# Chemistry (Theory) [Official]
# CISCE
# ISC (Science)
# Academic Year: 2023-2024
# Date & Time: 26th February 2024, 2:00 pm

**Duration: 3h** **Marks: 70**

1. Candidates are allowed an additional 15 minutes for only reading the paper.
2. They must NOT start writing during this time.
3. This paper is divided into four sections A, B, C and D.
4. Answer all questions.
5. Section A consists of one question having sub-parts of one mark each.
6. Section B consists of ten questions of two marks each.
7. Section C consists of seven questions of three marks each and
8. Section D consists of three questions of five marks each.
9. Internal choices have been provided in one question each in Section B, Section C and Section D.
10. All working, including rough work, should be done on the same sheet as, and adjacent to the rest of the answer.
11. The intended marks for questions or parts of questions are given in brackets [].
12. Balanced equations must be given wherever possible and diagrams where they are helpful.
13. When solving numerical problems, all essential working must be shown.
14. In working out problems, use the following data :
    Gas constant R = 1.987 cal $deg^{-1}$ $mol^{-1}$ = 8.314 $JK^{-1}mol^{-1}$ = 0.0821 $dm^3$ atm $K^{-1}$ $mol^{-1}$
    1 l. 1 atm =1 $dm^3$ atm = 101.3 J.
    1 Faraday = 96500 coulombs.
    Avogadro's number = $6.023 \times 10^{23}$

## SECTION A - 14 MARKS

**Q1.**

**1.** (a) Fill in the blanks by choosing the appropriate words(s) from those given below in the options:

**1.** (a) (i) For a particular reaction, the value of the rate constant is 0.05 $sec^{-1}$. The reaction is of _____ order and will be _____ of the initial concentration.

1. lead poisoning
2. zero
3. phosgene
4. dependent
5. cancer
6. independent
7. diethyl ether
8. first
9. ethyl carbonate
10. ethene

**Solution**

For a particular reaction, the value of the rate constant is 0.05 $sec^{-1}$. The reaction is **first** order and will be **dependent** of the initial concentration.

**1.** (a) (ii) EDTA is used in the treatment of _____ while Cis platin is used in the treatment of _____.

1. lead poisoning
2. zero
3. phosgene
4. dependent
5. cancer
6. independent

7. diethyl ether
8. first
9. ethyl carbonate
10. ethene

**Solution**

EDTA is used in the treatment of lead poisoning, while Cis platin is used in the treatment of cancer.

**1.** (a) (iii) The addition of small quantity of ethanol to chloroform prevents the formation of _____ and converts it into the harmless compound _____.

1. lead poisoning
2. zero
3. **phosgene**
4. dependent
5. cancer
6. independent
7. diethyl ether
8. first
9. **ethyl carbonate**
10. ethene

**Solution**

The addition of small quantity of ethanol to chloroform prevents the formation of **phosgene** and converts it into the harmless compound **ethyl carbonate**.

**1.** (a) (iv) The dehydration of ethyl alcohol with conc. $H_2SO_4$ at 140 °C mainly yields _____ while at 170 °C the main product formed is _____.

1. lead poisoning
2. zero
3. phosgene

4. dependent
5. cancer
6. independent
7. diethyl ether
8. first
9. ethyl carbonate
10. ethene

**Solution**

The dehydration of ethyl alcohol with conc. $H_2SO_4$ at 140 °C mainly yields **diethyl ether** while at 170 °C the main product formed is **ethene**.

**1.** (b) Select and write the correct alternative from the choices given below.

**1.** (b) (i) Which one of the following statements is correct regarding the dry cell?

(P) Zinc container acts as an anode in dry cell.

(Q) Zinc container touches the paste of $MnO_2$ and carbon.

(R) Dry cell can be charged easily.

(S) Graphite rod acts as a cathode in dry cell.

1. Only (P) and (R)
2. Only (Q) and (R)
3. Only (P) and (S)
4. Only (Q) and (S)

**Solution**

Only (P) and (S)

**Explanation:**

A dry cell consists of a zinc container acting as the negative terminal (anode) and a carbon (graphite) rod with a metal cap serving as the positive terminal (cathode). Between the positive and negative terminals, carbon particles and ammonium chloride coexist. When the cell's chemical contents are depleted, it ceases to generate

energy. The external electricity supply does not replenish these contents. As a result, the cell cannot be recharged or reused.

**1.** (b) (ii) The metal complex ion that is paramagnetic is _____.

(Atomic number of Fe = 26, Cu = 29, Co = 27 and Ni = 28)

1. $[Fe(CN)_4]^{2-}$
2. $[Co(NH_3)_6]^{3+}$
3. $[Ni(CN_4)]^{2-}$
4. **$[Cu(NH_3)_4]^{2+}$**

## Solution

The metal complex ion that is paramagnetic is **$[Cu(NH_3)_4]^{2+}$**.

## Explanation:

Paramagnetic substances have unpaired electrons, while diamagnetic substances have all electrons paired

1. $[Fe(CN)_4]^{2-}$
   Assume x is the oxidation number of Fe in given complex.
   $x + 4(-1) = -2$
   $x - 4 = -2$
   $x = -2 + 4$
   $= +2$
   Electronic configuration of Fe = $[Ar]3d^6 4s^2$
   $Fe^{+2} = [Ar]3d^6$
   All electrons are paired; hence, it is diamagnetic in nature $[Co(NH_3)_6]^{3+}$
2. Assume x is the oxidation number of Co in given complex.
   $x + 6(0) = +3$
   $x = +3$
   Electronic configuration of Co = $[Ar]\ 3d^7 4s^2$
   $Co^{+3} = [Ar]3d^6$
3. All electrons are paired; hence, it is diamagnetic $[Ni(CN_4)]^{2-}$
   Assume x is the oxidation number of Ni in the given complex.
   $x + 4(-1) = -2$
   $x - 4 = -2$

x = + 2

Electronic configuration of Ni = [Ar] $3d^8 4s^2$

$Ni^{2+}$ = $[Ar]3d^8$

4. All electrons are paired, hence, it is diamagnetic $[Cu(NH_3)_4]^{2+}$.
   Assume x is the oxidation number of Cu in the given complex.
   x + 4(0) = + 2
   x = + 2
   Electronic configuration of Cu = [Ar] $3d^{10}$ $4s^1$
   $Cu^{-2}$ = $[Ar]3d^9$
   It has one unpaired electron; hence, it is paramagnetic.

**1.** (b) (iii) When $KMnO_4$ is heated with acidified oxalic acid, gas bubbles are evolved. These gas bubbles are evolved due to the formation of _____.

1. $SO_2$
2. $CO_2$
3. $SO_3$
4. $O_2$

## Solution

When $KMnO_4$ is heated with acidified oxalic acid, gas bubbles are evolved. These gas bubbles are evolved due to the formation of **$CO_2$**.

## Explanation:

$KMnO_4$ reacts with oxalic acid according to the equation,

\[\ce{2MnO4- + 5C2O4^{2-} + 16H+ -> 2Mn^{2+} + 10CO2 + 8H2O}\]

Hence, bubbles evolved due to the formation of $CO_2$ gas.

**1.** (b) (iv) The reaction of ethanamide with alcoholic sodium hydroxide and bromine gives _____.

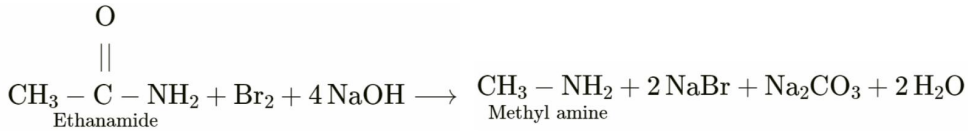
1. Ethylamine
2. Methylamine
3. Propylamine
4. Aniline

## Solution

The reaction of ethanamide with alcoholic sodium hydroxide and bromine gives **Methylamine**.

## Explanation:

When ethanamide is mixed with alcoholic sodium hydroxide and bromine, it makes methyl amine.




**1.** (b) (v) An equimolar solution of non-volatile solutes A and B shows a depression in freezing point in the ratio of 2:1. If A remains in its normal state in the solution, the state of B in the solution will be _____.

1. Normal
2. Hydrolysed
3. Associated
4. Dissociated

## Solution

An equimolar solution of non-volatile solutes A and B shows a depression in freezing point in the ratio of 2:1. If A remains in its normal state in the solution, the state of B in the solution will be **dissociated**.

## Explanation:

Since A and B are equimolar solutions of non-volatile solutes, their freezing points have decreased by a factor of two. If A is in a normal condition, then B must be dissociated, forming twice as many ions as A.

**1.** (b) (vi) **Assertion:** Specific conductivity of all electrolytes decreases on dilution.

**Reason:** On dilution, the number of ions per unit volume decreases.

1. Both Assertion and Reason are true and Reason is the correct explanation for Assertion.

2. **Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.**
3. Assertion is true but Reason is false.
4. Assertion is false but Reason is true.

**Solution**

Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.

**Explanation:**

The number of ions in a given volume determines conductivity. Both strong and weak electrolytes conductivity diminishes as concentration falls. The number of ions per unit volume that carry current in a solution falls as it is diluted. As a result, conductivity drops. As a result, both assertion and reason are true, and reason is the appropriate explanation for assertion.

**1.** (b) (vii) **Assertion:** Amimonolysis of alkyl halides involves the reaction between alkyl halides and alcoholic ammonia.

**Reason:** Ammonolysis of alkyl halides produces secondary amines only.

1. Both Assertion and Reason are true and Reason is the correct explanation for Assertion.
2. Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.
3. **Assertion is true but Reason is false.**
4. Assertion is false but Reason is true.

**Solution**

Assertion is true but Reason is false.

**Explanation:**

When an alkyl or benzyl halide combines with an ethanolic solution of ammonia, an amino ($-NH_2$) group replaces the halogen atom via a nucleophilic substitution reaction. Ammonolysis continues until all of the hydrogen in ammonia has been

replaced. As a result, a combination of primary, secondary and tertiary amines are produced. Thus, the assertion is correct, but the reasoning is incorrect.

**1.** (c) Read the passage given below and answer the questions that follow.

When two solutions are separated by a semi-permeable membrane, the solvent molecules move from a solution of lower molar concentration to a solution of higher molar concentration through osmosis.

i. Samar removed the outer hard shell of two different eggs while cooking at home. He then placed one egg in pure water and the other egg in a saturated solution of sucrose. What change is he likely to observe in the eggs after a few hours?

ii. Which solution, hypertonic or hypotonic, has a higher amount of solute in same quantity of solution?

iii. A 5% aqueous solution of glucose (molar mass = 180 g $mol^{-1}$) is isotonic with 1.66 % aqueous solution of urea. Calculate the molar mass of urea.

## Solution

i. The low concentration of solvent (water) in the egg allows it to swell after a few hours, whereas the low concentration of solvent (water) in the solution causes the other egg, which is placed in a saturated solution of sucrose, to shrink.

ii. A hypertonic solution has a higher amount of solute in the same quantity of solution.

iii. For isotonic solution, $\pi_1 = \pi_2$

$\pi_{Glucose} = C_1^{RT}$

$\pi_{Uurea} = C_2^{RT}$

For isotonic solution,

$\pi_{Glucose} = \pi_{Uurea}$

$C_1^{RT} = C_2^{RT}$

$C_1 = C_2$

$$\therefore \frac{W_1}{M_1} = \frac{W_2}{M_2}$$

$$\therefore \frac{5 \times 1000}{180 \times 100} = \frac{1.66 \times 1000}{M \times 100}$$

$M = 59.76\ g\ mol^{-1}$

Thus, the molar mass of urea will be $59.76\ g\ mol^{-1}$.

## SECTION B - 20 MARKS

**Q2.**

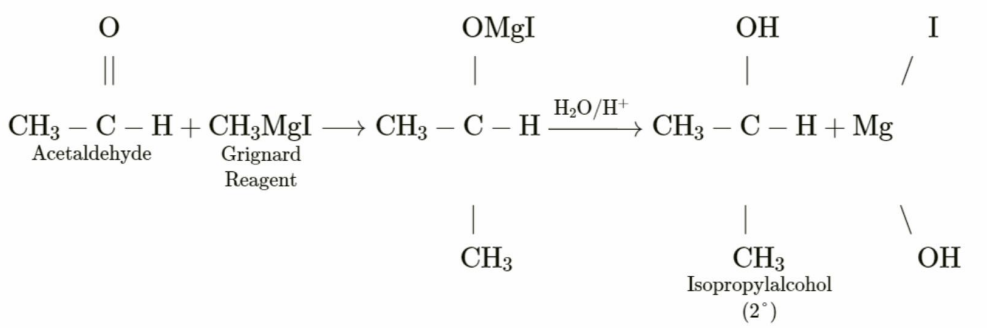
**2.** (a) Write a chemical test to distinguish between ethanol and phenol.

### Solution

Alcohol is almost neutral in nature, but phenol is slightly acidic. The ways that ethanol and phenol react with neutral $FeCl_3$ distinguish them from one another. Whereas ethanol does not react with neutral $FeCl_3$, phenol does, resulting in a green or purple solution.

**2.** (b) Give a chemical reaction to convert acetaldehyde into secondary propyl alcohol.

### Solution




**Q3.** Give a reason for each of the following:

**3.** (a) Zinc, cadmium and mercury are considered as d-block elements but not regarded as transition elements.

### Solution

Transition metals are elements that have partially filled d-orbitals. Due to the completely filled d orbitals in their ground state and a common oxidation state of +2. Zinc, cadmium and mercury are classified as d-block elements, but not as transition elements.

**3.** (b) Transition metals possess a great tendency to form complex compounds.

## Solution

Transition metals produce several coordination complexes for the reasons listed below:

a. Transition metal ions have small sizes and a high charge density.

b. The presence of vacant d-orbitals of sufficient energy that can accept lone pairs of electrons given by other groups.

**Q4.** Convert the following by giving chemical equations for each.

**4.** (a) Ethyl bromide to diethyl ether.

## Solution

The method known as Williamson synthesis forms ether by reacting an alkyl halide with sodium alkoxide.

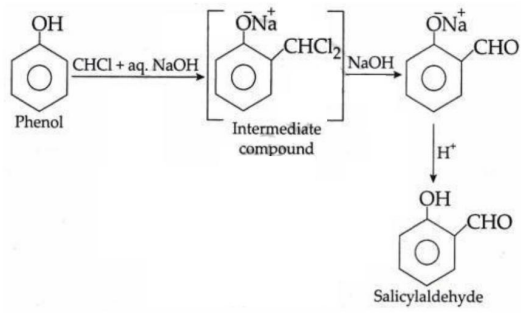
By heating ethyl bromide with sodium ethoxide, diethyl ether can be produced.

$$\underset{\text{Ethyl bromide}}{CH_3CH_2Br} + \underset{\text{Sodium ethoxide}}{CH_3CH_2ONa} \longrightarrow \underset{\text{Diethyl ether}}{CH_3CH_2OCH_2CH_3} + NaBr$$

**4.** (b) Phenol to salicylaldehyde.

## Solution

When phenol reacts with chloroform in the presence of a base, such as NaOH, salicylaldehyde is produced. The reaction is called the Reimer-Tiemann reaction.




**Q5.** Account for each of the following.

**5.** (a) Zirconium (Zr) and Hafnium (Hf) are difficult to separate.

## Solution

Zirconium (40) and hafnium (72) have the same size, possess similar characteristics and belong to the same group. These are found combined in natural minerals and are difficult to separate. As a result, lanthanide contraction makes it impossible to separate Zr and Hf.

**5.** (b) Salts of Cupric ($Cu^{2+}$) ion are coloured whereas salts of the Cuprous ($Cu^{+}$) ion are colourless.

## Solution

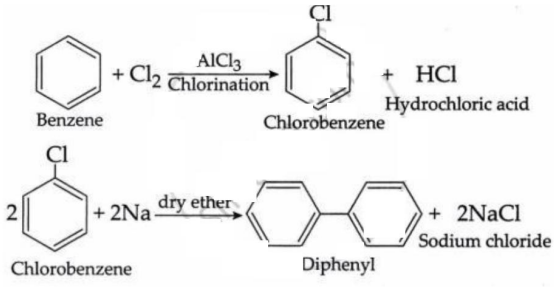
Salts of Cupric ($Cu^{2+}$) ions are coloured, whereas salts of cuprous ($Cu^{+}$) ions are colourless. This is due to the fact that the cupric ion has an incomplete d-orbital, whereas the cuprous ion has a complete one. Cuprous ions contain exactly half-filled d-orbitals, making d-d transitions impossible between them.

**Q6.** How will you bring the following conversion?

**6.** (a) Benzene to biphenyl

## Solution

Benzene is treated with chlorine in the presence of anhydrous $AlCl_3$ to produce chlorobenzene. Chlorobenzene, when treated with sodium in dry ether, forms Diphenyl by joining two aryl groups together.




**6.** (b) Iodoform to acetylene

## Solution

Two molecules of iodoform are heated with silver to form acetylene (ethyene).

$$\begin{array}{l} \quad\quad\ \ \mathrm{I} \qquad\quad \mathrm{I} \\ \quad\quad\ / \qquad\quad\ \backslash \\ \mathrm{H-C-I} + 6\,\mathrm{Ag} + \mathrm{I-C-H} \xrightarrow{\Delta} \underset{\text{Acetylene}}{\mathrm{H-C\equiv C-H}} + 6\,\mathrm{AgI} \\ \quad\quad\ \backslash \qquad\quad\ / \\ \quad\quad\ \mathrm{I} \qquad\quad \mathrm{I} \\ \quad\quad \text{Iodoform} \end{array}$$

**Q7.** Calculate the maximum possible electrical work that can be obtained from a galvanic cell under standard conditions at 298K.

$$\mathrm{Zn}|\underset{(aq)}{\mathrm{Zn}^{2+}}||\underset{(aq)}{\mathrm{Ag}^{+}}|\mathrm{Ag}$$

Given $\mathrm{E}^{\circ}_{(\mathrm{Zn}^{2}+/\mathrm{Zn})} = -0.76\,\mathrm{V};\ \mathrm{E}^{\circ}_{(\mathrm{Ag}+/\mathrm{Ag})} = +0.80\,\mathrm{V}$

## Solution

Given:

$E°_{anode}$ =−0.76V

$E°_{cathode}$ =+0.80V

To calculate: $W_{max}$

Cell equation: $Zn + 2Ag^{+} \longrightarrow Zn^{+2} + 2Ag$

n = 2

$E°_{cell} = E°_{cathode} - E°_{anode}$

= 0.80 − (− 0.76)

= + 1.56 V

Now,

$W_{electrical} = nFE°_{cell}$

= − 2 × 96500 × 1.56

= − 301080 J

Work = 301.08 KJ.

Hence, the maximum possible electrical work in a galvanic cell is 301.08 KJ.

**Q8.**

**8.** (a) Give a reason for each of the following.

**8.** (a) (i) Ethoxy ethane does not react with sodium, but ethanol does.

## Solution

Ethyl alcohol reacts with sodium metal due to the presence of an active hydrogen atom. In contrast, diethyl ether cannot react with sodium metal because it lacks a

replacement hydrogen atom.

$$\underset{\text{Ethyl alcohol}}{2\,CH_3CH_2OH} + 2\,Na \longrightarrow 2\,CH_3CH_2ONa + H_2$$

$$\underset{\text{Diethyl ether}}{(CH_3CH_2)_2O} + Na \longrightarrow \text{No reaction}$$

**8.** (a) (ii) Ethoxy ethane with conc. HI at 373 K gives $C_2H_5OH$ and $CH_3I$ but not $CH_3OH$ and $C_2H_5I$.

## Solution

At 373 K enthoxy ethane reacts with concentrated HI to produce $C_2H_5OH$ and $CH_3I$. This is due to the fact that this reaction uses a $S_N2$ mechanism, with the nucleophilic substitution taking place at the carbon linked to the ethoxy group. The iodide ion ($I^-$) from HI functions as a nucleophile, attacking the carbon atom in ethoxyethane and displacing the ethoxy group. This substitution process produces ethanol and methyl iodide.

$$\underset{\text{Ethoxy ethane}}{C_2H_5OH_5} + 2\,HI \longrightarrow \underset{\text{Ethanol}}{C_2H_5OH} + \underset{\text{Methyl iodide}}{CH_3I}$$

The absence of methanol ($CH_3OH$) and ethyl iodide ($C_2H_5I$) is most likely due to the instability of the methoxide ion ($CH_3O^-$) and the formation of ethyl carbocation ($C_2H_5^+$) as reaction intermediates.

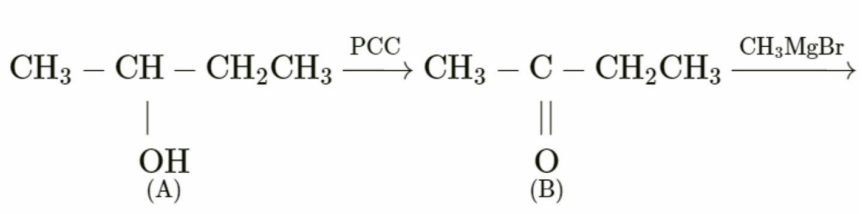
**OR**

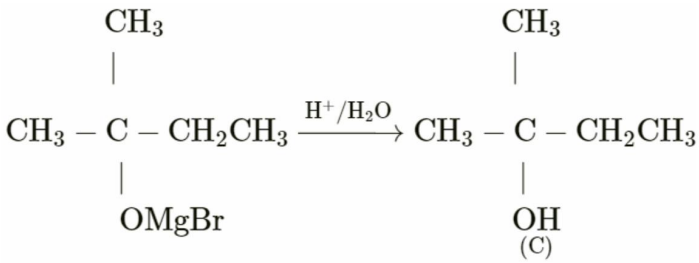
**8.** (b) An organic compound [A] having the molecular formula $C_4H_{10}O$ forms a compound [B] with the molecular formula $C_4H_8O$ on oxidation. Compound [B] gives a positive iodoform test. The reaction of compound [B] with $CH_3MgBr$ followed by hydrolysis, gives compound [C] with the molecular formula $C_5H_{12}O$. Identify the compounds [A], [B] and [C]. Write the reaction for the conversion of compound [A] to compound [B].

## Solution

Compound (B) produces a positive iodoform; hence, the test must be a methyl ketone. Butanone, $CH_3COCH_2CH_3$ is the only methyl ketone with four carbon atoms.

Butanone will be obtained by oxidising butan-2-ol. -So, chemical (A) is butan-2-ol $CH_3CH(OH)CH_2CH_3$. Butanone reacts with $CH_3MgBr$ and then hydrolyzes to produce 30 alcohol, so compound (C) is





**Q9.** If 200 $cm^3$ of an aqueous solution of a protein contains 1.26 g of protein, the osmotic pressure of the solution at 300K is found to be $2.57 \times 10^{-3}$ atm.

Calculate the molar mass of protein.

(R = 0.0821 L atm $K^{-1}$ $mol^{-1}$)

## Solution

Given:

mass of protein = 1.26 g

Volume of solution = 200 $cm^3$ = 0.20 L

R = 0.0821 L atrn $K^{-1}$ $mol^{-1}$

T = 300K

Osmatic pressure, $\pi = 2.57 \times 10^{-3}$ atrn

To calculate molar mass of protein:

$$\pi = CRT = \frac{WRT}{MV}$$

$$M = \frac{WRT}{\pi V}$$

$$= \frac{1.26 \times 0.0821 \times 300}{2.57 \times 10^{-3} \times 0.2}$$

$$= 60377 \text{ g mol}^{-1}$$

Hence, the molar mass of protein is 60377 g $mol^{-1}$.

Q10.

**10.** (a) Benzaldehyde is less reactive than propionaldehyde. Why?

Solution

When the benzene rings of benzaldehyde are connected with carbonyl carbon, the molecule's polarity decreases. Because benzene resonates, the positive charge spreads throughout the molecule. As a result, it is less reactive to nucleophile-based reactions.

In the case of propionaldehyde, polarity has an impact rather than any resonance effect. As a result, benzaldehyde's carbonyl carbon is less electrophilic than that of propionaldehyde. Thus, propionaldehyde is more reactive than benzaldehyde.

**10.** (b) In the preparation of ethanal by the oxidation of ethanol, ethanal should be removed immediately as it is formed. Why?

Solution

In the oxidation of ethanol to generate ethanal, it should be removed immediately to prevent further oxidation of ethanal to form ethanoic acid.

Q11.

**11.** (a) Why is Mn2+ ion more stable than Fe2+ ion?

(Atomic numbers of Mn = 25 and Fe = 26)

Solution

Electronic configuration of $Mn^{2+}$ = $[Ar]4s^0 3d^5$ and $Fe^{2+}$ = $[Ar]4s^0 3d^6$

$Mn^{2+}$ ions have half-filled d-orbitals, making them more stable. $Fe^{2+}$ complexes are slightly less stable since their third orbital contains six electrons.

As a result, they frequently achieve a stable $3d^5$ structure while losing one electron (from $Fe^{3+}$).

**11.** (b) Trivalent Lanthanoid ions such as $La^{3+}$ (Z = 57) and $Lu^{3+}$ (Z = 71) do not show any colour in their solution. Give a reason.

Solution

Many trivalent lanthanide ions are coloured in both solid and liquid forms because their f-orbitals are not fully filled. $Lu^{+3}$ and $La^{+3}$ are colourless in liquid form because

they do not have any unpaired electrons.

## SECTION C - 21 MARKS

**Q12.** For the reaction A+B⇌ Product, the following data was obtained.

| Experiment number | Initial conception of [A] (mol $L^{-1}$) | Initial concentration of [B] (mol $L^{-1}$) | Initial Rate (mol $L^{-1}$ $minL^{-1}$) |
|---|---|---|---|
| 1 | 0.15 | 0.15 | $9.6 \times 10^{-2}$ |
| 2 | 0.30 | 0.15 | $3.84 \times 10^{-1}$ |
| 3 | 0.15 | 0.30 | $1.92 \times 10^{-1}$ |
| 4 | 0.30 | 0.30 | $7.68 \times 10^{-1}$ |

Calculate the following:

i. The overall order of the reaction

ii. The rate law equation

iii. The value of rate constant

**Solution**

Let the rate of equation be:

Rate = $K[A]^x [B\}^y$

In experiment 1

Rate = $K[0.15]^x [0.15]^y = 9.6 \times 10^{-2}$ ...(1)

In experiment 2

Rate = $K[0.30]^x [0.15]^y = 3.84 \times 10^{-1}$ ...(2)

In experiment 3

Rate = $K[0.15]^x [0.30]^y = 1.92 \times 10^{-1}$ ...(3)

In experiment 4

Rate = $K[0.30]^x [0.30]^y = 7.68 \times 10^{-1}$ ...(4)

Dividing eq. (2) by eq. (1)

$$\frac{3.84 \times 10^{-1}}{9.6 \times 10^{-2}} = \frac{K[0.30]^x[0.15]^y}{K[0.15]^x[0.15]^y}$$

$4 = [2]^x$

$x = 2$

Thus, the order of reaction with respect to [A] is 2.

Dividing eq. (3) by eq. (1),

$$\frac{1.92 \times 10^{-1}}{9.6 \times 10^{-2}} = \frac{K[0.15]^x[0.30]^y}{K[0.15]^x[0.15]^y}$$

$2 = [2]^y$

$y = 1$

Thus, the order of reaction with respect to [B] is 1.

i. The overall order of reaction is 2 + 1 = 3

ii. The rate law equation
Rate = $K[A]^2 [B]^1$

iii. Rate constant (K)
From eq. (1),
Rate = $K[0.15]^2 [0.15]^1$
$= 9.6 \times 10^{-2}$

$$K = \frac{9.6 \times 10^{-2}}{[0.15]^2[0.15]^1}$$

$= 28.44 \text{ mol}^{-2} \text{ L}^2 \text{ min}^{-1}$

Thus, the value of the rate constant is 28.44 $\text{mol}^{-2} \text{ L}^2 \text{ min}^{-1}$.

**Q13.**

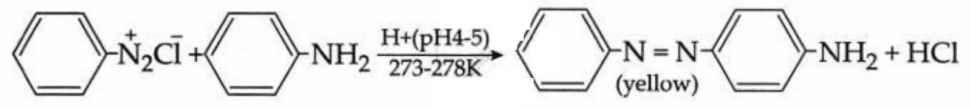
**13.** (a) Illustrate the following reaction by giving one suitable example:

**13.** (a) (i) Coupling reaction

## Solution

A coupling reaction occurs when diazonium salt reacts with phenols and aromatic amines to produce azo compounds with the general formula Ar − N = N − Ar.

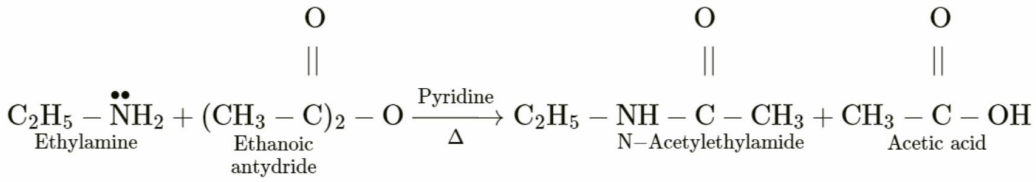
The reaction with phenol happens in a moderately alkaline medium, whereas the reaction with amines occurs in a faintly acidic environment.




**13.** (a) (ii) Acetylation of ethylamine

## Solution

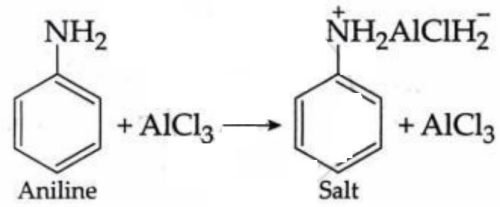
Acetylation of ethylamine entails introducing an acetyl group ($CH_3CO$) into the ethylamine molecule, leading to the synthesis of N-Acetylethylamine.




**13.** (b) Aniline does not give Friedel-Crafts reaction. Give a reason.

## Solution

Aniline does not undergo Friedel-Craft's reaction because the reaction takes place in the presence of $AlCl_3$, but $AlCl_3$ is a Lewis acid, whereas aniline is a strong basic. Thus, aniline interacts with $AlCl_3$ to produce a salt.




The positive charge on the N-atom prevents electrophilic substitution in the benzene ring. As a result, aniline does not undergo the Friedel-Craft reaction.

**Q14.**

**14.** (a) Aradhana visits a physician as she is suffering from rickets and joint pain. Which fat-soluble vitamin should the physician prescribe to her?

## Solution

Vitamin D is essential for the growth and maintenance of strong, healthy bones. Vitamin D deficiency impairs the body's capacity to regulate mineral levels, leading to an increased risk of developing rickets. Aradhana's doctor will prescribe fat-soluble vitamin D to her.

**14.** (b) Somesh put a few drops of vinegar in the milk. What change do you think he observed in the milk after some time? What is this phenomenon known as?

## Solution

When vinegar is added to heated milk, little white bits should form in the liquid. This is because adding an acid, such as vinegar, to milk alters its pH, causing the casein molecules to unfold and reorganise into a long chain, which results in curdling.

**14.** (c) Name the product of hydrolysis of sucrose. Is it a reducing sugar or a non-reducing sugar?

## Solution

Glucose and fructose. Sucrose is a non-reducing sugar.

**Q15.** An aqueous solution containing 12.50 g of barium chloride in 1000 g of water boils at 373.0834 K. Calculate the degree of dissociation of barium chloride.

Given $K_b$ for $H_2O$ = 0.52 K kg $mol^{-1}$; molecular mass of $BaCl_2$ = 208.34 g $mol^{-1}$.

## Solution

Given:

$W_{BaCl_2}$ = 12.50 g

$W_{H_2O}$ = 1000 g

$T_b$ = 373.0834 K

$K_b$ = 0.52 K kg/mol

$M_{BaCl_2}$ = 208.34 g $mol^{-1}$

To calculate, degree of dissociation (α)

$\Delta T_b$ = 373.0834 − 373

$\Delta T_b$ = 0.0834 K

$$\text{molality (m)} = \frac{\text{moles of } BaCl_2}{\text{Weight of water (kg)}}$$

$$= \frac{W_{BaCl_2}/M_{BaCl_2}}{1 \text{ Kg}}$$

$$= \frac{12.50/208.34}{1}$$

= 0.06 m

$$\Delta T_b = = iK_bm,\ i = \frac{\Delta T_b}{K_b\, m}$$

$$= \frac{0.0834}{0.52 \times 0.06}$$

= 2.67

$BaCl_2 - Ba^{+2} + 2Cl^-$

l − α  α 2α

i = 1 − α + α 2α

Putting the value of i

2.67 = 1 + 2α

2α = 1.67

α = 0.835

Therefore, the degree of dissociation of Barium chloride is 83.5%.

**Q16.** An organic compound $C_2H_4O$ gives a red precipitate when heated with Fehling solution. It also undergoes aldol condensation in the presence of dilute NaOH.

i. Identify the organic compound and write its IUPAC name.

ii. Which compound will be formed when this organic compound reacts with hydroxylamine?

iii. What is observed when the compound, referred to in subpart (i), is heated with ammonical silver nitrate?

## Solution

i. Reacting aliphatic aldehyde with Fehling solution produces a red cuprous oxide precipitate. As a result, acetaldehyde is the required organic component.
**IUPAC Name:** ethanal

ii. Ethanal reacts with hydroxylamine to form Ethanal oxime.

$$\underset{\text{Ethanal}}{CH_3CHO} + H_2NOH \longrightarrow \underset{\text{Ethanal oxime}}{CH_3 - C = NOH} + H_2O$$

iii. Aldehyde is oxidised to carboxylic acid. Silver reduces into metal, resulting in a silver mirror, indicating that the chemical is Aldehyde.

$$CH_3 - \overset{\overset{O}{\|}}{C} - H + 2\,[Ag(NH_3)_2]NO_3 + 2\,NH_4OH \longrightarrow 2\,NH_4NO_3 + RCOOH + \underset{\text{Silver mirror}}{2\,Ag\downarrow} + H_2O + 4\,NH_3$$

**Q17.**

**17.** (a)

**17.** (a) (i) Identify the compound A, B and C:

$$C_2H_5OH \xrightarrow{PCl_5} A \xrightarrow{KCN} B \xrightarrow{H_3O^+} C_2H_5COOH \xrightarrow[\Delta]{NH_3} C$$

## Solution

$$\underset{\text{Ethanal}}{C_2H_5OH} \xrightarrow{PCl_5} \underset{\substack{\text{Ethyl chloride}\\[A]}}{C_2H_5Cl} \xrightarrow{KCN} \underset{\substack{\text{Ethyl cyanide}\\[B]}}{C_2H_5CN} \xrightarrow{H_3O^+} \underset{\text{Ethanoic acid}}{C_2H_5COOH} \xrightarrow[\Delta]{NH_3} \underset{\substack{\text{Acetanamide}\\[C]}}{C_2H_5CONH_2}$$

**17.** (a) (ii) Identify the compound [A], [B] and [C] in the following reaction.

$$C_6H_5OH \xrightarrow{Zn/dust} [A] \xrightarrow[anhy \cdot AlCl_3]{CH_3Cl} [B] \xrightarrow[K_2Cr_2O_7+H_2SO_4]{[O]} [C]$$

## Solution

$$\underset{\text{Phenol}}{C_6H_5OH} \xrightarrow{Zn/dust} \underset{\substack{\text{Benzene}\\[A]}}{C_6H_6} \xrightarrow[anhy \cdot AlCl_3]{CH_3Cl} \underset{\substack{\text{Toluene}\\[B]}}{C_6H_5CH_3} \xrightarrow[K_2Cr_2O_7+H_2SO_4]{[O]} \underset{\substack{\text{Benzoic acid}\\[C]}}{C_6H_5COOH}$$

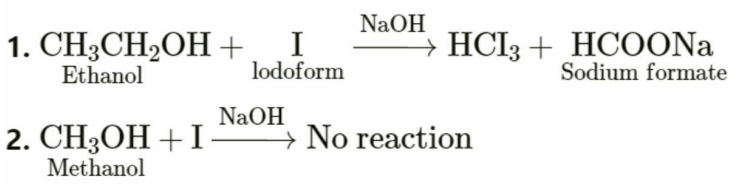
**OR**

**17.** (b) Give a chemical test to distinguish between the following pair of compound:

**17.** (b) (i) Ethanol and methanol

## Solution

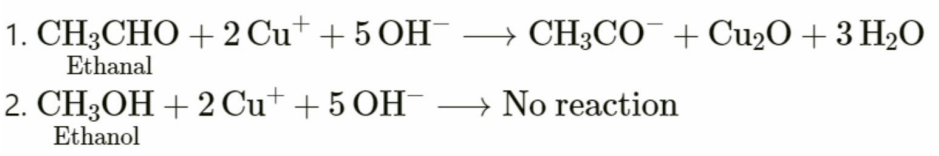
**Iodoform test:** Ethanol forms iodoform, while methanol does not.



**17.** (b) (ii) Ethanol and Ethanal

## Solution

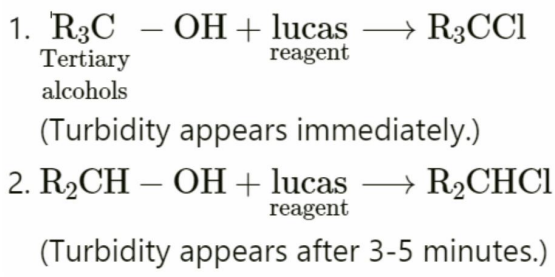
**Fehling solution:** Ethanal reacts with Fehling's solution to produce brick red ppt, when ethanol does not.



**17.** (b) (iii) Propan-2-ol and 2-methyl propan-2-ol

## Solution

**Lucas test:** 2-methylpropan-2-ol, a tertiary alcohol, produces quick turbidity when reacting with the Lucas reagent, whereas propan-2-ol does not. Turbidity after 5 minutes.



**Q18.**

**18.** (a) The rate constant of a reaction at 500K and 700K are 0.02 $sec^{-1}$ and 0.07 $sec^{-1}$ respectively. Calculate the value of $E_a$. (activation energy)

## Solution

Given, $k_1 = 0.02\ s^{-1}$; $T_1 = 500\ K$

$k_2 = 0.07\ s^{-1}$, $T_2 = 700\ K$.

The equation is,

$$\log \frac{k_2}{k_1} = \frac{E_a}{2.303 \times R}\left[\frac{(T_2 - T_1)}{T_2 \times T_1}\right]$$

Substituting the values in the equation

$$\log \frac{0.07}{0.02} = \frac{E_a}{8.314 \times 2.303\left(\text{JK}^{-1}\text{mol}^{-1}\right)700 \times 500K^2}$$

$$\frac{(700 - 500)K}{700 \times 500K^2}$$

$$\Rightarrow \log 3.5 = \frac{E_a}{19.147} \times \frac{200}{350000\left(\text{mol}^{-1}\right)}$$

$$\Rightarrow E_a = \frac{0.544 \times 19.147 \times 350000}{200}\text{J mol}^{-1} \quad \ldots[\log 3.5 = 0.544]$$

$$\therefore E_a = 18.228\ \text{kJ mol}^{-1}$$

Thus, the value of activation energy ($E_a$) is 18.228 kJ $mol^{-1}$

**18.** (b) A radioactive substance which emits alpha particle follows a first-order reaction. The half-life period of this radioactive substance is 30 hours. Calculate the fraction in percent (%) of the radioactive substance which remains after 90 hours.

## Solution

Given,

$$\text{Half life}\left(t_{\frac{1}{2}}\right) = 30\ \text{hr}$$

To calculate the fraction (in %) after 90 hr

For first-order kinetics

$$t_{\frac{1}{2}} = \frac{0.693}{\text{K}}$$

$$K = \frac{0.693}{30\text{hr}}$$

$= 0.0231\ hr^{-1}$

$$t = \frac{2.303}{K} \log \frac{[A_0]}{[A_t]}$$

$$90 = \frac{2.303}{0.0231} \log \frac{[100]}{[A_t]}$$

$$\log \frac{[100]}{[A_t]} = \frac{90 \times 0.0231}{2.303}$$

= 0.9027

$\log[100] - \log[A_t] = 0.9027$

$\log[A_t] = \log[100] - 0.9027$

= 2 − 0.9027

= 1.0973

$[A_t] = \text{antilog}_{10}\ (1.0973)$

= 12.5

Fraction = 100 − 12.5

= 87.5%

After 90 hours, 87.5% of the radioactive substance will still be present.

## SECTION D -15 MARKS

**Q19.**

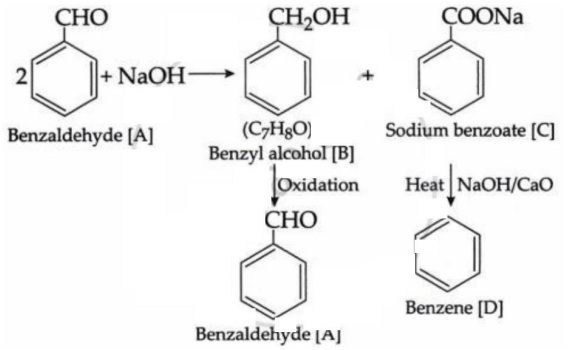
**19.** (a) An organic compound [A], having a specific smell forms two compounds [B] and [C] by reacting with conc. sodium hydroxide. The molecular formula of compound [B] is $C_7H_8O$, which forms compound [A] again on oxidation. Compound [C] forms benzene on heating with soda lime.

Write the structures of compounds [A], [B] and [C]. Also, write the reactions involved.

**Solution**

The chemical component [A] must be an aromatic aldehyde, i.e., benzaldehyde with a distinct odour. When benzaldehyde is combined with NaOH. It undergoes Cannizzaro's reaction, yielding benzyl alcohol, [B] of the formula $C_7H_8O$ and a sodium salt of benzoic acid [C]. Benzyl alcohol degrades into benzaldehyde [A] when oxidised.

When heated with soda lime, the chemical [C] produces an aromatic hydrocarbon [D], which is benzene. The enters series of reaction is as given:




**19.** (b)

**19.** (b) (i) Identify the compound [A] and [B] in the reaction given below:

$$C_6H_6 \xrightarrow[AlCl_3(anhy\cdot)]{CH_3Cl} [A] \xrightarrow[KrCr_2O_7+H_2SO_4]{[O]} [B]$$

## Solution

$$\underset{\text{Benzene}}{C_6H_6} \xrightarrow[AlCl_3(Anhy\cdot)]{CH_3Cl} \underset{\text{Toluene [A]}}{C_6H_5CH_3} \xrightarrow[KrCr_2O_7+H_2SO_4]{[O]} \underset{\text{Benzoic acid [B]}}{C_6H_5COOH}$$

**19.** (b) (ii) Identify the compound [A] and [B] in the reaction given below:

$$CH_3 - CHOH - CH_3 \xrightarrow[K_2CrO_7+H_2SO]{[O]} [A] \xrightarrow{NH_2OH} [B]$$

## Solution

$$\underset{\text{Isopropy lalcohol}}{CH_3 - CHOH - CH_3} \xrightarrow[K_2Cr_2O_7+H_2SO_4]{[O]} \underset{\substack{\text{Acetone}\\[A]}}{CH_3COCH_3} \xrightarrow{NH_2OH} \underset{\substack{\text{Acetaloxime}\\[B]}}{CH_3CHNOH}$$

**Q20.**

**20.** (a) A coordination compound has the formula $CoCl_3 \cdot 4NH_3$. It precipitates silver ions as AgCl and its molar conductance corresponds to a total of two ions.

Based on this information, answer the following question:

a. Deduce the structural formula of the complex compound.

b. Write the IUPAC name of the complex compound.

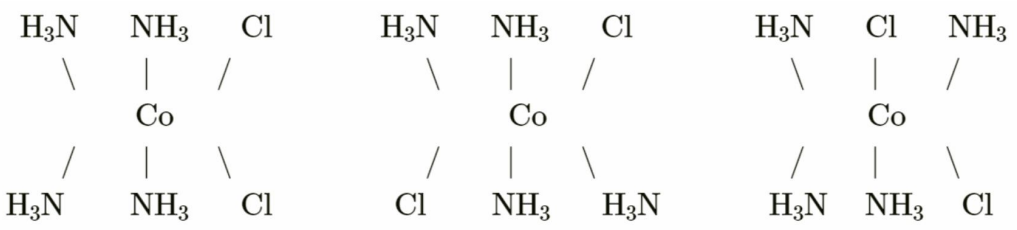
c. Draw the geometrical isomers of the complex compound.

## Solution

(a) Because just one AgCl is created, only one chloride ion is precipitated, which equals one negative ion. As a result, the structural formula for the complex will be. $[Co(NH_3)_4Cl_2]Cl$

(b) IUPAC name: tetraamminedichloridocobalt (Ill) chloride

(c) Geometrical isomers



**20.** (b) Give a chemical test to show that $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$ are ionisation isomers.

## Solution

$[Co(NH_3)5Cl]SO4$ produces a white precipitate when mixed with $BaCl_2$. This test yields no response from $[Co(NH_3)_5SO_4]Cl$. In contrast, $[Co(NH_3)_5SO_4]Cl$ produces a white precipitate in the presence of silver nitrate, whereas $[Co(NH_3)_5Cl]SO_4$ does not. These results demonstrate that $[Co(NH_3)_5Cl]$ $SO_4$ and $[Co(NH_3)5SO_4]Cl$ are ionisation isomers.

1. $[Co(NH_3)_5Cl]SO_4 \rightleftharpoons [Co(NH_3)_5Cl]^{2-} + SO_4^{2-} \downarrow \underset{\text{White ppt}\cdot}{BaSO_4}$ $BaCl_2$

   However, it does not react with $AgNO_3$

2. $[Co(NH_3)_5Cl]SO_4 \xrightarrow{AgNO_3}$ No reaction
3. $[Co(NH_3)_5SO_4]Cl \rightleftharpoons [Co(NH_3)_5SO_4]^+ + Cl^- \xrightarrow{AgNO_3} \underset{\text{White ppt}\cdot}{AgCl}$

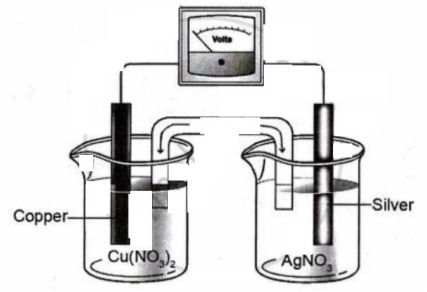
   But it does not react with the $BaCl_2$ solution

4. $Co(NH_3)_5SO_4]Cl \xrightarrow{BaCl_2}$ No reaction

**Q21.**

**21.** (a)

**21.** (a) (i) Study the diagram given below that represents Cu-Ag electrochemical cell and answer the questions that follow.




Given 2+E(Cu2+/Cu)0 = 0.337V; E(Ag+/Ag)0 = 0.799V

1. Write the cell reaction for the above cell.
2. Calculate the standard emf of the cell.
3. If the concentration of $[Cu^{2+}]$ is 0.1 M and $E_{cell}$ is 0.422 V, at 25°C, calculate the concentration of $[Ag^{+}]$.
4. Calculate ΔG for the cell.

## Solution

**1.** Anode: $Cu \longrightarrow Cu^{2+} + 2e^{-}$

Cathode: $2Ag^{+} + 2e^{-} \longrightarrow 2\ Ag$

Cell reaction: $Cu + 2\ Ag^{+} \longrightarrow Cu^{2+} + 2\ Ag$

**2.** Standard emf $(E°_{cell}) = E°_{cathode} - E°_{anode}$

= 0.799 − 0.337

= 0.462 V

**3.** $$E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{n} \log \frac{Cu^{2+}}{[Ag^{+}]^2}$$

$$0.422 = 0.462 - \frac{0.0591}{2} \log \frac{[0.1]}{[Ag^{+}]^2}$$

$$\log \frac{[0.1]}{[Ag^{+}]^2} = \frac{(0.462 - 0.422)}{0.0591} \times 2$$

= 1.35

$\log[0.1] - 2\log[Ag^{+}] = 1.35$

$-1 - 2\log [Ag^+] = 1.35$

$2\log [Ag^+] = -1 - 1.35 = -2.35$

$\log [Ag^+] = -1.125$

$[Ag^+] = 7.5 \times 10^{-2}$ M

**4.** $\Delta G = -nFE_{cel}$

$= -2 \times 96500 \times 0.422$

$= 81446$ J mol$^{-1}$

$= 81.446$ kJ mol$^{-1}$

**21.** (a) (ii)

Calculate $\wedge_m^0 BaCl_2$ and $Al_2(SO_4)$ from the following data.

For $\wedge_m^0 Ba^{2+} = 127.2\,S\,cm^2\,mol^{-1}$, $\wedge_m^0 Al^{3+} = 189\,S\,cm^2\,mol^{-1}$

$\wedge_m^0 Cl = 76.3\,S\,cm^2\,mol^{-1}$, $\wedge_m^0 SO_4^{2-} = 160\,S\,cm^2\,mol^{-1}$

**Solution**

$$\wedge_m^0 (BaCl_2) = \wedge_m^0 (Ba^{+2}) + 2 \wedge_m^0 (Cl^-)$$

$= 127.2 + 2 \times 76.3$

$= 279.8$ S cm$^2$ mol$^{-1}$

$$\wedge_m^0 (Al_2(SO_4)_3) = 2 \wedge_m^0 (Al^{+3}) + 3 \wedge_m^0 (SO_4^{2-})$$

$= 2 \times 189 + 3 \times 160$

$= 858$ S cm$^2$ mol$^{-1}$

**OR**

**21.** (b)

**21.** (b) (i) A 0.05 M $NH_4OH$ solution offers the resistance of 30.8 ohms to a conductivity cell at 298K. If the cell constant is 0.343 cm$^{-1}$ and the molar conductance of $NH_4OH$ at infinite dilution is 471.4 S cm$^2$ mol$^{-1}$, calculate the following:

1. Specific conductance
2. Molar conductance

3. Degree of dissociation

**Solution**

Given:

Molarity (M) = 0.05 M

Resistance = 30.8 Ω

Cell constant = 0.343 $cm^{-1}$

Molar conductance $\pi_m^\infty$ = 471.4 s $cm^2$ $mol^{-1}$

**(1)** Specific conductance (K)

$$= \frac{1}{R} \times \text{cell constant}$$

$$= \frac{1}{30.8} \times 0.343$$

$$= 0.011 \Omega^{-1}\ cm^{-1}$$

**(2)** Molar conductance ($\pi_m$)

$$\pi = \frac{K \times 1000}{M}$$

$$= \frac{0.011 \times 1000}{0.05}$$

$$= 220\ \Omega^{-1}\ cm^2/mol$$

**(3)** Degree of dissociation ($\alpha$)

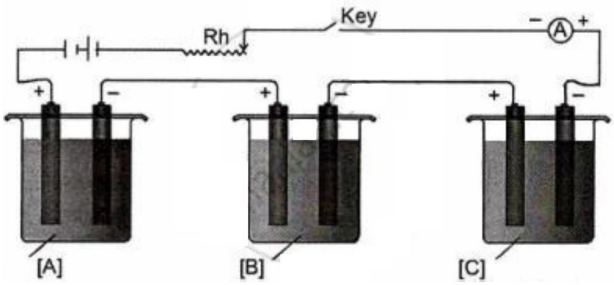
$$\alpha = \frac{\pi_m}{\pi_m^\infty}$$

$$= \frac{220}{471.4}$$

$$= 0.47$$

**21.** (b) (ii) In the diagram of the electrolytic cell given below, A, B and C are connected in series having electrolytes of $ZnSO_4$, $AgNO_3$ and $CuSO_4$, respectively.

A steady current of 1.5 A was passed until 1.45 g of Ag was deposited at the cathode of cell B.




(Atomic mass of Ag = 108, Cu = 63.5, Zn = 65.3)

Answer the following questions:

1. How long did the current flow?
2. What weight of Cu and Zn was deposited at the cathode?

## Solution

**(1)** Cell B

At Cathode$-Ag^{+} + e^{-} \longrightarrow Ag(s)$

96500 C of current deposits 1 mole (108 g) of Ag.

1295.6 C of current will deposit 1.45 g of Ag.

Now, Q = it

$1295.6 = 1.5 \times t$

t = 863.7 s

The current will flow for 863.7 seconds.

**(2)** Cell A

$Zn^{+2} + 2e^{-} \longrightarrow Zn(s)$

2 moles of current deposits 65.3 g of Zn and 1295.6 C of current will deposit 0.438 g of Zn.

Cell C

$Cu^{+2} + 2e^{-} \longrightarrow Cu(s)$

2 moles of current deposit 63.5 g of Cu, while 1295.6 C deposits 0.426 g of Cu.