes the C–Cl bond to gain partial double bond character, making the bond very strong to be broken.



→ Negative sign indicates delocalisation of lone pair of chlorine atom.

(Section C)

Q. No. 6 (Page 3)