CAREERS360

PRACTICE Series

UP Board Class 12

Chemistry

Previous Year Questions with Detailed Solution

UP Board Class 12 Chemistry Question with Solution- 2024

1. Four alternatives are given in each part of this question. Write the correct alternative in your answer-book.

(a) 5 g NaOH is dissolved in 450 mL solution. Molarity of the solution is :

(i) $0 \cdot 125 \text{ mol L}^{-1}$

(ii) 0.139 mol L^{-1}

(iii) 0.250 mol L^{-1}

(iv) 0.278 mol L^{-1}

Answer:

5 g of NaOH is dissolved in 450 mL solution.
1. Molecular weight of $\text{NaOH} = 40 \text{ g/mol}$
2. Moles of $\text{NaOH} = \frac{5}{40} = 0.125 \text{ mol}$
3. Molarity $= \frac{0.125 \text{ mol}}{0.450 \text{ L}} = 0.278 \text{ mol/L}$

Correct alternative: (iv) 0.278 mol/L

(b) The oxidation number of Cobalt in $K_3\left[Co(C_2O_4)_3\right]$ complex is :

(i) 1

(ii) 2

(iii) 3

(iv) 6

Answer:

The charge on the complex ion is neutral. The oxalate ion $C_2O_4^{2-}$ has a - 2 charge, and since there are three oxalate ions:

$$x + 3(-2) + 3(+1) = 0$$
$$x = +3$$

Correct alternative: (iii) 3

(c) The transition element in which variable oxidation state in not found, is :

(i) Sc

(ii) Ti

(iii) V

(iv) Cr

Answer:

Scandium (Sc) shows only a +3 oxidation state.

Correct alternative: (i) Sc

(d) The compound having most basic strength is :

(i) $(CH_3)_2NH$

(ii) CH_3NH_2

(iii) $(CH_3)_3N$

(iv) NH_3

Answer:

Dimethylamine $(CH_3)_2NH$ is the most basic due to the electron-donating effects of two methyl groups.

Correct alternative: (i) $(CH_3)_2NH$

(e) The compound which is not a disaccharide is:

(i) Sucrose

(ii) Cellulose

(iii) Lactose.

(iv) Maltose

Answer:

Cellulose is a polysaccharide, not a disaccharide.

Correct alternative: (ii) Cellulose

(f) Which of the following compound is identified by Tollen's Reagent?

(i) Alcohol

(ii) Aldehyde .

(iii) Ketone

(iv) Carboxylic acid

Answer:

Tollen's reagent is used to identify aldehydes.

Correct alternative: (ii) Aldehyde

(a) 30 g Ethylene glycol $(C_2H_6O_2)$ was mixed in 450 g water. Calculate the following :

(i) Depression in freezing point of solution

(ii) Freezing point of solution

Answer:

(a) Depression in Freezing Point of Ethylene Glycol Solution

Given:
- Mass of ethylene glycol $C_2H_6O_2 = 30 \mathrm{~g}$
- Mass of water $= 450 \mathrm{~g}$
- Molar mass of ethylene glycol $= 62 \mathrm{~g/mol}$

1. Moles of ethylene glycol:

$$\text{Moles of ethylene glycol } = \frac{30}{62} = 0.484 \mathrm{~mol}$$

2. Molality (m) :

$$\text{Molality } = \frac{0.484 \mathrm{~mol}}{0.450 \mathrm{~kg}} = 1.075 \mathrm{~mol/kg}$$

3. Depression in freezing point ΔT_f :

$\Delta T_f = K_f \times m$
For water, $K_f = 1.86^{\circ}\mathrm{C/mol/kg}$:

$\Delta T_f = 1.86 \times 1.075 = 2.00^{\circ}\mathrm{C}$

4. Freezing point of solution: The freezing point of pure water is $0^{\circ}\mathrm{C}$. So the freezing point of the solution is:

Freezing point of solution $= 0^{\circ}\mathrm{C} - 2.00^{\circ}\mathrm{C} = -2.00^{\circ}\mathrm{C}$

(b) Define the following :

(i) Mole fraction

(ii) Molality

Answer:

- **Mole Fraction:** Mole fraction is the ratio of the moles of one component to the total number of moles of all components in the solution.
- **Molality:** Molality is the number of moles of solute per kilogram of solvent.

(c) What is Lanthanoid Contraction ? Discuss the effect of Lanthanoid Contraction.

Answer:

- **Lanthanoid Contraction** refers to the gradual decrease in the ionic radii of the lanthanoids (from La to Lu) due to the ineffective shielding of nuclear charge by the 4f-electrons.
- **Effects of Lanthanoid Contraction:**

1. It leads to a reduction in atomic and ionic radii across the period.

2. It causes similarities in the properties of the second and third transition series.
3. It increases the hardness and high melting points of the compounds of later lanthanoids.

(d) Show the structure of geometrical isomers of $[Fe(NH_3)_2(CN/)]^-$.

Answer:

(d) Geometrical Isomers of $[Fe(NH_3)_2(CN)_4]^-$
- cis-isomer: The two NH_3 ligands are adjacent to each other.
- trans-isomer: The two NH_3 ligands are opposite each other.

These two configurations result from different spatial arrangements of the ligands around the central metal ion.

3. (a) Recognise all the possible monochloro structural isomers formed by free radical chlorination of $CH_3 - CH_2 - CH_2 - CH_3$.

Answer:

Possible Monochloro Isomers from Free Radical Chlorination of Butane $CH_3 - CH_2 - CH_2 - CH_3$

Free radical chlorination can occur at any of the hydrogen atoms in the butane molecule. Butane has two distinct types of hydrogen atoms:
- Primary hydrogens (attached to CH_3 groups)
- Secondary hydrogens (attached to CH_2 groups)

The possible monochloro structural isomers are:
1. 1-chlorobutane (chlorination at a primary hydrogen)
2. 2-chlorobutane (chlorination at a secondary hydrogen)

Thus, the two possible monochloro structural isomers are 1-chlorobutane and 2-chlorobutane.

(b) Phenol shows acidic properties but ethanol is almost neutral. Explain with reason.

Answer:

Phenol C_6H_5OH is acidic because the phenoxide ion $C_6H_5O^-$ formed after losing a proton is stabilized by resonance in the aromatic ring. This delocalization of the negative charge makes phenol more likely to donate a proton.

3. Ethanol CH_3CH_2OH is almost neutral because the ethoxide ion $CH_3CH_2O^-$ formed after losing a proton is not resonance-stabilized, making it less likely to lose a proton. The electrondonating alkyl group also increases the electron density on oxygen, making ethanol a weaker acid compared to phenol.

(c) Differentiate between the following :

(i) Acetaldehyde and Acetone

(ii) Acetophenone and Benzophenone

(d) What is the difference between nucleoside and nucleotide ? Explain.

Answer:

(i) Acetaldehyde CH_3CHO and Acetone CH_3COCH_3
1. Functional group:
- Acetaldehyde is an aldehyde (functional group - CHO).
- Acetone is a ketone (functional group -CO).
2. Chemical properties:
- Acetaldehyde can be easily oxidized to acetic acid.
- Acetone is less reactive towards oxidation compared to aldehydes.
3. Boiling point:
- Acetaldehyde has a lower boiling point than acetone because aldehydes form fewer hydrogen bonds compared to ketones.
(ii) Acetophenone $C_6H_5COCH_3$ and Benzophenone $C_6H_5COC_6H_5$
1. Structure:
- Acetophenone has a methyl group CH_3 attached to the carbonyl group.
- Benzophenone has two phenyl groups C_6H_5 attached to the carbonyl group.
2. Reactivity:
- Acetophenone is more reactive towards nucleophilic addition reactions than benzophenone due to the electron- $\downarrow$ nating nature of the methyl group.

3. (d) Difference Between Nucleoside and Nucleotide
1. Nucleoside:

A nucleoside consists of two components:
- A nitrogenous base (either a purine or pyrimidine)
- A sugar molecule (either ribose or deoxyribose)
2. Nucleotide:

A nucleotide is a nucleoside with an additional phosphate group attached to the sugar. Thus, a nucleotide has three components:
- A nitrogenous base
- A sugar molecule
- One or more phosphate groups

4. (a) Define solution. In how many different ways may the concentration of a solution be expressed? Explain.

Answer:

(a) Definition of Solution and Ways to Express Concentration

- **Solution:** A homogeneous mixture of two or more substances, where one substance (solute) is dissolved in another (solvent).

  The concentration of a solution can be expressed in various ways:

1. **Molarity (M):** Number of moles of solute per liter of solution.
2. **Molality (m):** Number of moles of solute per kilogram of solvent.
3. **Normality (N):** Number of gram equivalents of solute per liter of solution.
4. **Weight/Volume Percent (w/v):** Mass of solute per 100 mL of solution.
5. **Weight/Weight Percent (w/w):** Mass of solute per 100 g of solution.
6. **Volume/Volume Percent (v/v):** Volume of solute per 100 mL of solution.
7. **Mole Fraction (χ):** The ratio of the moles of a solute to the total moles of all components in the solution

(b) Define the conductance and molar conductance of a solution of any electrolyte. Discuss their variation with concentration.

Answer:

1. Conductance:

Conductance (G) is the reciprocal of resistance (R) and is the ability of a solution to conduct electric current. It is measured in Siemens (S).
2. Molar Conductance:

Molar conductance Λ_m is the conductance of all the ions present in one mole of an electrolyte dissolved in a given volume of solution. It is related to the concentration of the solution and is expressed as:

$\Lambda_m=\frac{\text{Conductance}}{\text{Molar concentration}}$
Variation with concentration:
- As concentration decreases, molar conductance increases due to the increased mobility of ions in dilute solutions.

A first-order reaction is one where the rate of reaction depends linearly on the concentration of one reactant. The rate equation for a first-order reaction is:

$$\text{Rate }=k[A]$$

where k is the rate constant and $[A]$ is the concentration of the reactant.

For a first-order reaction:

$\ln \left(\frac{[A_0]}{[A]}\right)=kt$
Given:
- Initial concentration $[A_0]=0.6 \mathrm{~mol}/\mathrm{L}$
- Final concentration $[A]=0.4 \mathrm{~mol}/\mathrm{L}$
- Time taken $=5$ minutes

From the first-order equation:

$\ln \left(\frac{0.6}{0.4}\right)=k \times 5$

Solving for k :

$k=\frac{\ln (1.5)}{5}=0.0811 \mathrm{~min}^{-1}$
To find the time for the concentration to reach $0.3 \mathrm{~mol}/\mathrm{L}$:

$$\ln \left(\frac{0.6}{0.3}\right)=0.0811 \times t$$
$$\ln (2)=0.0811 \times t$$
$$t=\frac{\ln (2)}{0.0811}=8.55 \mathrm{~min}$$
Thus, the time required to reach $0.3 \mathrm{~mol}/\mathrm{L}$ is 8.55 minutes.

(c) What do you understand by first order reaction? The time taken in becoming $0.4 \mathrm{~mol} \mathrm{~L}^{-1}$ from initial concentration of $0.6 \mathrm{~mol} \mathrm{~L}^{-1}$ is 5 minutes in a first order reaction. How much time will be required for the initial concentration to reach $0.3 \mathrm{~mol} \mathrm{~L}^{-1}$?

(d) Describe with reason:

(i) Fe^{2+} is a reducing agent while Mn^{2+} is an oxidising agent.

(ii) $\mathrm{Sc}(\mathrm{Z}=21)$ is a transition element but $\mathrm{Zn}(\mathrm{Z}=30)$ is not.

(iii) Transition elements and their compounds work as good catalysts.

Answer:

(i) Fe^{2+} is a Reducing Agent and Mn^{2+} is an Oxidizing Agent
- Fe^{2+} as a reducing agent:
Fe^{2+} can lose an electron to form Fe^{3+}, making it a good reducing agent.
- Mn^{2+} as an oxidizing agent:
Mn^{2+} is stable but can be further oxidized to Mn^{7+} (in permanganate MnO_4^{-}), making it an oxidizing agent.
(ii) Sc is a Transition Element but Zn is Not
- Scandium $(Z=21)$ has an incomplete 3d orbital, which qualifies it as a transition element.
- Zinc $(Z=30)$ has a completely filled 3 d subshell $\left(3 d^{10}\right)$, so it is not considered a transition element.
(iii) Transition Elements and Their Compounds as Catalysts

Transition elements and their compounds are good catalysts because:
- They can exhibit variable oxidation states, facilitating the exchange of electrons in catalytic reactions.
- Their surface properties allow them to adsorb reactants, which aids in catalysis.

5. (a) (i) Cu (s) does not dissolve in HCl . Why ?

(ii) Can you keep copper sulphate solution in a vessel of zine? Explain with reason.

Answer:

(i) Why Cu (s) does not dissolve in HCl ?

Copper (Cu) is a less reactive metal and is located below hydrogen in the electrochemical series. Since HCl is not a strong enough oxidizing agent, it cannot oxidize Cu to Cu^{2+} ions. As a result, Cu does not dissolve in HCl because there is no reaction to displace hydrogen ions from HCl .
(ii) Can you keep copper sulfate solution in a vessel made of zinc?

Yes, you can keep copper sulfate solution in a zinc vessel, but a reaction will occur. Zinc is more reactive than copper, so it will displace copper from the solution. The reaction is as follows:

$\mathrm{Zn}(\mathrm{~s})+\mathrm{CuSO}_4(\mathrm{aq}) \rightarrow \mathrm{ZnSO}_4(\mathrm{aq})+\mathrm{Cu}(\mathrm{~s})$
Zinc dissolves, and copper precipitates out. This is because zinc is higher than copper in the reactivity series.

(b) What is Activation Energy ? At 600 K , on decomposition of ethyl iodide by following first order reaction, the velocity constant is $1.60 \times 10^{-5} \mathrm{~s}^{-1}$. Activation Energy of this reaction is $209 \mathrm{~kJ} / \mathrm{mole}$. Calculate velocity constant at 700 K temperature.

$C_2H_5I(g) \longrightarrow C_2H_4(g) + HI(g)$

Answer:

Activation Energy is the minimum energy required for a chemical reaction to occur. It is the energy barrier that reactants must overcome to form products.

For the reaction $C_2H_5I(g) \rightarrow C_2H_4(g) + HI(g)$, the velocity constant k at 700 K can be calculated using the Arrhenius equation:

$$k_2 = k_1 \exp\left[\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right]$$

Given:
- $k_1 = 1.60 \times 10^{-5}\ s^{-1}$ at $T_1 = 600\ K$
- $E_a = 209\ kJ/mol = 209 \times 10^3\ J/mol$
- $T_2 = 700\ K$
- $R = 8.314\ J/mol.K$

Let's calculate k_2 :

$$k_2 = 1.60 \times 10^{-5} \exp\left[\frac{209\times10^3}{8.314}\left(\frac{1}{600} - \frac{1}{700}\right)\right]$$

Simplifying the term in the exponent:

$$\frac{209\times}{8.314}7^{2^3} = 25141.1$$

Simplifying the term in the exponent:

$$\frac{209 \times 10^3}{8.314} = 25141.1$$

$$\frac{1}{600} - \frac{1}{700} = 0.001666 - 0.001428 = 0.000238$$

$$k_2 = 1.60 \times 10^{-5} \times \exp(25141.1 \times 0.000238)$$

$$k_2 = 1.60 \times 10^{-5} \times \exp(5.985)$$

$$k_2 = 1.60 \times 10^{-5} \times 397.6$$

$$k_2 = 6.36 \times 10^{-3}\ s^{-1}$$

(c) (i) Solution of $[Ni(H_2O)_6]^{2+}$ is green, but solution of $[Ni(CN)_4]^{2-}$ is colourless. Explain.

Answer:

The color of transition metal complexes is due to d-d electronic transitions. In $[Ni(H_2O)_6]^{2+}$, water is a weak field ligand, so the splitting of d-orbitals is small, allowing d-d transitions to absorb visible light, resulting in a green color.

In $[Ni(CN)_4]^{2-}$, cyanide is a strong field ligand that causes large splitting of d-orbitals, so $d-d$ transitions require higher energy than visible light. As a result, the complex appears colorless because no visible light is absorbed.

(ii) Why is $[Cr(NH_3)_6]^{3+}$ paramagnetic, while $[Ni(CN)_4]^{2-}$ is diamagnetic?

- $[Cr(NH_3)_6]^{3+}$ is paramagnetic because chromium has a $3d^3$ configuration, and the presence of

three unpaired electrons leads to paramagnetism.
- $[Ni(CN)_4]^{2-}$ is diamagnetic because nickel in this complex has a $3d^{10}$ configuration, with all electrons paired, resulting in no net magnetic moment.

(ii) $[Cr(NH_3)_6]^{3+}$ is paramagnetic, while $[Ni(CN)_4]^{2-}$ is diamagnetic. Explain.

Answer:

(ii) Why is $[Cr(NH_3)_6]^{3+}$ paramagnetic, while $[Ni(CN)_4]^{2-}$ is diamagnetic?
- $[Cr(NH_3)_6]^{3+}$ is paramagnetic because chromium has a $3d^3$ configuration, and the presence of three unpaired electrons leads to paramagnetism.
- $[Ni(CN)_4]^{2-}$ is diamagnetic because nickel in this complex has a $3d^{10}$ configuration, with all electrons paired, resulting in no net magnetic moment.

(d) Write the structural formula of fructose. Write chemical equations of three chemical properties of glucose.

Answer:

(i) Structural Formula of Fructose:

Fructose is a ketohexose with the following structure:
Fructose: $HOCH_2(CHOH)_3COCH_2OH$
(ii) Three Chemical Properties of Glucose:
1. Reduction of Tollens' Reagent:

$$C_6H_{12}O_6 + 2Ag(NH_3)_2^+ + 2OH^- \rightarrow C_6H_{12}O_7 + 2Ag + 2NH_3 + H_2O$$
Glucose reduces Tollens' reagent to metallic silver.
2. Reaction with Bromine Water (Mild Oxidation):

$$C_6H_{12}O_6 + Br_2 + H_2O \rightarrow C_6H_{12}O_7 + 2HBr$$
Glucose is oxidized to gluconic acid by bromine water.
3. Fermentation:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$
Glucose undergoes fermentation to form ethanol and carbon dioxide.

6. (a) What happens when :

(Give chemical equations only)

(i) Ethyl bromide reacts with sodium ethoxide?

(ii) Chlorobenzene reacts with nitric acid?

(iii) Chlorobenzene is heated at 623 K and 300 atmospheric pressure with aqueous sodium hydroxide?

(iv) Chlorobenzene reacts with sulphuric acid?

(v) Ethyl chloride is heated with aqueous KOH ?

Answer:

(i) Ethyl bromide reacts with sodium ethoxide:

This is an example of the Williamson ether synthesis:

$$C_2H_5Br + C_2H_5ONa \rightarrow C_2H_5OC_2H_5 + NaBr$$

Ethyl bromide reacts with sodium ethoxide to form diethyl ether.

(ii) Chlorobenzene reacts with nitric acid:

$$C_6H_5Cl + HNO_3 \rightarrow C_6H_4\left(NO_2\right)Cl + H_2O$$

Chlorobenzene reacts with nitric acid to form nitrochlorobenzene.

(iii) Chlorobenzene is heated with aqueous sodium hydroxide ($623\ K, 300\ atm$):

$$C_6H_5Cl + 2NaOH \rightarrow C_6H_5ONa + NaCl + H_2O$$

Chlorobenzene reacts with NaOH under extreme conditions to form sodium phenoxide.

(iv) Chlorobenzene reacts with sulfuric acid:

$$C_6H_5Cl + H_2SO_4 \rightarrow C_6H_5SO_3H + HCl$$

Chlorobenzene reacts with sulfuric acid to fr $\downarrow'$ benzenesulfonic acid.

(v) Ethyl chloride heated with aqueous KOH :

$$C_2H_5Cl + KOH(aq) \rightarrow C_2H_5OH + KCl$$

Ethyl chloride reacts with aqueous KOH to form ethanol.

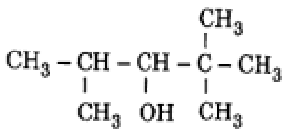
6. What is electrophilic substitution reaction? Explain with chemical equation the reactions of electrophilic substitution reactions of halogenation,

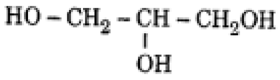
Answer:

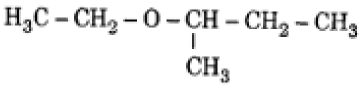
An electrophilic substitution reaction occurs when an electrophile replaces a hydrogen atom in an aromatic compound, such as benzene. In halogenation, a halogen like chlorine or bromine reacts with benzene in the presence of a catalyst (like $FeCl_3$ or $FeBr_3$), generating the electrophile Cl^+or Br^+. The electrophile attacks the π-electron-rich benzene ring, forming an intermediate carbocation (sigma complex). The reaction concludes with the release of a proton H^+, restoring aromaticity. For example, chlorination of benzene yields chlorobenzene and HCl :

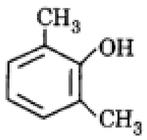
$$C_6H_6 + Cl_2 \xrightarrow{FeCl_3} C_6H_5Cl + HCl$$

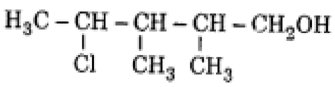
(b) Write IUPAC name of the following compounds :

(i) 

(ii) 

(iii) 

(iv) 

(v) 

The structure shows a compound with four carbon atoms in the main chain and hydroxyl groups attached at positions 2 and 3 :
- The longest chain has four carbon atoms, so the root name is butane.
- There are methyl groups attached at positions 2 and 3 .
- Hydroxyl groups are attached at positions 2 and 3.

IUPAC Name:
2,3-Dimethyl-2,3-butanediol
(ii)

This compound has three carbon atoms with hydroxyl groups attached at the 1st and 3rd carbon atoms:
- The longest chain is three carbons long, so the root name is propane.
- Two hydroxyl groups are attached, at positions 1 and 3.

IUPAC Name:
Propane-1,3-diol

(iii)

This is an ether with a three-carbon chain on one side and a two-carbon chain on the other:
- The longest chain is three carbons, so the root name is propane.
- The ethoxy group $(-OCH_2CH_3)$ is attached at the 1st carbon.

IUPAC Name:
1-Ethoxypropane
(iv)

This is a benzene ring with two substituents, a hydroxyl group (-OH) and a methyl group $(-CH_3)$:
- The hydroxyl group is given priority in naming.
- The methyl group is at the 4 th position relative to the hydroxyl group.

IUPAC Name:
4-Methylphenol (also known as p-cresol)

(v)

The structure shows a six-carbon chain with two chlorine atoms and one hydroxyl group:
- The longest chain has six carbons, so the root name is hexane.
- There are chlorine atoms at positions 1 and 3 .
- There is a hydroxyl group at position 6.

IUPAC Name:
1,3-Dichloro-6-hexanol

7 a) A carboxylic acid 'B' and an alcohol 'C' was obtained after hydrolysis of an organic compound ' A ' (molecular formula $\left(C_8H_{16}O_2\right)$ with dilute sulphuric acid. 'B' is produced on oxidation of ' C ' with chromic acid. But-1-ene is obtained on dehydration of ' C '.

Identify ' A ', ' B ' and ' C. Write chemical equations for all the reactions involved.

Answer:

Step 1: Hydrolysis of Compound 'A'
- The molecular formula of compound 'A' is $C_8H_{16}O_2$, which suggests that it could be an ester because esters hydrolyze to produce a carboxylic acid and an alcohol.
- Upon hydrolysis with dilute sulfuric acid, 'A' gives a carboxylic acid ' B ' and an alcohol ' C '.

Step 2: Oxidation of Alcohol ' C'
- ' C ' is the alcohol obtained from the hydrolysis of ' A '.
- ' B ' is formed from the oxidation of ' C ' with chromic acid (a strong oxidizing agent). Since alcohols are oxidized to carboxylic acids, this suggests that ' C ' is a primary alcohol.

Step 3: Dehydration of Alcohol 'C'
- When ' C ' undergoes dehydration, but-1-ene is produced. This indicates that ' C ' is butan-1-ol $\left(CH_3CH_2CH_2CH_2OH\right)$, because upon dehydration, butan-1-ol forms but-1-ene.

Step 4: Conclusion on Compounds 'A', 'B', and 'C'
- The alcohol ' C ' is identified as butan-1-ol $\left(CH_3CH_2CH_2CH_2OH\right)$.
- ' B ' is the carboxylic acid formed from the oxidation of ' C ', which is butanoic acid ($CH_3CH_2CH_2COOH$).
- ' A ' is an ester formed from ' B' (butanoir $\downarrow \mathrm{d}$) and ' C' (butan-1-ol). Thus, ' A ' is butyl butanoate $\left(CH_3CH_2CH_2COOCH_2CH_2CH_2CH_3\right)$.

b) Write short notes on the following :
(i) Carbylamine reaction
(ii) Diazotization
(iii) Gabriel Phthalimide Synthesis

Answer:

(i) Carbylamine Reaction

The Carbylamine Reaction is a chemical test used to detect primary amines (both aliphatic and aromatic). In this reaction, a primary amine reacts with chloroform $\left(CHCl_3\right)$ and alcoholic potassium hydroxide (KOH) to produce an isocyanide (carbylamine), which has a very foul smell. This reaction is only applicable for primary amines; secondary and tertiary amines do not give this reaction.

Reaction:

$$R-NH_2+CHCl_3+3KOH \rightarrow R-NC+3KCl+3H_2O$$

Example:

$$C_6H_5NH_2+CHCl_3+3KOH \rightarrow C_6H_5NC+3KCl+3H_2O$$

(Aniline reacts to form phenyl isocyanide.)

(ii) Diazotization

Diazotization is the process of converting a primary aromatic amine into a diazonium salt using nitrous acid (HNO_2), which is typically generated in situ from sodium nitrite $(NaNO_2)$ and a strong acid like hydrochloric acid (HCl). The reaction takes place at low temperatures $(0-5^{\circ}C)$ to stabilize the diazonium salt.

Reaction:

$$Ar-NH_2+HNO_2+HCl \rightarrow Ar-N_2^+Cl^-+2H_2O$$

Example:

$$C_6H_5NH_2+HNO_2+HCl \rightarrow C_6H_5\ N_2^+Cl^-+2H_2O$$

(Aniline reacts to form benzenediazonium chloride.)

Diazonium salts are highly useful intermediates in the synthesis of various aromatic compounds through reactions such as Sandmeyer reaction, coupling reactions, etc.

(iii) Gabriel Phthalimide Synthesis

The Gabriel Phthalimide Synthesis is a method used to synthesize primary amines, particularly aliphatic primary amines, without producing secondary or tertiary amines as by-products. In this method, potassium phthalimide is reacted with an alkyl halide to form an N -alkylphthalimide, which is then hydrolyzed (or subjected to hydrazinolysis) to release the primary amine.

Reaction:

1. Alkylation:

$$\text{Phthalimide }+R-X \rightarrow \text{ N}-\text{ alkylphthalimide}$$

2. Hydrolysis or Hydrazinolysis:

$$N-\text{ alkylphthalimide }+H_2O/NH_2NH_2 \rightarrow R-NH_2+\text{ Phthalic acid}$$

Example:

$$C_6H_4(CO)_2NH+R-Br \rightarrow C_6H_4(CO)_2\,N-R \xrightarrow{\text{hydrolysis}} R-NH_2+\text{ Phthalic acid}$$

The Gabriel synthesis is widely used to prepare primary amines while avoiding the formation of secondary and tertiary amines.

UP Board Class 12 Chemistry Question with Solution-2023

1) Four alternatives are given in each part of this question. Select the correct alternative and write it in your answer-book :

a) The solid which is electrical conductor, ductile and tensile, is called

i) Molecular solid

ii) Ionic solid

iii) Metallic solid

iv) Coordinate solid.

Answer:

The solid which is an electrical conductor, ductile, and tensile is called: iii) Metallic solid

b) In a 200 g solution of glucose with 10% mass per cent, amount of glucose will be

i) $5.0 \mathrm{~g}$

ii) 10.0 g

iii) $20.0 \mathrm{~g}$

iv) 40.0 g .

Answer:

In a 200 g solution of glucose with 10% mass per cent, the amount of glucose will be: iii) $\mathbf{20.0 \ g}$

c) Velocity constant (k) for a reaction is $2.3 \times 10^{-5} \mathrm{~L} \mathrm{~mol}^{-1} \mathrm{~s}^{-1}$. Order of the reaction will be

i) Zero order

ii) First order

iii) Second order

iv) None of these.

Answer:

Velocity constant (k) for a reaction is $2.3 \times 10^{-5} \mathrm{~L} \mathrm{~mol}^{-1} \mathrm{~s}^{-1}$. The order of the reaction will be: iii) Second order

d) The base not present in RNA is

i) Adenine

ii) Guanine

iii) Thymine

iv) Uracil.

Answer:

The base not present in RNA is: iii) Thymine

e) Cannizzaro's reaction is exhibited by

i) Benzoic acid

ii) Toluene

iii) Benzaldehyde

iv) Formic acid.

Answer:

Cannizzaro's reaction is exhibited by: iii) Benzaldehyde
f) Carbylamine reaction gives
i) CH_3NH_2
ii) $(CH_3)_2NH$
iii) $(CH_3)_3 N$
iv) $(C_2H_5)_2NH$.

Answer:

Carbylamine reaction gives: i) CH_3NH_2

2 a) Calculate the packing capacity (efficiency) of a simple cubic lattice.

Answer:

1. Volume of a unit cell:
- Let the edge length of the unit cell be a.
- The volume of the unit cell is $V = a^3$.
2. Volume of atoms in a unit cell:
- The atom is assumed to be spherical.
- The radius r of the atom is related to the edge length of the unit cell by $a = 2r$.
- The volume of one atom (sphere) is Volume of sphere $= \frac{4}{3}\pi r^3$.
- Since there is 1 atom in a simple cubic unit cell, the total volume of atoms in the unit cell is $V_{\text{atoms}} = \frac{4}{3}\pi r^3$.
3. Packing efficiency:

$$\text{Packing efficiency } = \frac{\text{Volume of atoms in the unit cell}}{\text{Volume of the unit cell}} \times 100$$

Substituting $r = \frac{a}{2}$:

$$\text{Packing efficiency } = \frac{\frac{4}{3}\pi\left(\frac{a}{2}\right)^3}{a^3} \times 100 = \frac{\frac{4}{3}\pi\left(\frac{a^3}{8}\right)}{a^3} \times 100 = \frac{\pi}{6} \times 100 \approx 52.36\%$$

Thus, the packing efficiency of a simple cubic lattice is 52.36%.

b) The structure of a cell of an element is body centred cubic (bcc). The length of the core of the cell is 200 pm . Density of the element is $7 \mathrm{~g/cm}^3$. Determine the number of atoms in 20 g element.

Answer:

- The element has a bcc structure.
- Length of the core of the cell, $a = 200\text{pm} = 200 \times 10^{-10} \text{ cm}$.
- Density, $\rho = 7 \mathrm{~g/cm}^3$.
- Mass of the element is 20 g .
1. Volume of the unit cell:

$$V_{\text{unit cell }} = a^3 = \left(200 \times 10^{-10}\right)^3 \mathrm{~cm}^3 = 8 \times 10^{-24} \mathrm{~cm}^3$$

2. Mass of one unit cell:

$$\text{Mass of unit cell } = \rho \times V_{\text{unit cell }} = 7 \times 8 \times 10^{-24} = 5.6 \times 10^{-23} \mathrm{~g}$$

3. Number of atoms per unit cell in bcc: 2 atoms per unit cell.
4. Mass of 1 atom: Let M be the molar mass of the element, and N_A be Avogadro's number (6.022×10^{23}).

$$\text{Mass of one atom } = \frac{M}{N_A}$$

5. Number of atoms in $\mathbf{20\ g}$: The number of atoms in the element can be calculated using the mass and the atomic mass (not given directly in the problem). Assuming we know the atomic mass, the number of atoms in 20 g is found using:

$$\text{Number of atoms } \downarrow \text{ as } = \frac{\text{mass of element}}{\text{mass of one atom}}$$

c) Give answers :

i) Why does the conducivity of any solution decreases with dilution ?

Answer:

Conductivity depends on the number of ions per unit volume of the solution. With dilution, the concentration of ions decreases as the volume increases, leading to fewer ions in the same volume, thus decreasing the conductivity.

ii) Conductivity of $^{\top}0.20\mathrm{MKCl}$ solution at 298 K is $0.248\ \mathrm{S\ cm}^{-1}$. What will be its molar conductivity?

Answer:

Given:
- Conductivity (κ) of 0.20 M KCl solution $= 0.248\ \mathrm{S\ cm}^{-1}$.
- Molarity $C = 0.20\mathrm{M}$.

Molar conductivity (Λ_m) is calculated using the formula:

$$\Lambda_m = \frac{\kappa}{C}$$

Substituting the values:

$$\Lambda_m = \frac{0.248}{0.20} = 1.24\ \mathrm{S\ cm}^2\ \mathrm{mol}^{-1}$$

d) Initial concentration of $\mathrm{N_2O_5}$ in a first order reaction $\mathrm{N_2O_5}(g) \rightarrow 2\mathrm{NO_2}(g) + \frac{1}{2}\mathrm{O_2}(g)$ was $1.24 \times 10^{-2}\mathrm{molL}^{-1}$ at 310 K , which remained $0.20 \times 10^{-2}\mathrm{molL}^{-1}$ after 30 minutes. Calculate velocity constant at $310\ \mathrm{K}.\ (\log_{10} 6 \cdot 2 = 0 \cdot 7924)$

Answer:

Given:
- Initial concentration of N_2O_5, $[A_0] = 1.24 \times 10^{-2}\ \mathrm{mol/L}$.
- Concentration after time $t = 30$ minutes, $[A_t] = 0.20 \times 10^{-2}\ \mathrm{mol/L}$.
- Time $t = 30$ minutes $= 1800$ seconds.

For a first-order reaction, the rate constant k is given by the formula:

$$k = \frac{2.303}{t} \log\left(\frac{[A_0]}{[A_t]}\right)$$

Substitute the values:

$k=\frac{2.303}{1800}\log\left(\frac{1.24\times10^{-2}}{0.20\times10^{-2}}\right)=\frac{2.303}{1800}\log(6.2)$
From the given value of $\log 6.2=0.7924$:

$k=\frac{2.303}{1800}\times 0.7924=0.001013\ \mathrm{s}^{-1}$
Thus, the velocity constant k is approximately $1.013\times10^{-3}\ \mathrm{s}^{-1}$.

3. a) Justify with reasons :

i) Why does physical adsorption decrease on increasing temperature?

Answer:

Physical adsorption (physisorption) is an exothermic process, meaning it releases heat during the adsorption of molecules onto the surface of a solid. According to Le Chatelier's principle, increasing temperature tends to oppose exothermic processes. Therefore, when the temperature is increased, the energy provided causes the adsorbed molecules to gain kinetic energy, making it easier for them to leave the surface of the adsorbent. As a result, the extent of adsorption decreases with an increase in temperature.

In summary:

- Physical adsorption involves weak van der Waals forces, which are disrupted by increased molecular motion at higher temperatures.
- Higher temperatures increase the kinetic energy of adsorbed molecules, leading to desorption and thus a decrease in adsorption.

ii) Why are the powdered materials better effective adsorbent in comparison to their crystalline forms ?

Answer:

Powdered materials have a **much larger surface area** compared to their crystalline forms. Adsorption is a surface phenomenon, meaning the effectiveness of an adsorbent depends directly on the available surface area. The finely divided powdered form provides more surface area per unit mass for the adsorbate molecules to adhere to, making adsorption more efficient.

In summary:

- **Higher surface area:** Powdered materials offer greater surface area for adsorption, allowing more adsorbate molecules to be adsorbed.
- **More active sites:** The increased surface area exposes more adsorption sites, making powdered materials more effective adsorbents than their crystalline counterparts.

4. a) The resistance of a conductivity cell, filled with $0.1\ \mathrm{mol\ L^{-1}KCl}$ solution is 100Ω. If the resistance of this cell is 500Ω on filling $0.02\ \mathrm{mol\ L^{-1}KCl}$ solution, then calculate the conductivity and molar conductivity of $0.02\ \mathrm{mol\ L^{-1}KCl}$ solution. The conductivity of $0.1\ \mathrm{mol\ L^{-1}KCl^{-1}}$ solution is $1.29\ \mathrm{S\ m^{-1}}$.

Answer

Given:
- Resistance of $0.1\ \mathrm{mol/LKCl}$ solution, $R_1=100\Omega$
- Conductivity of $0.1\ \mathrm{mol/LKCl}$ solution, $\kappa_1=1.29\ \mathrm{S\ m^{-1}}$
- Resistance of $0.02\ \mathrm{mol/LKCl}$ solution, $R_2=500\Omega$

We use the following relationship between resistance (R) and conductivity (κ) :

$\kappa=\frac{1}{R} \times$ Cell constant

First, we calculate the cell constant using the known values for $0.1 \mathrm{~mol} / \mathrm{LKCl}$:

$$\text{Cell constant } = R_1 \times \kappa_1 = 100 \times 1.29 = 129 \mathrm{~m}^{-1}$$

Now, we can calculate the conductivity of $0.02 \mathrm{~mol} / \mathrm{LKCl}$ solution using the resistance R_2 :

$$\kappa_2=\frac{\text{Cell constant}}{R_2}=\frac{129}{500}=0.258 \mathrm{~S} \mathrm{~m}^{-1}$$

To calculate the molar conductivity (Λ_m) of $0.02 \mathrm{~mol} / \mathrm{LKCl}$ solution, we use the formula:

$$\Lambda_m=\frac{\kappa}{C}$$

b) Differentiate between the following :

i) True solution and suspension

Answer:

Property	True Solution	Suspension
Particle Size	Less than 1 nm	Greater than 1000 nm
Visibility	Particles are not visible	Particles are visible
Stability	Stable, does not settle on standing	Unstable, particles settle on standing
Filtration	Cannot be separated by filtration	Can be separated by filtration
Example	Salt in water	Sand in water

ii) Lyophilic and Lyophobic colloid

Answer:

Property	Lyophilic Colloid	Lyophobic Colloid
Affinity for Solvent	High affinity for solvent	Low or no affinity for solvent
Stability	Highly stable	Less stable, easily coagulated
Reversibility	Reversible colloids	Irreversible colloids

Example	Gum, starch, gelatin	Gold sol, sulfur sol

iii) Multimolecular and macromolecular colloid.

Answer:

Property	Multimolecular Colloid	Macromolecular Colloid
Formation	Aggregates of smaller molecules or atoms	Large molecules form the dispersed phase
Size	Smaller size (formed by aggregation)	Large size (single molecules)
Example	Gold sol, sulfur sol	Starch, proteins

c) Write short notes on the following

Answer:

i) Secondary structure of proteins

Answer:

The secondary structure of proteins refers to the local folding of the polypeptide chain into regular structures, such as **alpha-helix** and **beta-pleated sheets**, due to hydrogen bonding between the backbone atoms. In the alpha-helix, the backbone coils in a right-handed spiral, whereas, in the beta-sheet, strands of the polypeptide chain are aligned next to each other, forming a sheet-like arrangement.

ii) Peptide bond

Answer:

A **peptide bond** is a covalent bond formed between the **carboxyl group** of one amino acid and the **amino group** of another amino acid, with the elimination of a water molecule. This bond is the fundamental linkage in proteins and polypeptides, joining amino acids into chains.

iii) Monosaccharides.

Answer:

Monosaccharides are the simplest form of carbohydrates, consisting of single sugar molecules with the general formula $\mathrm{C}_n(\mathrm{H}_2\mathrm{O})_n$, where n is typically $3-7$. They cannot be hydrolyzed into simpler sugars. Examples include glucose, fructose, and galactose. Monosaccharides are important energy sources and building blocks for more complex carbohydrates like disaccharides and polysaccharides.

d) Give reasons of the following :
i) Aniline does not exhibit Friedel-Crafts reaction.

Answer:

Aniline $(C_6H_5NH_2)$ does not undergo the Friedel-Crafts reaction (alkylation or acylation) because the lone pair of electrons on the nitrogen atom of the amino group forms a complex with the Lewis acid catalyst (such as $AlCl_3$). This coordination reduces the availability of the lone pair for activating the benzene ring toward electrophilic substitution. Moreover, the amino group, being an electron-donating group, increases the electron density on the benzene ring, making the interaction with the Lewis acid catalyst stronger and thus deactivating the ring for Friedel-Crafts reactions. The catalyst also protonates the amino group, further reducing its ability to participate in the reaction.

In summary:
- The amino group forms a complex with the Lewis acid catalyst.
- The benzene ring becomes deactivated for electrophilic substitution due to this interaction.

ii) Ethyl amine is soluble in water while aniline is not.

Answer:

Ethylamine $(C_2H_5NH_2)$ is soluble in water because it can form hydrogen bonds with water molecules due to the presence of its small polar amino group. The alkyl chain of ethylamine is short and does not significantly hinder the interaction with water molecules. This hydrogen bonding allows ethylamine to easily dissolve in water.

On the other hand, aniline ($C_6H_5NH_2$) has a much larger non-polar aromatic ring (benzene) attached to the amino group. This bulky hydrophobic benzene ring reduces the overall polarity of the molecule and makes it difficult for aniline to form hydrogen bonds with water. As a result, the non-polar benzene ring disrupts the interaction with polar water molecules, making aniline less soluble in water.

In summary:
- Ethylamine is more soluble due to its smaller, polar structure, which allows hydrogen bonding with water.
- Aniline is less soluble because the large non-polar benzene ring disrupts hydrogen bonding with water.

a) What do you understand by osmosis and osmotic pressure ? 1.26 g protein is present in $200 \mathrm{~cm}^3$ aqueous solution of protein. Molar mass of protein is $61.022 \mathrm{~g} \mathrm{~mol}^{-1}$. What will be osmotic pressure of this solution at 300 K ?

Solution:

Osmosis is the process by which solvent molecules pass through a semipermeable membrane from a region of lower solute concentration to a region of higher solute concentration. This process continues until equilibrium is achieved, with equal concentrations of solute on both sides of the membrane.

Osmotic Pressure is the minimum pressure that must be applied to the solution side to stop the flow of solvent into the solution through the semipermeable membrane. It is a colligative property, which means it depends on the number of solute particles in the solution rather than their nature.

Given:
- Mass of protein $= 1.26$ g
- Volume of solution $= 200 \text{ cm}^3 = 0.200 \text{ L}$
- Molar mass of protein $= 61,022 \text{ g/mol}$
- Temperature $= 300 \text{ K}$

The formula for osmotic pressure (π) is:

$$\pi = \frac{n}{V} RT$$

where:
- n is the number of moles of solute,
- V is the volume of the solution (in liters),
- R is the gas constant $(0.0821 \text{ L} \cdot \text{atm} \cdot \text{K}^{-1} \cdot \text{mol}^{-1})$,
- T is the temperature in Kelvin.

First, calculate the number of moles of protein:

$$n = \frac{\text{Mass of solute}}{\text{Molar mass}} = \frac{1.26 \text{ g}}{61{,}022 \text{ g/mol}} = 2.064 \times 10^{-5} \text{ mol}$$

Now, substitute the values into the osmotic pressure formula:

$$\pi = \frac{2.064 \times 10^{-5}}{0.200} \times 0.0821 \times 300$$

$$\pi = 2.544 \times 10^{-3} \text{ atm}$$

Thus, the osmotic pressure of the solution is approximately 0.00254 atm.

b) i) What do you understand by velocity of a chemical reaction ?

Answer:

The velocity of a chemical reaction (or rate of reaction) is the change in concentration of reactants or products per unit time. It is typically expressed as the rate at which reactants are consumed or products are formed. For a reaction $A \rightarrow B$, the rate can be expressed as:

$$\text{Rate } = -\frac{d[A]}{dt} = \frac{d[B]}{dt}$$

where $[A]$ and $[B]$ are the concentrations of reactants and products, respectively, and t is time.

ii) Explain Raoult's law.

Raoult's Law states that the vapor pressure of a solvent in a solution is directly proportional to the mole fraction of the solvent in the solution. For an ideal solution, the partial vapor pressure of a component A is given by:

$$P_A = P_A^0 \cdot X_A$$

where:
- P_A is the partial vapor pressure of component A,
- P_A^0 is the vapor pressure of the pure solvent,
- X_A is the mole fraction of component A in the solution.

For a solution with two components (solute and solvent), the total vapor pressure is the sum of the partial pressures of both components.

c) Explain the following with reasons :

i) Transition metals generally form coloured compounds.

ii) Transition metals and their maximum compounds are paramagnetic.

Answer:

i) Transition metals generally form colored compounds.

Transition metals form colored compounds because they have partially filled **d-orbitals**. When light falls on these compounds, electrons in the d-orbitals can absorb energy and transition from lower-energy d-orbitals to higher-energy d-orbitals (d-d transitions). The specific wavelengths of light absorbed correspond to certain colors, and the remaining wavelengths are transmitted or reflected, giving the compounds their characteristic colors.

ii) Transition metals and their compounds are paramagnetic.

Paramagnetism occurs when a substance has unpaired electrons. Most transition metals and their compounds have unpaired electrons in their d-orbitals, which creates a magnetic moment. As a result, these metals and their compounds exhibit paramagnetism, meaning they are attracted to an external magnetic field.

d) Write IUPAC names of the following coordination compounds :

i) $[CrCl_2(\text{ en })_2]Cl$

ii) $Cs\,[FeCl_4]$

iii) $K_3\,[Co(C_2O_4)_3]$

iv) $[CoCl_3(NH_3)_3]$

Answer:

i) $[CrCl_2(en)_2]Cl$
- IUPAC Name: Dichloridobis(ethylenediamine)chromium(III) chloride
ii) $Cs\,[FeCl_4]$
- IUPAC Name: Caesium tetrachloridoferrate(III)
iii) $K_3\,[Co(C_2O_4)_3]$
- IUPAC Name: Potassium tris(oxalato)cobaltate(III)
iv) $[CoCl_3(NH_3)_3]$
- IUPAC Name: Triamminetrichloridocobalt(III)

6. a) Describe the industrial manufacture of sulphur dioxide gas. Give also chemical equations of the reactions. Give chemical equations of the reactions of sulphuric acid with calcium fluoride, copper and sulphur.

Answer:

The industrial manufacture of sulphur dioxide (SO_2) is typically carried out by burning sulfur or roasting sulfide ores. The two main methods are:

1. Burning of Sulfur

Sulfur is burned in excess air to produce sulfur dioxide gas:

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

This is a highly exothermic reaction and produces pure sulfur dioxide gas.

2. Roasting of Sulfide Ores

Metal sulfide ores such as zinc blende (ZnS) or iron pyrites (FeS_2) are roasted in the presence of air. During the roasting process, the sulfide is converted into sulfur dioxide and metal oxide.

For zinc blende:

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

For iron pyrites:

$$4FeS_2(s) + 11O_2(g) \rightarrow 2Fe_2O_3(s) + 8SO_2(g)$$

Reactions of Sulphuric Acid

1. Sulfuric Acid with Calcium Fluoride (CaF_2) When sulfuric acid reacts with calcium fluoride, hydrogen fluoride (HF) gas is produced:

$$CaF_2(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + 2HF(g)$$

2. Sulfuric Acid with Copper (Cu) When sulfuric acid reacts with copper, especially hot concentrated sulfuric acid, sulfur dioxide, copper sulfate, and water are formed:

$$Cu(s) + 2H_2SO_4(\text{ conc }) \rightarrow CuSO_4(aq) + SO_2(g) + 2H_2O(l)$$

3. Sulfuric Acid with Sulfur (S) When sulfur reacts with hot concentrated sulfuric acid, sulfur dioxide, water, and sulfur dioxide are formed:

$$S(s) + 2H_2SO_4(\text{ conc }) \rightarrow 3SO_2(g) + 2H_2O(l)$$

These are the industrial and chemical reactions involving sulfur dioxide and sulfuric acid.

b) What happens when (Give chemical equations only) -

i) n-butyl chloride reacts with alcoholic KOH ?

ii) Methyl iodide reacts with magnesium in presence of dry ether?

iii) Methyl bromide reacts with sodium in presence of dry

iv) Methyl iodide reacts with KCN solution ?

v) Chlorobenzene reacts with aqueous NaOH ?

Answer:

i) n-butyl chloride reacts with alcoholic KOH :

$CH_3CH_2CH_2CH_2Cl + KOH\ (alc) \rightarrow CH_3CH_2CH_2CH = CH_2 + KCl + H_2O$
This is an elimination reaction, resulting in the formation of but-1-ene.
ii) Methyl iodide reacts with magnesium in presence of dry ether:

$$CH_3I + Mg \xrightarrow{\text{dry ether}} CH_3MgI$$
This forms methylmagnesium iodide, which is a Grignard reagent.
iii) Methyl bromide reacts with sodium in presence of dry ether:

$$2CH_3Br + 2Na \xrightarrow{\text{dry ether}} CH_3CH_3 + 2NaBr$$
This is the Wurtz reaction, leading to the formation of ethane.

iv) Methyl iodide reacts with KCN solution:

$$CH_3I + KCN \rightarrow CH_3CN + KI$$
This reaction leads to the formation of methyl cyanide (acetonitrile).
v) Chlorobenzene reacts with aqueous NaOH :

$$C_6H_5Cl + NaOH(aq) \xrightarrow{300^{\circ}C, 300\ atm} C_6H_5OH + NaCl$$
This reaction produces phenol in the Dow process.

7. a) Deseribe the industrial manufacture of ethanol. Give also the chemical equation of reactions. What is formed after dehydrogenation of ethanol ? Write the mechanism of acidic dehydration of ethanol to ret ethenc.

Answer:

1. Fermentation of Sugars

This is the biological method of producing ethanol by the fermentation of sugars, such as glucose, using yeast. This process occurs in the absence of oxygen (anaerobic conditions).

Reaction:

In this reaction, glucose $(C_6H_{12}O_6)$ is converted into ethanol (C_2H_5OH) and carbon dioxide (CO_2).
2. Hydration of Ethylene

In this industrial process, ethanol is produced by the acid-catalyzed hydration of ethylene. Ethylene (or ethene) is reacted with water in the presence of an acid catalyst, typically sulfuric acid or phosphoric acid.

Reaction:

$$C_2H_4 + H_2O \xrightarrow{H_2SO_4} C_2H_5OH$$
This process involves the addition of water to ethene to produce ethanol.

Dehydrogenation of Ethanol
Dehydrogenation of ethanol refers to the removal of hydrogen atoms from ethanol. When ethanol is dehydrogenated, acetaldehyde (ethanal) is formed.

Reaction:

$CH_3CH_2OH \xrightarrow{Cu, 573\ K} CH_3CHO + H_2$
In this reaction, ethanol (CH_3CH_2OH) is converted into acetaldehyde (CH_3CHO) and hydrogen gas (H_2).

Mechanism of Acidic Dehydration of Ethanol to Form Ethene
In acidic conditions, ethanol undergoes dehydration (loss of a water molecule) to form ethene. This reaction typically occurs in the presence of concentrated sulfuric acid or phosphoric acid at elevated temperatures.

b) An organic compound ' A ' having molecular formula (C_8H_8O), gives orange red precipitate with 2,4-DNP (2,4-Dinitrophenyl hydrazine) reagent. ' A ' gives yellow precipitate on heating with iodine in presence of NaOH . ' A ' neither reduces Tollen's reagent, Fehling's solution nor decolourises bromine water. It forms a carboxylic acid ' B ' having molecular formula $C_7H_6O_2$, on strong oxidation with chromic acid. Identify compounds ' A ' and ' B ' and explain the main reactions.

Answer:

1. Molecular formula of ' A ' is C_8H_8O : This indicates that the compound is unsaturated and likely contains a functional group such as a carbonyl group (as the oxygen atom suggests the presence of a carbonyl or hydroxyl group).
2. 'A' gives an orange-red precipitate with 2,4-DNP (2,4-Dinitrophenyl hydrazine): This test is positive for compounds containing a carbonyl group (either an aldehyde or ketone). Therefore, 'A' must be a ketone or an aldehyde.
3. 'A' gives a yellow precipitate on heating with iodine in the presence of NaOH (iodoform test): The iodoform test is positive for compounds containing a methyl ketone group (i.e., CH_3CO-) or ethanol $(CH_3CH(OH))$. This indicates that ' A ' contains a methyl group adjacent to a carbonyl group.
4. ' A ' does not reduce Tollen's reagent, Fehling's solution, or decolorize bromine water: This indicates that ' A ' is not an aldehyde and does not have any unsaturation (double or triple bonds) in the aliphatic chain that can decolorize bromine water. Since it does not react with Tollen's reagent or Fehling's solution, it is not an aldehyde.
5. Strong oxidation of ' A ' with chromic acid gives a carboxylic acid ' B ' $(C_7H_6O_2)$: The molecular formula $C_7H_6O_2$ corresponds to benzoic acid, which suggests that ' A ' has a benzene ring with an alkyl group that is oxidized to a carboxyl group.

UP Board Class 12 Chemistry Question with Solution-2022

1. Four alternatives are given in each part of this question. Select the correct alternative and write it in your answerbook :

a) In a crystal system $a=b=c$ and $\alpha=\beta=\gamma\neq 90^{\circ}$. This system is

i) Hexagonal

ii) Rhombohedral

iii) Quadrilateral

iv) Monoclinic

Answer: (ii) Rhombohedral

Explanation: In a rhombohedral crystal system, all three edges are of equal length ($a=b=c$) and the angles between them $(\alpha=\beta=\gamma)$ are equal but not 90°, distinguishing it from other systems like cubic, where the angles are 90°.

b) Which of the following 0.1 M aqueous solution has minimum freezing point?

i) Sodium chloride

ii) Urea

iii) Potassium sulphate

iv) Glucose

Answer: (iii) Potassium sulphate

Explanation: Freezing point depression is a colligative property that depends on the number of particles in solution. Potassium sulfate (K_2SO_4) dissociates into three ions $(2\,K^{+}+SO_4^{2-}$), resulting in the highest number of particles compared to the other solutes. This causes the greatest freezing point depression, leading to the lowest freezing point among the given solutions. Sodium chloride dissociates into two ions, while urea and glucose do not dissociate.

c) On increasing the temperature rate constant will

i) increase

ii) decrease

iii) remain unchanged

iv) none of these

Answer: (i) increase

Explanation: According to the Arrhenius equation, the rate constant k increases with increasing temperature because the molecules have more kinetic energy, resulting in more frequent and effective collisions

d) Which of the following is monosaccharide?

i) Lactose

ii) Starch

iii) Maltose

iv) Fructose

Answer: (iv) Fructose

Explanation: Fructose is a simple sugar (monosaccharide), whereas lactose and maltose are disaccharides, and starch is a polysaccharide.

e) Which of the following compounds is obtained when acetic acid is heated with P_2O_5 ?

i) $(CH_3CO_2O$

ii) CH_4

iii) CH_3COCH_3

iv) CH_3CHO

Answer: (i) (CH_3CO_2O) (Acetic anhydride)
Explanation: Heating acetic acid with phosphorus pentoxide (P_2O_5) leads to the formation of acetic anhydride by dehydration of acetic acid. CH_3CO_2O is acetic anhydride.

f) Conversion of amide into amine is done by which of the following reactions?
i) Carbylamine reaction
ii) Hoffman Bromamide reaction
iii) Wurtz reaction
iv) Cannizzaro reaction

Answer: (ii) Hoffman Bromamide reaction

Explanation: The Hoffman Bromamide reaction is a chemical reaction where an amide is converted into an amine with one fewer carbon atom. This reaction involves the use of bromine and a strong base, such as sodium hydroxide, and results in the formation of a primary amine.

2. a) Classify crystalline solids on the basis of intermolecular forces. Give one example for each class.

Answer:

Crystalline solids can be classified into four types based on the nature of intermolecular forces acting between their constituent particles:
1. Ionic Solids:
- Intermolecular Force: Electrostatic forces (ionic bonds) between oppositely charged ions.
- Example: Sodium chloride (NaCl).

2. Molecular Solids:
- Intermolecular Force: Van der Waals forces (dispersion forces, dipole-dipole interactions, or hydrogen bonds) between molecules.
- Example: Ice (H_2O) for hydrogen-bonded molecular solids, or Carbon dioxide (CO_2) for dispersion force molecular solids.
3. Covalent (or Network) Solids:
- Intermolecular Force: Strong covalent bonds between atoms throughout the solid.
- Example: Diamond (C) or Silicon carbide (SiC).
4. Metallic Solids:
- Intermolecular Force: Metallic bonds due to the electrostatic attraction between the positively charged metal ions and the sea of delocalized electrons.
- Example: Copper (Cu).

b) Define Raoult's law and write its limitations.

Answer:

Raoult's Law: Raoult's law states that the partial vapor pressure of a component in a solution is directly proportional to its mole fraction in the solution. For a solution of two volatile liquids, it can be mathematically represented as:

$$P_A = X_A \cdot P_A^0 \quad \text{and} \quad P_B = X_B \cdot P_B^0$$

Where:
- P_A and P_B are the partial vapor pressures of components A and B .
- X_A and X_B are their mole fractions.
- P_A^0 and P_B^0 are the vapor pressures of the pure components.

Limitations of Raoult's Law:
1. Ideal Solutions: Raoult's law is strictly valid only for ideal solutions where the intermolecular forces between different components are similar to those in pure components. In non-ideal solutions, deviations from Raoult's law occur.
2. Non-volatile Solutes: Raoult's law is limited to solutions where both solute and solvent are volatile. In the case of a non-volatile solute, the law only applies to the solvent.
3. Strong Interactions: If there are strong specific interactions, such as hydrogen bonding between solute and solvent, the solution may show positive or negative deviations from Raoult's law.

c) Explain Kohlrausch's law. Write two applications of this law.

Answer:

Kohlrausch's Law of Independent Migration of Ions: This law states that at infinite dilution, each ion contributes independently to the total molar conductivity of the electrolyte. Mathematically, it can be expressed as:

$$\Lambda_m^\circ = \lambda_+^\circ + \lambda_-^\circ$$

Where:
- Λ_m° is the molar conductivity at infinite dilution.
- λ_+° and λ_-° are the limiting molar conductivities of the cation and anion, respectively.

Applications of Kohlrausch's Law:

1. Determination of Molar Conductivity at Infinite Dilution for Weak Electrolytes: Kohlrausch's law is used to calculate the molar conductivity at infinite dilution (Λ_m°) for weak electrolytes like acetic acid, which cannot be directly measured due to their low degree of ionization.
2. Determination of the Degree of Dissociation (α) : The degree of dissociation of weak electrolytes can be determined using Kohlrausch's law by relating the molar conductivity at a given concentration to the molar conductivity at infinite dilution:

$\alpha=\frac{\Lambda_m}{\Lambda_m^{\circ}}$

d) Differentiate between true solution and colloidal solution with example.

Answer:

Property	True Solution	Colloidal Solution
Nature of Mixture	Homogeneous mixture	Heterogeneous mixture
Particle Size	Very small, less than 1 nm	Intermediate, 1 nm to 1000 nm
Visibility of Particles	Particles are not visible, even under a microscope	Particles can be seen under an ultramicroscope
Stability	True solutions are stable and do not settle	Colloidal solutions are relatively stable but can be coagulated
Tyndall Effect	Does not show Tyndall effect (no scattering of light)	Shows Tyndall effect (scattering of light by colloidal particles)
Filtration	Can pass through ordinary filter paper and membranes	Can pass through ordinary filter paper but not through semi-permeable membranes
Example	Sugar dissolved in water (sugar solution)	Milk, starch in water (colloidal starch solution)

3. a) A cubic structured compound is made of elements A and B. In this, atom A is in the corner of the cube and atom B is at face centre. Determine the formula of the compound:

Answer:

- Atom A is located at the corners of the cube.
- Atom B is located at the face centers of the cube.

To determine the formula of the compound, let's analyze the contribution of each atom to the unit cell:

Atoms at the Corners (A) :
- Each unit cell has 8 corners.
- Each corner atom is shared by 8 adjacent unit cells.
- Therefore, the contribution of each corner atom to one unit cell is $\frac{1}{8}$.
- Total contribution of atoms A in one unit cell:

$8 \times \frac{1}{8}=1$ atom of A

Atoms at the Face Centers (B):
- Each unit cell has 6 faces.
- Each face-centered atom is shared by 2 adjacent unit cells.
- Therefore, the contribution of each face-centered atom to one unit cell is $\frac{1}{2}$.
- Total contribution of atoms B in one unit cell:

$6 \times \frac{1}{2}=3$ atoms of B

Formula of the Compound:
- The ratio of atoms A to B in the unit cell is $1: 3$.
- Therefore, the empirical formula of the compound is $\mathbf{AB}_3$.

b) Write IUPAC names for the following coordination compounds :

i) $K_3 \mid Cr(C_2O_4)_3$

Answer:

This is a coordination compound where the central metal atom is chromium (Cr), and the ligand is oxalate $\left(C_2O_4^{2-}\right)$. Since there are three oxalate ligands and chromium is in the +3 oxidation state, the name is:

IUPAC Name: Potassium tris(oxalato) chromate(III)

ii) $\mid Co(NH_3)_5\,(CO_3)]Cl$

Answer:

In this compound, cobalt (Co) is the central metal ion, and it is coordinated with five ammine (NH_3) ligands and one carbonate $\left(CO_3^{2-}\right)$ ligand. The oxidation state of cobalt is +3 .

IUPAC Name: Pentaamminecarbonatocobalt(III) chloride

c) What do you understand by Nucleic acids ? Give example.

Answer:

Nucleic acids are large biomolecules that are essential for all known forms of life. They are polymers made up of monomer units called **nucleotides**. Each nucleotide consists of a nitrogenous base (adenine, guanine, cytosine, thymine/uracil), a sugar molecule (either ribose in RNA or deoxyribose in DNA), and a phosphate group.

Nucleic acids are responsible for storing and transmitting genetic information and play a crucial role in protein synthesis.

Examples:

- **DNA (Deoxyribonucleic Acid)**: Stores genetic information.

- **RNA (Ribonucleic Acid)**: Involved in protein synthesis.

d) What are p-block elements ? Why are they called p-block elements ?

Answer:

p-block elements are the elements in which the last electron enters any of the three p-orbitals of the outermost electron shell. The p-block is located on the right side of the periodic table and includes groups 13 to 18 .
- The general electronic configuration of p-block elements is ns^2np^{1-6}, where n represents the principal quantum number.
- These elements include metals, nonmetals, and metalloids, and they display a wide range of properties.

They are called p-block elements because their valence electrons occupy the p-orbital. The highest energy electron in the p-block elements is found in the p-subshell, hence the name.

Examples of p-block elements:
- Group 13: Boron (B), Aluminum (Al)
- Group 14: Carbon (C), Silicon (Si)
- Group 15: Nitrogen (N), Phosphorus (P)
- Group 16: Oxygen (O), Sulfur (S)
- Group 17: Fluorine (F), Chlorine (Cl)
- Group 18: Helium (He), Neon (Ne), Argon (Ar).

4. a) Write Nernst equation and calculate emf of the following cell at 298 K :

$$\left(E^0_{\mathrm{Cu}^{2+}/\mathrm{Cu}} = 0.34, E^0_{\mathrm{Mg}^{2+}/\mathrm{Mg}} = -2.37\right)$$
$$\mathrm{Mg(s)}\left|\mathrm{Mg}^{2+}(0.001\mathrm{M})\right|\left|\mathrm{Cu}^{2+}(0.0001\mathrm{M})\right|\mathrm{Cu(s)}$$

Answer:

The Nernst equation for a general electrochemical cell is given by:

$$E_{\text{cell}} = E^0_{\text{cell}} - \frac{0.059}{n}\log\left(\frac{[\text{products}]}{[\text{reactants}]}\right)$$

Where:
- E_{cell} is the cell potential at non-standard conditions.
- E^0_{cell} is the standard cell potential.
- n is the number of electrons transferred in the reaction.
- The concentrations of the products and reactants are used in the equation.

The given cell is:

$$\mathrm{Mg}(s)\left|\mathrm{Mg}^{2+}(0.001\mathrm{M})\right|\left|\mathrm{Cu}^{2+}(0.0001\mathrm{M})\right|\mathrm{Cu}(s)$$

- $E^0_{\mathrm{Mg}^{2+}/\mathrm{Mg}} = -2.37\ \mathrm{V}$
- $E^0_{\mathrm{Cu}^{2+}/\mathrm{Cu}} = +0.34\ \mathrm{V}$

The standard EMF of the cell is:

$$E^0_{\text{cell}} = E^0_{\text{cathode}} - E^0_{\text{anode}} = 0.34\ \mathrm{V} - (-2.37\ \mathrm{V}) = 2.71\ \mathrm{V}$$

Now, using the Nernst equation:

$$E_{\text{cell}} = E_{\text{cell}}^0 - \frac{0.059}{n}\log\left(\frac{[\mathrm{Mg}^{2+}]}{[\mathrm{Cu}^{2+}]}\right)$$

For the reaction:

$$\mathrm{Mg} + \mathrm{Cu}^{2+} \rightarrow \mathrm{Mg}^{2+} + \mathrm{Cu}$$

Here, $n = 2$ (since two electrons are transferred).

Substitute the values:

$$E_{\text{cell}} = 2.71 - \frac{0.059}{2}\log\left(\frac{0.001}{0.0001}\right)$$

$$E_{\text{cell}} = 2.71 - \frac{0.059}{2}\log(10)$$

$$E_{\text{cell}} = 2.71 - \frac{0.059}{2} \times 1 = 2.71 - 0.0295$$

$$E_{\text{cell}} = 2.6805 \text{ V}$$

Thus, the EMF of the cell at 298 K is 2.68 V .

b) Write short notes on the following :

i) Brownian movement

ii) Coagulation.

Answer:

i) Brownian Movement:

- **Definition**: Brownian movement refers to the random, zig-zag motion of particles suspended in a fluid (liquid or gas) due to continuous collisions with the molecules of the surrounding medium.
- **Explanation**: This phenomenon is observed in colloidal solutions where the dispersed particles are constantly bombarded by solvent molecules. This erratic movement helps keep the colloidal particles from settling, thereby stabilizing the colloidal system.

ii) Coagulation:

- **Definition**: Coagulation is the process by which colloidal particles aggregate and settle out of a solution, often resulting from the neutralization of the charges on the particles.
- **Explanation**: In colloids, particles are stabilized by electrostatic repulsion. When an electrolyte is added, the charges on the colloidal particles are neutralized, leading to the formation of larger aggregates that can settle out of the dispersion. Coagulation is important in processes like water purification.

c) Describe laboratory method for preparation of ethylamine. Give equations for related reactions also. How is acetic acid obtained from ethylamine ?

Answer:

Ethylamine can be prepared in the laboratory by the Hofmann Bromamide Degradation Reaction. The starting material is an amide, which is reacted with bromine and an alkali $(\mathrm{NaOH}$ or KOH$)$ to yield a primary amine.

Reaction:

$CH_3CONH_2 + Br_2 + 4NaOH \rightarrow CH_3CH_2NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$
In this reaction, acetamide reacts with bromine in the presence of sodium hydroxide to form ethylamine.

Preparation of Acetic Acid from Ethylamine:

Ethylamine can be converted to acetic acid by the following steps:
1. Ethylamine is first oxidized to acetic acid by oxidation with a suitable oxidizing agent like potassium permanganate $(KMnO_4)$.

$$CH_3CH_2NH_2 \xrightarrow{\text{Oxidation}} CH_3COOH$$

d) Write structural formula for glucose. How does glucose react with Tollen's reagent ? Give chemical equations also.

Answer:

Structural Formula of Glucose (Open-chain form):

$CH_2OH - (CHOH)_4 - CHO$
Reaction with Tollen's Reagent: Glucose, in its open-chain form, has an aldehyde group (-CHO) which reacts with Tollen's reagent $\left(Ag(NH_3)_2^+\right)$to reduce it to metallic silver. This reaction confirms the presence of an aldehyde group in glucose.

Chemical Equation:

$C_6H_{12}O_6 + 2\left[Ag(NH_3)_2^+\right] + 2OH^- \rightarrow C_6H_{12}O_7 + 2Ag + 4NH_3 + H_2O$
In this reaction, glucose is oxidized to gluconic acid, and silver ions are reduced to metallic silver, which forms a silver mirror on the surface of the reaction vessel.

5. a) What is elevation in boiling point ? Explain. 12 gm glucose is dissolved in 100 gm water. The boiling point of this solution is $100 \cdot 34^\circ C$. Calculate k_b for water in K^{-1} mole $^{-1}$.

Answer:

Elevation in boiling point is a colligative property that occurs when a non-volatile solute is added to a solvent. The presence of the solute reduces the vapor pressure of the solution, which means that a higher temperature is required to make the vapor pressure of the solution equal to the external pressure, thereby increasing the boiling point of the solution.

The change in boiling point $(\Delta T_b$) is directly proportional to the molality (m) of the solution and is given by the equation:

$\Delta T_b = k_b \cdot m$
Where:
- ΔT_b is the elevation in boiling point.
- k_b is the ebullioscopic constant (boiling point elevation constant) for the solvent.
- m is the molality of the solution, which is defined as the number of moles of solute per kilogram of solvent.

Calculation of k_b for Water:
Given:
- Mass of glucose $= 12$ g

- Molar mass of glucose $(C_6H_{12}O_6) = 180 \text{ g/mol}$
- Mass of water $= 100 \text{ g} = 0.1 \text{ kg}$
- Boiling point of solution $= 100.34^\circ\text{C}$
- Boiling point of pure water $= 100^\circ\text{C}$

Step 1: Calculate the number of moles of glucose:

$$\text{Number of moles of glucose } = \frac{\text{Mass of glucose}}{\text{Molar mass of glucose}} = \frac{12}{180} = 0.0667 \text{ mol}$$

Step 2: Calculate the molality of the solution:

$$\text{Molality } = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in kg}} = \frac{0.0667}{0.1} = 0.667 \text{ mol/kg}$$

Step 3: Calculate the elevation in boiling point:

$$\Delta T_b = \text{ Boiling point of solution } - \text{ Boiling point of pure water } = 100.34^\circ\text{C} - 100^\circ\text{C} = 0.34^\circ\text{C}$$

Step 4: Use the formula for elevation in boiling point:

$$\Delta T_b = k_b \cdot m$$

Substitute the known values:

$$0.34 = k_b \cdot 0.667$$

Step 5: Solve for k_b :

$$k_b = \frac{0.34}{0.667} = 0.510 \text{ K/mol/kg}$$

b) Explain the difference between equilibrium constant and rate constant. For a first order reaction, in 50 seconds the concentration of substance remains half of the initial concentration. Calculate its rate constant.

Answer:

1. Equilibrium Constant (K):
- Definition: The equilibrium constant, K, is a ratio of the concentration of products to the concentration of reactants at equilibrium for a reversible chemical reaction.
- Expression: For a general reaction $aA + bB \leftrightarrow cC + dD$, the equilibrium constant is given by:

$$K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

- Meaning: It tells us about the extent of the reaction at equilibrium but provides no information about the speed at which equilibrium is reached.
- Units: The equilibrium constant is unitless or can have units depending on the reaction.
2. Rate Constant $(\mathbf{k})$:
- Definition: The rate constant, k, is a proportionality constant that relates the rate of a chemical reaction to the concentration of the reactants.
- Expression: For a reaction of the form $aA + bB \rightarrow$ products, the rate of reaction is given by:

$$\text{Rate } = k[A]^a[B]^b$$

- Meaning: The rate constant gives information about the speed of the reaction. A higher value of k indicates a faster reacticn.

- Units: The units of k depend on the order of the reaction. For a first-order reaction, k has units of s^{-1}.

Calculation of Rate Constant for a First-Order Reaction:
Given:
- The concentration of the substance becomes half in 50 seconds, which means the half-life $t_{1/2}=50$ seconds.
- For a first-order reaction, the relationship between the rate constant k and the half-life $t_{1/2}$ is:

$$k=\frac{\ln (2)}{t_{1/2}}=\frac{0.693}{50 \text{ seconds}}$$
$$k=0.01386 \text{ s}^{-1}$$

So, the rate constant is $k=0.0139 \text{ s}^{-1}$.

c) What are the characteristics of transition metals ? Why are they called transition metal ?

Answer:

Transition metals are elements that have partially filled d-orbitals in their atomic or ionic forms. They are typically found in groups 3 to 12 of the periodic table.

Characteristics:
1. Variable Oxidation States: Transition metals exhibit multiple oxidation states due to the involvement of both s - and d-electrons in bonding. For example, iron shows oxidation states of +2 and +3 .
2. Formation of Colored Compounds: Many transition metal compounds are colored due to electronic transitions between d-orbitals of different energy levels (known as $d \rightarrow d$ transitions).
3. Magnetic Properties: Transition metals and their compounds exhibit magnetic properties due to unpaired electrons in the d-orbitals.
4. Catalytic Properties: Transition metals and their compounds often act as catalysts in industrial and biological reactions. For example, iron is used as a catalyst in the Haber process for ammonia synthesis.
5. Formation of Complexes: Transition metals readily form coordination complexes with ligands, due to their ability to accommodate additional ligands through their vacant d-orbitals.

They are called "transition metals" because they occupy the transition between the highly reactive **s-block** elements and the **p-block** elements, with which they share some properties. The name also reflects the fact that they exhibit transitional properties, like forming colored compounds and having variable oxidation states.

d) Explain the following along with example :

i) Coordination number

ii) Magnetic properties of coordination compounds.

Answer:

i) Coordination Number:
- Definition: The coordination number of a central metal atom in a coordination compound is the number of ligand atoms that are directly bonded to it.
- Example: In the complex $\left[\mathrm{Co}\left(\mathrm{NH}_3\right)_6\right]^{3+}$, the central cobalt atom is surrounded by six ammonia molecules, so the coordination number is 6 .
ii) Magnetic Properties of Coordination Compounds:
- Definition: The magnetic properties of coordination compounds depend on the presence of unpaired electrons in the d-orbitals of the central metal atom.

- Paramagnetic compounds have unpaired electrons and are attracted to a magnetic field.
- Diamagnetic compounds have all electrons paired and are weakly repelled by a magnetic field.
- Example: The complex $[Fe(CN)_6]^{4-}$ is diamagnetic because iron in this complex has all paired electrons, while $[Fe(H_2O)_6]^{2+}$ is paramagnetic due to the presence of unpaired electrons.

6 a) Explain the following with reason :

i) At normal temperature H_2O is liquid and H_2S is gas.

ii) Fluorine does not show any positive oxidation state.

ii) In comparison to phosphorus, nitrogen is comparatively inert.

iv) Amongst all hydrides of group 15 elements, BiH_3 is the strongest reducing agent.

v) The boiling point of noble gases is low.

Answer:

i) At normal temperature, H_2O is a liquid and H_2S is a gas.
- Reason: Water (H_2O) is a liquid at room temperature because it forms strong hydrogen bonds between its molecules. These hydrogen bonds require more energy to break, leading to a higher boiling point.
- Hydrogen sulfide (H_2S), on the other hand, has weaker van der Waals forces due to sulfur's lower electronegativity compared to oxygen, and it does not form strong hydrogen bonds. As a result, H_2S exists as a gas at room temperature.
ii) Fluorine does not show any positive oxidation state.
- Reason: Fluorine is the most electronegative element in the periodic table. Due to its high electronegativity and small size, fluorine always attracts electrons rather than donating them, which makes it impossible for fluorine to show a positive oxidation state. Fluorine is always found in the -1 oxidation state in its compounds.
iii) In comparison to phosphorus, nitrogen is comparatively inert.
- Reason: Nitrogen is inert compared to phosphorus due to the strong triple bond $(N \equiv N)$ in molecular nitrogen (N_2). This triple bond has a very high bond dissociation energy, making it difficult for nitrogen to react under normal conditions.
- Phosphorus, on the other hand, forms single bonds $(P - P)$ in its molecular form (such as white phosphorus), which are weaker apd more reactive than nitrogen's triple bond.

iv) Amongst all hydrides of group 15 elements, BiH_3 is the strongest reducing agent.
- Reason: The reducing strength of hydrides increases down the group in group 15 because the bond strength between the hydrogen and the central atom decreases. In BiH_3, the $Bi - H$ bond is the weakest among the group 15 hydrides due to the large atomic size of bismuth. This makes it easier for BiH_3 to donate hydrogen atoms and act as a strong reducing agent.
v) The boiling point of noble gases is low.
- Reason: Noble gases are monoatomic and have very weak van der Waals forces (London dispersion forces) between their atoms. Since these forces are weak, little energy is required to overcome them, resulting in low boiling points. The boiling points of noble gases increase slightly with increasing atomic size because larger atoms have more electrons, leading to slightly stronger dispersion forces.

b) Write the method for preparation of ether from alkyl halide giving chemical equations. Write the chemical equation for Friedel-Crafts reaction and Nitration reaction.

Answer:

Ethers can be prepared from alkyl halides by Williamson Ether Synthesis, which involves the reaction of an alkyl halide with an alkoxide ion.

General Reaction:

$$R-O^{-}+R'-X \rightarrow R-O-R'+X^{-}$$

Where:
- $R-O^{-}$ is an alkoxide ion.
- R'-X is an alkyl halide.

For example, when sodium ethoxide reacts with ethyl bromide, diethyl ether is formed:

$$C_2H_5ONa+C_2H_5Br \rightarrow C_2H_5OC_2H_5+NaBr$$

Friedel-Crafts Reaction:
The Friedel-Crafts alkylation involves the substitution of an alkyl group onto an aromatic ring using an alkyl halide and a Lewis acid catalyst (such as $AlCl_3$).

General Reaction:

$$C_6H_6+R-Cl \xrightarrow{AlCl_3} C_6H_5R+HCl$$

For example, in the alkylation of benzene with methyl chloride:

$$C_6H_6+CH_3Cl \xrightarrow{AlCl_3} C_6H_5CH_3+HCl$$

Nitration Reaction:
The nitration of an aromatic compound involves the substitution of a nitro group (NO_2) onto the aromatic ring using a mixture of concentrated nitric acid and sulfuric acid.

General Reaction:

$$C_6H_6+HNO_3 \xrightarrow{H_2SO_4} C_6H_5NO_2+H_2O$$

For example, in the nitration of benzene:

$$C_6H_6+HNO_3 \xrightarrow{H_2SO_4} C_6H_5NO_2+H_2O$$

7. a) What are Electrophilic substitution reactions ? Write electrophilic substitution reactions, along with chemical equations, for halogenation, nitration and sulphonation of chlorobenzene.

Answer:

Electrophilic substitution reactions are a type of reaction where an electrophile (an electrondeficient species) replaces a hydrogen atom (or another substituent) in an aromatic ring. These reactions are common for aromatic compounds like benzene and its derivatives. In electrophilic substitution, the aromatic ring acts as a nucleophile and reacts with an electrophile, while maintaining its aromaticity.

Electrophilic Substitution Reactions of Chlorobenzene:
Chlorobenzene (C_6H_5Cl) undergoes electrophilic substitution reactions at the ortho and para positions because the chlorine atom is an electron-donating group through resonance, which increases electron density at these positions.

Here are three key electrophilic substitution reactions for chlorobenzene:

In halogenation, chlorobenzene reacts with bromine (Br_2) in the presence of a Lewis acid catalyst such as iron(III) bromide $(FeBr_3)$. This leads to the substitution of a hydrogen atom at the ortho or para position relative to the chlorine atom, forming ortho-bromochlorobenzene and parabromochlorobenzene.

Reaction:

$$C_6H_5Cl + Br_2 \xrightarrow{FeBr_3} C_6H_4ClBr + HBr$$

The major product is para-bromochlorobenzene, and the minor product is orthobromochlorobenzene.

Nitration involves the reaction of chlorobenzene with a mixture of concentrated nitric acid (HNO_3) and sulfuric acid (H_2SO_4). This generates the nitronium ion (NO_2^+), which acts as the electrophile and substitutes a hydrogen atom at the ortho or para position relative to the chlorine atom, forming ortho-nitrochlorobenzene and para-nitrochlorobenzene.

Reaction:

$$C_6H_5Cl + HNO_3 \xrightarrow{H_2SO_4} C_6H_4ClNO_2 + H_2O$$

The major product is para-nitrochlorobenzene, and the minor product is orthonitrochlorobenzene.

3. Sulphonation (Sulphonation of Chlorobenzene):

Sulphonation occurs when chlorobenzene reacts with concentrated sulfuric acid or fuming sulfuric acid (containing sulfur trioxide, SO_3). This reaction substitutes a hydrogen atom at the ortho or para position with a sulfonic acid group $(-SO_3H)$, forming ortho-chlorobenzenesulfonic acid and para-chlorobenzenesulfonic acid.

Reaction:

$$C_6H_5Cl + H_2SO_4 \rightarrow C_6H_4ClSO_3H + H_2O$$

The major product is para-chlorobenzenesulfonic acid, and the minor product is orthochlorobenzenesulfonic acid.

b) Explain the following :
i) Cannizzaro reaction

Answer:

i) Cannizzaro Reaction:

The Cannizzaro reaction is a redox reaction that occurs when an aldehyde without an alphahydrogen (i.e., a non-enolizable aldehyde) is treated with a strong base, such as concentrated sodium hydroxide $(NaOH)$. In this reaction, one molecule of the aldehyde is oxidized to a carboxylate ion, and another molecule of the aldehyde is reduced to an alcohol.

This reaction is particularly observed in aldehydes like formaldehyde and benzaldehyde, which lack an alpha-hydrogen.

General Reaction:

$$2RCHO \xrightarrow{NaOH} RCOO^- + RCH_2OH$$

Example with Benzaldehyde:

$$2C_6H_5CHO \xrightarrow{NaOH} C_6H_5COO^- + C_6H_5CH_2OH$$

In this example, benzaldehyde undergoes the Cannizzaro reaction, yielding sodium benzoate (the carboxylate) and benzyl alcohol.

ii) Cross Aldol condensation.

Answer:

Cross Aldol condensation is a reaction between two different aldehydes or ketones, at least one of which has an alpha-hydrogen. In the presence of a base, the carbonyl compounds undergo an aldol condensation, where the alpha-hydrogen of one compound (acting as the nucleophile) reacts with the carbonyl group of another compound (acting as the electrophile), forming a betahydroxy aldehyde or beta-hydroxy ketone. This product can further undergo dehydration to form an α, β-unsaturated aldehyde or ketone.

In a cross aldol condensation, the reactants are two different carbonyl compounds. However, for a successful reaction, it's ideal if one of the reactants lacks an alpha-hydrogen (so it can't undergo self-condensation).

General Reaction:

$$\text{Aldehyde}_1 + \text{Aldehyde}_2 \xrightarrow{\text{Base}} \text{Aldol product} \rightarrow \alpha, \beta\text{-unsaturated aldehyde or ketone}$$

Example:

If acetaldehyde (CH_3CHO) reacts with benzaldehyde (C_6H_5CHO) in the presence of a base:

$$CH_3CHO + C_6H_5CHO \xrightarrow{NaOH} C_6H_5CH = CHCHO + H_2O$$