JEE Main 2024 April 5 Shift 2 Chemistry Question Paper with solution

Time Allowed :1 Hour	**Maximum Marks :**100	**Total Questions :**30

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours duration.
2. The question paper consists of 90 questions. The maximum marks are 300.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage.
4. Each part (subject) has two sections.
   (i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and –1 mark for wrong answer.
   (ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

Chemistry

Question 1: Match List-I with List-II.

List-I	**List-II**
(A) ICl	(I) T-Shape
(B) ICl_3	(II) Square pyramidal
(C) ClF_5	(III) Pentagonal bipyramidal
(D) IF_7	(IV) Linear

Options:
(1) (A)–(I), (B)–(IV), C–(III), D–(II)
(2) (A)–(I), (B)–(III), C–(II), D–(IV)
(3) (A)–(IV), (B)–(I), C–(II), D–(III)
(4) (A)–(IV), (B)–(III), C–(II), D–(I)

Answer: (3)
(A) - (IV), (B) - (I), (C) - (II), (D) - (III)

Solution:
To determine the correct matches, we analyze the molecular geometry of each compound based on the number of bond pairs and lone pairs of electrons around the central atom.
Step 1: Molecular geometry of ICl ICl consists of only two atoms (iodine and chlorine), forming a diatomic molecule. Its molecular geometry is linear. Thus:

$$\text{(A) ICl} \rightarrow \text{(IV) Linear.}$$

Step 2: Molecular geometry of ICl_3 ICl_3 has 3 bond pairs and 2 lone pairs around the iodine atom. According to the VSEPR theory, this results in a T-shaped molecular geometry. Thus:

$$\text{(B) } ICl_3 \rightarrow \text{(I) T-Shape.}$$

Step 3: Molecular geometry of ClF_5 ClF_5 has 5 bond pairs and 1 lone pair around the central chlorine atom. According to the VSEPR theory, this configuration forms a square pyramidal geometry. Thus:

$$\text{(C) } ClF_5 \rightarrow \text{(II) Square pyramidal.}$$

Step 4: Molecular geometry of IF_7 IF_7 has 7 bond pairs and no lone pairs around the iodine atom. This configuration corresponds to a pentagonal bipyramidal geometry. Thus:

$$\text{(D) } IF_7 \rightarrow \text{(III) Pentagonal bipyramidal.}$$

Final Matches

$$\text{(A) - (IV)}, \quad \text{(B) - (I)}, \quad \text{(C) - (II)}, \quad \text{(D) - (III)}.$$

Correct Answer: (3)

Quick Tip

The VSEPR theory is a powerful tool to predict the geometry of molecules. The number of bond pairs and lone pairs around the central atom determines the molecular shape.

Question 2: While preparing crystals of Mohr's salt, dil. H_2SO_4 is added to a mixture of ferrous sulphate and ammonium sulphate. Before dissolving this mixture in water, dil. H_2SO_4 is added here to:

Options:
(1) prevent the hydrolysis of ferrous sulphate
(2) prevent the hydrolysis of ammonium sulphate
(3) make the medium strongly acidic
(4) increase the rate of formation of crystals

Answer: (1)

Solution:
When preparing Mohr's salt, H_2SO_4 is added for the following reasons:

Step 1: Understanding the role of H_2SO_4 Ferrous sulphate is prone to hydrolysis in aqueous solutions, especially when exposed to atmospheric oxygen. The hydrolysis leads to the formation of ferric hydroxide, which can contaminate the Mohr's salt crystals.

Adding dilute sulphuric acid prevents the hydrolysis of ferrous sulphate by maintaining an acidic medium, which stabilizes the ferrous ions and prevents oxidation or decomposition.

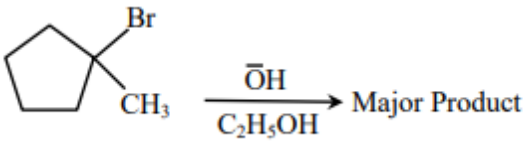
Step 2: Reason for not choosing other options - Option (2): Ammonium sulphate does not hydrolyze under normal conditions, so preventing its hydrolysis is irrelevant. - Option (3): Although adding H_2SO_4 makes the medium acidic, the main purpose is to prevent hydrolysis. - Option (4): The rate of formation of crystals is not directly influenced by H_2SO_4 but rather by cooling and saturation.

Conclusion The correct reason for adding H_2SO_4 is to prevent the hydrolysis of ferrous sulphate.

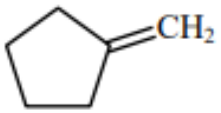
Quick Tip

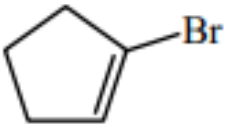
While preparing salts like Mohr's salt, it is crucial to maintain the stability of ferrous ions by adding acids to prevent unwanted hydrolysis or oxidation.

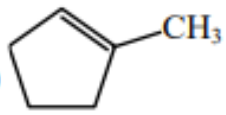
Question 3: Identify the major product in the following reaction.

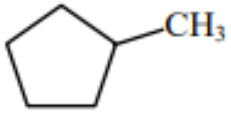


Options:

(1) 

(2) 

(3) 

(4) 

Answer: (3)

Solution:

This is an elimination reaction (E2 mechanism) where the hydroxide ion acts as a strong base. The steps of the reaction are as follows:

Step 1: Identify the base and leaving group In the presence of OH^- and EtOH, the bromine atom (Br) acts as the leaving group. The hydroxide ion abstracts a proton (H^+) from the adjacent carbon atom, resulting in the formation of a double bond.

Step 2: Formation of the double bond Since the reaction proceeds via the E2 mechanism, the elimination occurs in a single step. The base removes a -hydrogen atom (attached to the carbon next to the carbon with Br), and the Br^- leaves, resulting in the formation of a double bond between the and carbons.

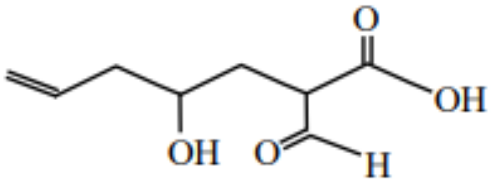
Step 3: Determine the major product The double bond forms between the -carbon and the -carbon (the one originally bonded to the bromine atom). Due to Zaitsev's rule, the most substituted alkene is the major product. Hence, the major product is cyclopentene with a methyl (CH_3) substituent.

Final Answer: (3) Cyclopentene with a CH_3 substituent.

Quick Tip

In E2 reactions, the base removes a -hydrogen, and the product follows Zaitsev's rule, favoring the formation of the more substituted alkene.

Question 4: The correct nomenclature for the following compound is:



Options:
(1) 2-carboxy-4-hydroxyhept-6-enal
(2) 2-carboxy-4-hydroxyhept-7-enal
(3) 2-formyl-4-hydroxyhept-6-enoic acid
(4) 2-formyl-4-hydroxyhept-7-enoic acid

Answer: (3)

Solution:
To determine the correct IUPAC nomenclature, follow these steps:

Step 1: Identify the parent chain The parent chain consists of 7 carbon atoms (hept-) with a double bond at the 6th carbon (hept-6-en-).

Step 2: Functional groups and priority The compound contains the following functional groups: 1. A formyl group ($-CHO$) at the 2nd carbon, 2. A hydroxyl group ($-OH$) at the 4th carbon, 3. A carboxylic acid group ($-COOH$) at the end of the chain.

The carboxylic acid group has the highest priority, so the chain is named as a derivative of "hept-6-enoic acid".

Step 3: Naming the substituents 1. The $-CHO$ group is named as "formyl" since it is a substituent and not the main functional group. 2. The $-OH$ group is named as "hydroxy".

Step 4: Combine the name The substituents and parent chain are combined in the order of their positions:

2-formyl-4-hydroxyhept-6-enoic acid.

Step 5: Validate the given options From the options provided, the correct name matches:

(3) 2-formyl-4-hydroxyhept-6-enoic acid.

Final Answer: (3)

Quick Tip

When naming compounds, always prioritize functional groups based on IUPAC rules. The carboxylic acid group takes precedence over aldehydes and alcohols in the nomenclature.

Question 5: Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R).

Assertion (A): NH_3 and NF_3 molecules have a pyramidal shape with a lone pair of electrons on the nitrogen atom. The resultant dipole moment of $NH3$ is greater than that of NF_3.
Reason (R): In $NH3$, the orbital dipole due to the lone pair is in the same direction as the resultant dipole moment of the $N-H$ bonds. F is the most electronegative element.

In the light of the above statements, choose the correct answer from the options given below:

Options:
(1) Both (A) and (R) are true, and (R) is the correct explanation of (A).
(2) (A) is false, but (R) is true.
(3) (A) is true, but (R) is false.

(4) Both (A) and (R) are true, but (R) is NOT the correct explanation of (A).

Answer: (1)

Solution:
The analysis of the molecules $NH3$ and $NF3$ is as follows:
Step 1: Structure and dipole moment of NH_3 - NH_3 has a pyramidal shape due to the presence of one lone pair on the nitrogen atom. - The dipole moments of the $N-H$ bonds and the lone pair point in the same direction, leading to a higher resultant dipole moment.
Step 2: Structure and dipole moment of NF_3 - NF_3 also has a pyramidal shape, but the $N-F$ bonds are highly electronegative. - The dipole moment of the lone pair on nitrogen is opposite to the resultant dipole moment of the $N-F$ bonds, which reduces the overall dipole moment.
Step 3: Comparison of dipole moments - The dipole moment of NH_3 is approximately 1.47 D, while that of NF_3 is approximately 0.80 D. - This confirms that $NH3$ has a greater dipole moment than $NF3$.
Step 4: Validating the statements - Assertion (A): True, because NH_3 has a higher dipole moment than NF_3. - Reason (R): True, as the lone pair's dipole in NH_3 aligns with the bond dipoles, while in NF_3, it opposes them. - (R) is the correct explanation of (A).
Final Answer: (1)

Quick Tip

The net dipole moment of a molecule depends on the vector sum of the bond dipoles and the dipole moment due to lone pairs. Opposing directions reduce the overall dipole moment.

Question 6: Given below are two statements:

Statement I: On passing $HCl(g)$ through a saturated solution of $BaCl_2$, at room temperature, white turbidity appears.
Statement II: When $HCl(g)$ is passed through a saturated solution of $NaCl$, sodium chloride is precipitated due to the common ion effect.

In the light of the above statements, choose the most appropriate answer from the options given below:

Options:
(1) Statement I is correct but Statement II is incorrect
(2) Both Statement I and Statement II are incorrect
(3) Statement I is incorrect but Statement II is correct
(4) Both Statement I and Statement II are correct

Answer: (1)

Solution:

To determine the correctness of the statements, consider the solubility and precipitation behavior of $BaCl2$ and $NaCl$ in the presence of $HCl(g)$:

Step 1: Analyze Statement I When $HCl(g)$ is bubbled through a saturated solution of $BaCl2$, the concentration of Cl^- ions increases significantly due to the dissociation of HCl. The increased Cl^- ions reduce the solubility of $BaCl_2$ through the common ion effect, causing the precipitation of $BaCl2$ as white turbidity.
Statement I is correct.

Step 2: Analyze Statement II Sodium chloride ($NaCl$) is highly soluble in water. Passing $HCl(g)$ through a saturated solution of $NaCl$ does not lead to precipitation because the solubility of $NaCl$ is not significantly affected by the common ion effect under these conditions.
Statement II is incorrect.

Step 3: Conclusion From the above analysis: - Statement I is correct, but Statement II is incorrect.
Final Answer: (1)

Quick Tip

The common ion effect reduces the solubility of ionic compounds in solutions containing a common ion. However, highly soluble salts like $NaCl$ are not significantly affected.

Question 7:
The metal atom present in the complex $MABXL$ (where A, B, X, and L are unidentate ligands and M is metal) involves sp^3 hybridization. The number of geometrical isomers exhibited by the complex is:

Options:
(1) 4
(2) 0
(3) 2
(4) 3

Answer: (2)

Solution:
Step 1: Understanding sp^3 hybridization In a complex with sp^3 hybridization, the geometry is tetrahedral. Tetrahedral complexes do not exhibit geometrical isomerism because all positions around the central atom are equivalent in three-dimensional space.

Step 2: Analysis of the given complex The complex $MABXL$ has four unidentate ligands arranged tetrahedrally around the metal center. Since the tetrahedral geometry does not allow for distinct arrangements of ligands that result in different spatial configurations, geometrical

isomerism is not possible.

Conclusion The number of geometrical isomers for the complex $MABXL$ is:

0.

Final Answer: (2)

> **Quick Tip**
>
> Geometrical isomerism is only possible in complexes with square planar or octahedral geometries. Tetrahedral complexes do not exhibit this type of isomerism.

Question 8: Match List-I with List-II.

List-I (Pair of Compounds)	**List-II (Isomerism)**
(A) n-propanol and isopropanol	(I) Metamerism
(B) Methoxypropane and ethoxyethane	(II) Chain Isomerism
(C) Propanone and propanal	(III) Position Isomerism
(D) Neopentane and isopentane	(IV) Functional Isomerism

Options:
(1) (A)–(III), (B)–(I), (C)–(IV), (D)–(II)
(2) (A)–(II), (B)–(I), (C)–(IV), (D)–(III)
(3) (A)–(I), (B)–(III), (C)–(IV), (D)–(II)
(4) (A)–(IV), (B)–(I), (C)–(III), (D)–(II)

Answer: (4)

Solution:
To determine the correct matches, we analyze the isomeric relationships of the compounds in List-I:
Step 1: Analyze (A) n-propanol and isopropanol - n-propanol ($CH_3CH_2CH_2OH$) and isopropanol ($CH_3CHOHCH_3$) differ in their functional group positions. This is an example of **functional isomerism**.

(A) - (IV)

Step 2: Analyze (B) Methoxypropane and ethoxyethane - Methoxypropane ($CH_3OCH_2CH_2CH_3$) and ethoxyethane ($CH_3CH_2OCH_2CH_3$) differ in the arrangement of the ether groups. This is an example of **metamerism**.

(B) - (I)

Step 3: Analyze (C) Propanone and propanal - Propanone (CH_3COCH_3) and propanal ($CH3CH2CHO$) have different functional groups (ketone vs. aldehyde). This is an example of **functional isomerism**.

(C) - (III)

Step 4: Analyze (D) Neopentane and isopentane - Neopentane ($C(CH_3)_4$) and isopentane ($CH_3CH(CH_3)CH_2CH_3$) differ in the arrangement of their carbon chains. This is an example of **chain isomerism**.

$$\text{(D) - (II)}$$

Final Matches

$$\text{(A) - (IV)}, \quad \text{(B) - (I)}, \quad \text{(C) - (III)}, \quad \text{(D) - (II)}.$$

Correct Answer: (4)

Quick Tip

Isomerism can be classified based on structural differences (e.g., chain, position, and functional isomerism) or spatial arrangement differences (stereoisomerism). Analyze the molecular structure carefully to determine the type.

Question 9: The quantity of silver deposited when one coulomb charge is passed through $AgNO_3$ solution:

Options:
(1) 0.1 g atom of silver
(2) 1 chemical equivalent of silver
(3) 1 g of silver
(4) 1 electrochemical equivalent of silver

Answer: (4)

Solution:
The amount of a substance deposited during electrolysis is determined using Faraday's laws of electrolysis. The formula is:

$$W = ZIt,$$

where: - W is the mass of the substance deposited, - Z is the electrochemical equivalent of the substance, - I is the current passed, and - t is the time for which the current is passed.
Step 1: Relating charge to electrochemical equivalent We know that:

$$Q = It,$$

where Q is the total charge passed through the solution. Substituting this into the equation for W, we get:

$$W = ZQ.$$

Step 2: Deposition of silver For one coulomb of charge ($Q = 1\,\text{C}$), the mass of silver deposited is directly proportional to the electrochemical equivalent (Z) of silver. Thus:

$$W = ZQ = \text{(electrochemical equivalent of silver)}.$$

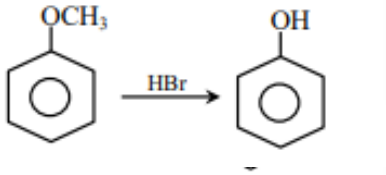
Step 3: Conclusion The quantity of silver deposited when one coulomb of charge is passed is equal to the electrochemical equivalent of silver. This matches the given option.

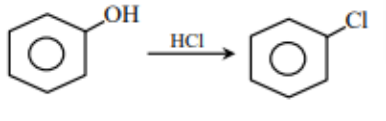
Final Answer: (4)

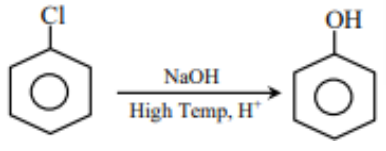
> Quick Tip
>
> To calculate the mass deposited during electrolysis, always use $W = ZIt$, where Z is the electrochemical equivalent. For one coulomb of charge, $W = Z$.

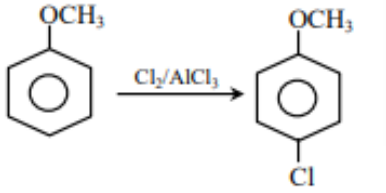
Question 10: Which one of the following reactions is NOT possible?

Options:

(1) 

(2) 

(3) 

(4) 

Answer: (2)

Solution:

Step 1: Analyze each reaction

1. **Reaction (1):**

The reaction involves the cleavage of the ether bond ($C - OCH_3$) by HBr, producing phenol ($C_6H_5 - OH$). This reaction is possible due to the nucleophilic substitution mechanism.

2. **Reaction (2):**

The reaction involves the conversion of phenol ($C6H5 - OH$) to chlorobenzene ($C_6H_5 - Cl$) by HCl. However, this reaction is **NOT** possible because the hydroxyl group in phenol is directly attached to the benzene ring, and it does not undergo nucleophilic substitution to form $C_6H_5 - Cl$. The lone pair on oxygen in phenol makes the $-OH$ group resistant to substitution by HCl.

3. **Reaction (3):**

The reaction involves the hydrolysis of chlorobenzene ($C_6H_5 - Cl$) under high temperature

and pressure in the presence of $NaOH$. This reaction is possible via nucleophilic aromatic substitution, producing phenol ($C6H5 - OH$).

4. **Reaction (4):**
The reaction involves the electrophilic substitution of anisole ($C_6H_5 - OCH_3$) with chlorine in the presence of $AlCl3$. This reaction is possible, producing a mixture of ortho and para substituted products.

Step 2: Conclusion Among the given reactions, only Reaction (2) is not possible because phenol does not undergo nucleophilic substitution with HCl to form chlorobenzene.

Final Answer: (2)

> Quick Tip
>
> Phenol ($C6H5 - OH$) does not react with HCl to form chlorobenzene because the $-OH$ group is strongly bonded to the benzene ring, making nucleophilic substitution reactions difficult.

Question 11: Given below are two statements:

Statement I: The metallic radius of Na is 1.86 Å, and the ionic radius of Na^+ is lesser than 1.86 Å.
Statement II: Ions are always smaller in size than the corresponding elements.

In the light of the above statements, choose the correct answer from the options given below:

Options:
(1) Statement I is correct but Statement II is false
(2) Both Statement I and Statement II are true
(3) Both Statement I and Statement II are false
(4) Statement I is incorrect but Statement II is true

Answer: (1)

Solution:
Step 1: Analysis of Statement I
- The metallic radius of Na (neutral sodium atom) is 1.86 Å.
- The ionic radius of Na^+ is smaller than the neutral atom because Na^+ has one less electron, resulting in reduced electron-electron repulsion and greater effective nuclear charge on the remaining electrons. - Thus, **Statement I is correct**.

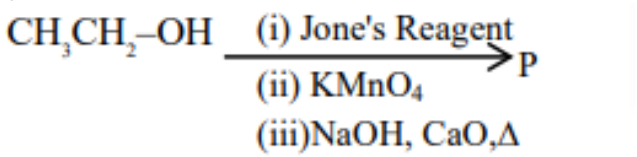
Step 2: Analysis of Statement II - While cations (Na^+) are always smaller than their corresponding neutral atoms, anions (e.g., Cl^-) are larger than their corresponding neutral atoms due to increased electron-electron repulsion in the outer shell.

- Hence, ions are **not always smaller** than the corresponding elements.
- Thus, **Statement II is false**.

Step 3: Conclusion - Statement I is correct, but Statement II is false.
Final Answer: (1)

> Quick Tip
>
> Cations are smaller than their neutral atoms due to the loss of electrons, while anions are larger than their neutral atoms because of increased electron-electron repulsion.

Question 12:



Consider the above reaction sequence and identify the major product P.

Options:
(1) Methane
(2) Methanal
(3) Methoxymethane
(4) Methanoic acid

Answer: (1)

Solution:
The reaction sequence is as follows:
Step 1: Oxidation using Jones Reagent - Jones reagent ($CrO_3 + H_2SO_4$) oxidizes primary alcohols (CH_3CH_2OH) to carboxylic acids. Ethanol (CH_3CH_2OH) is oxidized to acetic acid (CH_3COOH).

$$CH_3CH_2OH -> [JonesReagent]CH_3COOH$$

Step 2: Oxidation using $KMnO_4$ - The acetic acid (CH_3COOH) is further oxidized to carbonic acid (H_2CO_3) by $KMnO_4$. Carbonic acid is unstable and decomposes to CO_2 and water.

$$CH_3COOH -> [KMnO_4]H_2CO_3 -> CO_2 + H_2O$$

Step 3: Decarboxylation using Soda Lime - The carbon dioxide (CO_2) reacts with soda lime ($NaOH + CaO$) to form methane (CH_4) via decarboxylation.

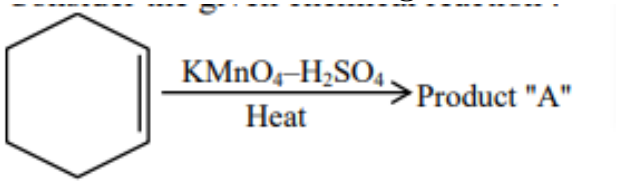
$$CO_2 + NaOH -> CH_4 + Na_2CO_3$$

Final Product The major product P is methane (CH_4).
Final Answer: (1)

Quick Tip

Soda lime decarboxylation is a common reaction for converting carboxylic acids or their derivatives to alkanes by removing the $CO2$ group.

Question 13: Consider the given chemical reaction:



Product "A" is:

Options:
(1) Picric acid
(2) Oxalic acid
(3) Acetic acid
(4) Adipic acid

Answer: (4)

Solution:
The reaction of cyclohexane with potassium permanganate ($KMnO_4$) in an acidic medium (H_2SO_4) and heat results in the oxidation of cyclohexane to adipic acid.

Step 1: Oxidation of cyclohexane - Cyclohexane (C_6H_{12}) undergoes oxidation in the presence of $KMnO_4$ and H_2SO_4. - The $KMnO_4$ oxidizes the $-CH_2-$ groups in cyclohexane to carboxylic acid ($-COOH$) groups. - This results in the formation of adipic acid ($HOOC-(CH_2)_4-COOH$).

$$C_6H_{12}- > [KMnO_4, H_2SO_4, Heat]HOOC-(CH_2)_4-COOH(AdipicAcid)$$

Step 2: Conclusion The product A is adipic acid.

Final Answer: (4)

Quick Tip

Oxidation reactions with $KMnO4$ in acidic conditions are effective for converting cyclic alkanes or alkenes into di-carboxylic acids.

Question 14: For the electrochemical cell:

$$M—M^{2+}||X—X^{2-}$$

If:

$$E^\circ(\mathrm{M}^{2+}/\mathrm{M}) = 0.46\,\mathrm{V}, \quad E^\circ(\mathrm{X}/\mathrm{X}^{2-}) = 0.34\,\mathrm{V},$$

Which of the following is correct?

Options:
(1) $E_{\text{cell}} = -0.80\,\mathrm{V}$
(2) $M + X^{2-} -> M^{2+} + X^{2-}$ is a spontaneous reaction
(3) $M^{2+} + X^{2-} -> M + X$ is a spontaneous reaction
(4) $E_{\text{cell}} = 0.80\,\mathrm{V}$

Answer: (3)

Solution:
The standard cell potential E°_{cell} is calculated as:

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}.$$

Step 1: Identify the anode and cathode - $E^\circ(\mathrm{M}^{2+}/\mathrm{M}) = 0.46\,\mathrm{V}$, - $E^\circ(\mathrm{X}/\mathrm{X}^{2-}) = 0.34\,\mathrm{V}$.
Since M^{2+}/M has a higher reduction potential, it will act as the cathode, and X/X^{2-} will act as the anode.
Step 2: Calculate E°_{cell}

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = 0.34 - 0.46 = -0.12\,\mathrm{V}.$$

Step 3: Analyze the spontaneity of the reaction - Since E°_{cell} is negative, the reaction will proceed in the reverse direction (the reverse reaction is spontaneous). - The spontaneous reaction is:

$$M^{2+} + X^{2-} -> M + X.$$

Step 4: Validate the options - Option (1): Incorrect, as $E_{\text{cell}} = -0.12\,\mathrm{V}$, not $-0.80\,\mathrm{V}$. - Option (2): Incorrect, as $M + X^{2-} -> M^{2+} + X^{2-}$ is not spontaneous. - Option (3): Correct, as $M^{2+} + X^{2-} -> M + X$ is the spontaneous reaction. - Option (4): Incorrect, as $E_{\text{cell}} = -0.12\,\mathrm{V}$, not $0.80\,\mathrm{V}$.

Final Answer: (3)

> **Quick Tip**
>
> The direction of spontaneity in an electrochemical reaction can be determined by the sign of E°_{cell}. A negative E°_{cell} indicates that the reverse reaction is spontaneous.

Question 15: The number of moles of methane required to produce 11 g of $CO_2(g)$ after complete combustion is:
(Given molar mass of methane in g mol^{-1}: 16)

Options:
(1) 0.75

(2) 0.25
(3) 0.35
(4) 0.5

Answer: (2)

Solution:
The general combustion reaction of alkanes is:

$$C_nH_{2n+2} + \frac{3n+1}{2}O2- > nCO2 + (n+1)H2O.$$

For methane (CH_4), the specific balanced equation is:

$$CH_4 + 2O_2- > CO_2 + 2H_2O.$$

Step 1: Molar mass of CO_2 The molar mass of CO_2 is:

$$\text{Molar mass of } CO_2 = 12 + (2 \times 16) = 44\,\text{g/mol}.$$

Step 2: Calculate moles of CO_2 The number of moles of CO_2 in 11 g is:

$$\text{Moles of } CO_2 = \frac{\text{Mass of } CO2}{\text{Molar mass of } CO_2} = \frac{11}{44} = 0.25\,\text{mol}.$$

Step 3: Relate CH_4 to CO_2 From the balanced reaction: - 1 mole of CH_4 produces 1 mole of CO_2.
Therefore, to produce 0.25 moles of CO_2, the moles of CH_4 required are:

$$\text{Moles of } CH4 = 0.25\,\text{mol}.$$

Step 4: Mass of CH_4 The mass of 0.25 moles of CH_4 can be verified as:

$$\text{Mass of } CH_4 = \text{Moles of } CH_4 \times \text{Molar mass of } CH_4 = 0.25 \times 16 = 4\,\text{g}.$$

Conclusion The number of moles of methane required to produce 11 g of CO_2 is 0.25 mol.
Final Answer: (2)

Quick Tip

To solve combustion problems, always start with the balanced equation, calculate moles using molar masses, and use stoichiometric ratios to relate reactants and products.

Question 16: The number of complexes from the following with no electrons in the t_2 orbital is:

$$TiCl_4, [MnO_4]^-, [FeO_4]^{2-}, [FeCl_4]^-, [CoCl_4]^{2-}$$

Options:
(1) 3

(2) 1
(3) 4
(4) 2

Answer: (1) Solution:

To determine the number of complexes with no electrons in the t_2 orbital, analyze each complex and its oxidation state, electronic configuration, and crystal field splitting.

Step 1: Analyze each complex 1. $TiCl4$: - Oxidation state of Ti: +4 (Ti^4+). - Electronic configuration of Ti^4+: $3d^0$. - No electrons in t_2 orbitals.

2. $[MnO4]^-$: - Oxidation state of Mn: +7 (Mn^7+). - Electronic configuration of Mn^7+: $3d^0$. - No electrons in t_2 orbitals.

3. $[FeO4]^{2-}$: - Oxidation state of Fe: +6 (Fe^6+). - Electronic configuration of Fe^6+: $3d^0$. - No electrons in t_2 orbitals.

4. $[FeCl4]^-$: - Oxidation state of Fe: +2 (Fe^2+). - Electronic configuration of Fe^2+: $3d^6$. - t_2 orbitals are populated with electrons ($t_2^3e^3$).

5. $[CoCl4]^{2-}$: - Oxidation state of Co: +2 (Co^2+). - Electronic configuration of Co^2+: $3d^7$. - t_2 orbitals are populated with electrons ($t_2^4e^3$).

Step 2: Count complexes with no t_2 electrons - $TiCl4$, $[MnO4]^-$, and $[FeO4]^{2-}$ have no electrons in t_2 orbitals. - $[FeCl4]^-$ and $[CoCl4]^{2-}$ have electrons in t_2 orbitals.

Conclusion The number of complexes with no electrons in the t_2 orbital is:
3 (TiCl4, $[MnO4]^-$, $[FeO4]^{2-}$). Final Answer: (1)

Quick Tip

The t_2 orbital is unoccupied in complexes with a $3d^0$ electronic configuration, typically for ions with high oxidation states.

Question 17: The number of ions from the following that have the ability to liberate hydrogen from a dilute acid is _____: Ti^{2+}, Cr^{2+}, V^{2+}

Options:
(1) 0
(2) 2
(3) 3
(4) 1

Answer: (3)

Solution:
To determine the number of ions that can liberate hydrogen from a dilute acid, we need to analyze their reducing abilities. Strong reducing agents can donate electrons to H^+, reducing it to H_2.

Step 1: Evaluate Ti^{2+} - Titanium(II) (Ti^{2+}) has a strong tendency to get oxidized to Ti^{3+}, making it a strong reducing agent. - It can react with H^+ from dilute acids to liberate $H2$.

Step 2: Evaluate Cr^{2+} - Chromium(II) (Cr^{2+}) is a strong reducing agent and can be oxidized to Cr^{3+}. - It reacts with H^+ from dilute acids to liberate $H2$.

$$2Cr^{2+}(aq) + 2H^+(aq) -> 2Cr^{3+}(aq) + H2(g)$$

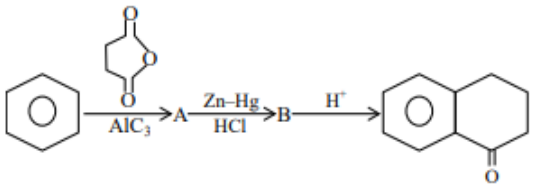
Step 3: Evaluate V^{2+} - Vanadium(II) (V^{2+}) is also a strong reducing agent and can be oxidized to V^{3+}. - It reacts with H^+ from dilute acids to liberate $H2$.

Conclusion All three ions (Ti^{2+}, Cr^{2+}, and V^{2+}) can liberate $H2$ from dilute acids.
Final Answer: (3)

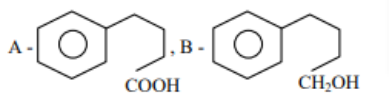
Quick Tip

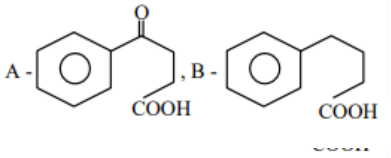
Reducing agents with low oxidation states tend to liberate $H2$ from dilute acids by reducing H^+ ions. Check the tendency of each ion to get oxidized.

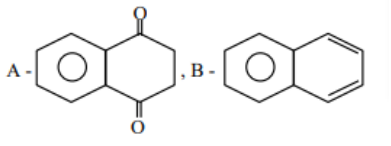
Question 18: Identify A and B in the given chemical reaction sequence : -

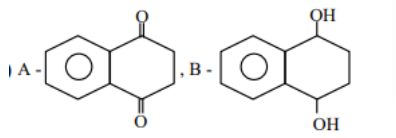


Options:

(1)


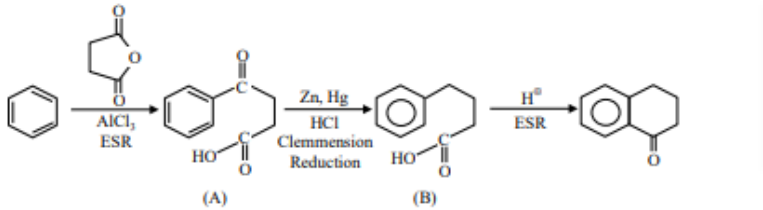
(2)


(3)


(4) 

Answer: (3)

Solution:



The given sequence involves the following steps:

Step 1: Friedel-Crafts Acylation - Benzene (C_6H_6) reacts with acetyl chloride (CH_3COCl) in the presence of $AlCl_3$, an electrophilic catalyst. - This forms acetophenone ($C_6H_5COCH_3$) as compound A.

$$C_6H_6 + CH_3COCl- > [AlCl_3]C_6H_5COCH_3(A).$$

Step 2: Clemmensen Reduction - Acetophenone ($C_6H_5COCH_3$) undergoes Clemmensen reduction using zinc amalgam ($Zn - Hg$) and hydrochloric acid (HCl). - The carbonyl group ($-CO$) is reduced to a methylene group ($-CH_2-$), resulting in ethylbenzene ($C6H5CH2CH3$) as compound B.

$$C6H5COCH3- > [Zn - Hg, HCl]C_6H_5CH_2CH_3(B).$$

Step 3: Acidic Oxidation - Ethylbenzene reacts with H^+ under oxidation conditions to form acetophenone again. This completes the reaction cycle.

Final Products - $A = C_6H_5COCH_3$ (Acetophenone). - $B = C_6H_5CH_2CH_3$ (Ethylbenzene).

Conclusion The correct identification of A and B is given in option (3).

Final Answer: (3)

Quick Tip

Friedel-Crafts acylation is useful for introducing carbonyl groups, while Clemmensen reduction selectively reduces carbonyl groups to methylene groups.

Question 19: The correct statements from the following are:

(A) The decreasing order of atomic radii of group 13 elements is $Tl > In > Ga > Al > B$.
(B) Down the group 13, electronegativity decreases from top to bottom.

(C) Al dissolves in dilute HCl and liberates $H2$, but concentrated $HNO3$ renders Al passive by forming a protective oxide layer on the surface.
(D) All elements of group 13 exhibit a highly stable $+1$ oxidation state.
(E) Hybridization of Al in $[Al(H2O)_6]^{3+}$ ion is sp^3d^2.

Choose the correct answer from the options given below:

Options:
(1) (C) and (E) only
(2) (A), (C) and (E) only
(3) (A), (B), (C) and (E) only
(4) (A) and (C) only

Answer: (1)

Solution:
Step 1: Analyze each statement
1. Statement (A): - The correct order of atomic radii in group 13 elements is $Tl > In > Al > Ga > B$, not $Tl > In > Ga > Al > B$. - **This statement is incorrect.**

2. Statement (B): - Down the group, electronegativity generally decreases. However, due to the presence of d-electrons in Ga, In, and Tl, their electronegativity values do not follow a simple trend. - **This statement is incorrect.**

3. Statement (C): - Al reacts with dilute HCl to release H_2:

$$2Al + 6HCl- > 2AlCl_3 + 3H_2.$$

- Concentrated HNO_3 forms a passive oxide layer on Al, protecting it from further reaction. - **This statement is correct.**

4. Statement (D): - In group 13, the $+3$ oxidation state is more stable than $+1$. The $+1$ state is exhibited by Tl due to the inert pair effect, but it is not highly stable for all elements. - **This statement is incorrect.**

5. Statement (E): - In $[Al(H_2O)_6]^{3+}$, the hybridization of Al is sp^3d^2, corresponding to an octahedral geometry. - **This statement is correct.**

Step 2: Conclusion The correct statements are (C) and (E).

Final Answer: (1)

Quick Tip

When analyzing periodic trends and chemical properties, always cross-check with known exceptions, such as the inert pair effect and irregularities in electronegativity trends.

Question 20: Coagulation of egg, on heating, is because of:

Options:
(1) Denaturation of protein occurs
(2) The secondary structure of protein remains unchanged
(3) Breaking of the peptide linkage in the primary structure of protein occurs
(4) Biological property of protein remains unchanged

Answer: (1)

Solution:
Coagulation of an egg upon heating is due to the denaturation of protein. Denaturation involves: - The disruption of the secondary, tertiary, and quaternary structures of the protein. - The breaking of weak bonds, such as hydrogen bonds and hydrophobic interactions, while leaving the primary structure (peptide bonds) intact.

Key Explanation: - Denaturation alters the protein's native conformation, leading to coagulation (solidification). - The biological properties of the protein are lost due to denaturation.

Incorrect Options: (2) The secondary structure of the protein does not remain unchanged; it is disrupted during denaturation.
(3) The peptide bonds in the primary structure are not broken during coagulation.
(4) The biological properties of the protein do not remain unchanged; they are lost due to denaturation.

Final Answer: (1)

Quick Tip

Denaturation of proteins is caused by heat, strong acids, or bases and disrupts higher-order structures, leading to loss of solubility and biological function.

Question 21: Combustion of 1 mole of benzene is expressed as:

$$C_6H_6(l) + \frac{15}{2}O_2(g) -> 6CO_2(g) + 3H_2O(l)$$

The standard enthalpy of combustion of 2 mol of benzene is $-x$ kJ. Calculate the value of x given the following data:
Standard enthalpy of formation of $C_6H_6(l)$: $48.5\,\text{kJ mol}^{-1}$.
Standard enthalpy of formation of $CO_2(g)$: $-393.5\,\text{kJ mol}^{-1}$.
Standard enthalpy of formation of $H_2O(l)$: $-286\,\text{kJ mol}^{-1}$.

Answer: $6535\,\text{kJ}$

Solution:

The enthalpy change for the combustion reaction can be calculated using Hess's law:

$$\Delta H = \sum \Delta H_f(\text{products}) - \sum \Delta H_f(\text{reactants}).$$

Step 1: Write the given reaction The reaction for 1 mole of benzene is:

$$C_6H_6(l) + \frac{15}{2}O_2(g) -> 6CO_2(g) + 3H_2O(l).$$

Step 2: Calculate the enthalpy change for 1 mole of benzene Using the standard enthalpies of formation:

$$\Delta H_f(CO_2(g)) = -393.5\,\text{kJ/mol},$$
$$\Delta H_f(H_2O(l)) = -286\,\text{kJ/mol},$$
$$\Delta H_f(C_6H_6(l)) = 48.5\,\text{kJ/mol}.$$

For the products:

$$\Delta H_f(\text{products}) = [6 \times (-393.5)] + [3 \times (-286)].$$
$$\Delta H_f(\text{products}) = -2361 - 858 = -3219\,\text{kJ/mol}.$$

For the reactants:

$$\Delta H_f(\text{reactants}) = [1 \times 48.5] + \left(\frac{15}{2} \times 0\right).$$
$$\Delta H_f(\text{reactants}) = 48.5\,\text{kJ/mol}.$$

The enthalpy change for the combustion of 1 mole of benzene is:

$$\Delta H = \Delta H_f(\text{products}) - \Delta H_f(\text{reactants}),$$
$$\Delta H = -3219 - 48.5 = -3267.5\,\text{kJ/mol}.$$

Step 3: Calculate for 2 moles of benzene For 2 moles of benzene:

$$\Delta H = 2 \times (-3267.5) = -6535\,\text{kJ}.$$

Final Answer: $x = 6535\,\text{kJ}$.

Quick Tip

Use Hess's law and the given standard enthalpies of formation to calculate the enthalpy change for a reaction. Always ensure that stoichiometric coefficients are included in the calculations.

Question 22:
The fusion of chromite ore with sodium carbonate in the presence of air leads to the formation of products A and B along with the evolution of CO_2. The sum of spin-only magnetic moment values of A and B is ____B.M. (Nearest integer).
(Given atomic numbers: $C = 6, Na = 11, O = 8, Fe = 26, Cr = 24$**)**

Answer: (6)

Solution:
The reaction for the fusion of chromite ore is:

$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 -> 8Na_2CrO_4 + 2Fe2O_3 + 8CO_2.$$

Here: - $A = Na_2CrO_4$ - $B = Fe_2O_3$
Step 1: Calculate the spin-only magnetic moment The spin-only magnetic moment is given by:

$$\mu_s = \sqrt{n(n+2)}\,\mu_B,$$

where n is the number of unpaired electrons.
For Na_2CrO_4: - Chromium in Na_2CrO_4 is in the +6 oxidation state (Cr^{6+}). - The electronic configuration of Cr^{6+} is $[Ar]3d^0$. - $n = 0$, so $\mu_s = 0\,\mu_B$.
For Fe_2O_3: - Iron in Fe_2O_3 is in the +3 oxidation state (Fe^{3+}). - The electronic configuration of Fe^{3+} is $[Ar]3d^5$. - $n = 5$, so:

$$\mu_s = \sqrt{5(5+2)} = \sqrt{35} \approx 5.9\,\mu_B.$$

Step 2: Sum of magnetic moments The sum of spin-only magnetic moments of A and B is:

$$\mu_{\text{total}} = 0 + 5.9 = 5.9\,\mu_B.$$

Rounding to the nearest integer:

$$\mu_{\text{total}} = 6\,\mu_B.$$

Final Answer: 6 B.M.

Quick Tip

The spin-only magnetic moment is calculated using the number of unpaired electrons. For ions with $n = 0$, the magnetic moment is zero, while $n = 5$ corresponds to the highest magnetic moment for $3d$ elements.

Question 23: X of ethanamine was subjected to reaction with $NaNO_2/HCl$ followed by hydrolysis to liberate N_2 and HCl. The HCl generated was completely neutralized by 0.2 moles of $NaOH$. X is ____ g.

Answer: (9)

Solution:
The reaction sequence is as follows:
Step 1: Reaction of ethanamine with $NaNO_2$ and HCl Ethanamine ($CH_3CH_2NH_2$) reacts with $NaNO_2$ and HCl to form an unstable diazonium salt ($CH_3CH_2N2^+Cl^-$).

$$CH_3CH_2NH_2 + NaNO_2 + HCl -> CH_3CH_2N2^+Cl^- + NaCl + H_2O.$$

Step 2: Hydrolysis of the diazonium salt The diazonium salt decomposes upon hydrolysis, liberating N_2, HCl, and ethanol (CH_3CH_2OH).

$$CH_3CH2N2^+Cl^- + H_2O -> CH3CH2OH + N_2 + HCl.$$

Step 3: Calculation of the mass of ethanamine - The reaction generates 0.2 moles of HCl, which neutralizes 0.2 moles of $NaOH$. - From the stoichiometry of the reaction, 1 mole of ethanamine produces 1 mole of HCl. - Therefore, the moles of ethanamine ($CH_3CH_2NH_2$) required are 0.2 moles.

The molar mass of ethanamine is:

$$\text{Molar mass of } CH_3CH_2NH_2 = 12 + 3 + 12 + 2 + 14 + 1 = 44\,\text{g/mol}.$$

The mass of ethanamine is:

$$\text{Mass} = \text{Moles} \times \text{Molar mass} = 0.2 \times 44 = 8.8(\textit{Nearest Integer to } 9)\,\text{g}.$$

Final Answer: $X = 9\,\text{g}$.

Quick Tip

For stoichiometric calculations, use the mole ratio from the balanced reaction and the molar mass of the compound to determine the required mass.

Question 24: In an atom, the total number of electrons having quantum numbers $n = 4$, $|m_l| = 1$, and $m_s = -\frac{1}{2}$ is:

Answer: (6)

Solution:
The quantum numbers are defined as follows: - $n = 4$: Principal quantum number. - $|m_l| = 1$: Absolute value of the magnetic quantum number. - $m_s = -\frac{1}{2}$: Spin quantum number.
Step 1: Determine the possible values of l and m_l For $n = 4$, the possible values of the azimuthal quantum number l are:

$$l = 0, 1, 2, 3.$$

For each l, the possible values of m_l are as follows: - $l = 0$: $m_l = 0$ - $l = 1$: $m_l = -1, 0, +1$ - $l = 2$: $m_l = -2, -1, 0, +1, +2$ - $l = 3$: $m_l = -3, -2, -1, 0, +1, +2, +3$
From the given condition $|m_l| = 1$, the possible values of m_l are:

$$m_l = -1 \text{ or } +1.$$

Step 2: Count the orbitals corresponding to $n = 4$ and $|m_l| = 1$ - For $l = 1$: $m_l = \pm 1$ (2 orbitals). - For $l = 2$: $m_l = \pm 1$ (2 orbitals). - For $l = 3$: $m_l = \pm 1$ (2 orbitals).
The total number of orbitals with $|m_l| = 1$ is:

$$2 + 2 + 2 = 6\,\text{orbitals}.$$

Step 3: Assign electrons with $m_s = -\frac{1}{2}$ Each orbital can hold one electron with $m_s = -\frac{1}{2}$. Thus, the total number of electrons is:

$$6\,\text{electrons}.$$

Final Answer: 6

Quick Tip

The spin quantum number $m_s = -\frac{1}{2}$ specifies one electron per orbital. When counting orbitals, ensure to match the absolute value of m_l with the given constraints.

Question 25: Using the given figure, the ratio of R_f values of sample A and sample C is $x \times 10^{-2}$. Value of x is:

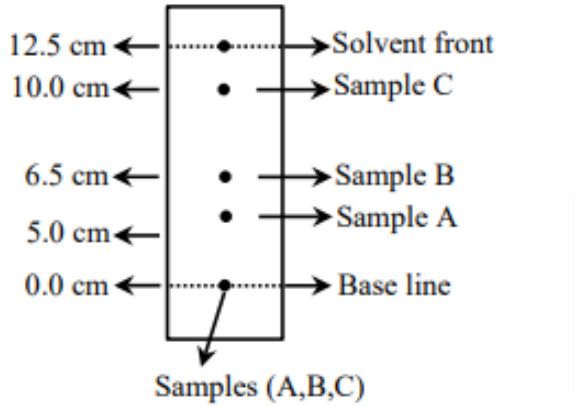


Fig : Paper chromatography of Samples

Answer: (50)

Solution:
The R_f value in chromatography is given by:

$$R_f = \frac{\text{Distance traveled by the sample spot}}{\text{Distance traveled by the solvent front}}.$$

Step 1: Calculate R_f for sample A For sample A:

$$R_f(A) = \frac{\text{Distance traveled by sample } A}{\text{Distance traveled by solvent front}} = \frac{5}{12.5}.$$

$$R_f(A) = 0.4.$$

Step 2: Calculate R_f for sample C For sample C:

$$R_f(C) = \frac{\text{Distance traveled by sample } C}{\text{Distance traveled by solvent front}} = \frac{10}{12.5}.$$

$$R_f(C) = 0.8.$$

Step 3: Calculate the ratio of R_f values The ratio of R_f values for sample A and sample C is:

$$\text{Ratio} = \frac{R_f(A)}{R_f(C)} = \frac{0.4}{0.8} = 0.5.$$

Expressing the ratio as $x \times 10^{-2}$:

$$\text{Ratio} = 50 \times 10^{-2}.$$

Final Answer: $x = 50$.

Quick Tip

In chromatography, R_f values are always ratios of distances. Ensure accurate measurements of both the sample spot and solvent front distances for precise results.

Question 26: In the Claisen-Schmidt reaction to prepare 351 g of dibenzalacetone using 87 g of acetone, the amount of benzaldehyde required is _____ g. (Nearest integer)

Answer: (318)

Solution:
The reaction involved is the Claisen-Schmidt condensation:

$$2C_6H_5CHO + CH_3COCH_3 -> [NaOH]C_6H_5CH = CHCOCH = CHC_6H_5 + H_2O.$$

Step 1: Reaction Stoichiometry - 2 moles of benzaldehyde (C_6H_5CHO) react with 1 mole of acetone (CH_3COCH_3) to form 1 mole of dibenzalacetone ($C_6H_5CH = CHCOCH = CHC_6H_5$).
- Given that 87 g of acetone is used, the molar mass of acetone is:

$$\text{Molar mass of } CH_3COCH_3 = 12 + (1 \times 3) + 12 + 16 + 1 = 58\,\text{g/mol}.$$

$$\text{Moles of acetone} = \frac{\text{Mass of acetone}}{\text{Molar mass of acetone}} = \frac{87}{58} \approx 1.5\,\text{moles}.$$

Step 2: Calculate moles of benzaldehyde required From the reaction stoichiometry, 2 moles of benzaldehyde are required for every 1 mole of acetone. Thus, the moles of benzaldehyde needed are:

$$\text{Moles of benzaldehyde} = 2 \times \text{Moles of acetone} = 2 \times 1.5 = 3\,\text{moles}.$$

Step 3: Calculate the mass of benzaldehyde required The molar mass of benzaldehyde (C_6H_5CHO) is:

$$\text{Molar mass of benzaldehyde} = (6 \times 12) + (5 \times 1) + 12 + 16 = 106\,\text{g/mol}.$$

Mass of benzaldehyde = Moles of benzaldehyde$\times$Molar mass of benzaldehyde = $3 \times 106 = 318\,\text{g}$.

Step 4: Verify with product formation The reaction produces 1 mole of dibenzalacetone for every 2 moles of benzaldehyde. For 1.5 moles of acetone, 1.5 moles of dibenzalacetone are formed, which corresponds to 351 g (given).

Final Answer: 318 g.

Quick Tip

In Claisen-Schmidt condensation, use stoichiometry to determine the required reactant quantities. The molar ratio of benzaldehyde to acetone is always 2:1.

Question 27: Consider the following single-step reaction in the gas phase at constant temperature:

$$2A_{(g)} + B_{(g)} -> C_{(g)}.$$

The initial rate of the reaction is recorded as r_1, when the reaction starts with 1.5 atm pressure of A and 0.7 atm pressure of B. After some time, the rate r_2 is

recorded when the pressure of C becomes $0.5\,\text{atm}$. The ratio $\frac{r_1}{r_2}$ is _____ $\times 10^{-1}$ (Nearest integer).

Answer: (315)

Solution:
The rate law for the reaction is:

$$r = k[A]^2[B],$$

where $[A]$, $[B]$, and $[C]$ represent the partial pressures of the reactants and product.
Step 1: Initial conditions At r_1: - $[A] = 1.5\,\text{atm}$, $[B] = 0.7\,\text{atm}$.

$$r_1 = k[1.5]^2[0.7].$$

Step 2: Conditions when r_2 is measured When the pressure of C is $0.5\,\text{atm}$, due to stoichiometry:

$$2A_{(g)} + B_{(g)} -> C_{(g)},$$

the change in $[C]$ corresponds to:

$$\Delta[C] = 0.5\,\text{atm}.$$

This means:

$$\Delta[A] = 2 \times \Delta[C] = 2 \times 0.5 = 1.0\,\text{atm}.$$

$$\Delta[B] = \Delta[C] = 0.5\,\text{atm}.$$

The remaining pressures of A and B are:

$$[A] = 1.5 - 1.0 = 0.5\,\text{atm},$$

$$[B] = 0.7 - 0.5 = 0.2\,\text{atm}.$$

At r_2:

$$r_2 = k[0.5]^2[0.2].$$

Step 3: Calculate the ratio $\frac{r_1}{r_2}$ The ratio of the rates is:

$$\frac{r_1}{r_2} = \frac{k[1.5]^2[0.7]}{k[0.5]^2[0.2]}.$$

Simplify:

$$\frac{r_1}{r_2} = \frac{(1.5)^2(0.7)}{(0.5)^2(0.2)} = \frac{2.25 \times 0.7}{0.25 \times 0.2}.$$

$$\frac{r_1}{r_2} = \frac{1.575}{0.05} = 31.5 \times 10^{-1}.$$

Step 4: Nearest integer

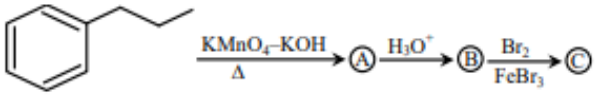
$$x = 315.$$

Final Answer: 315.

Quick Tip

For single-step reactions, use stoichiometric relations to determine the changes in reactant pressures and apply the rate law consistently to compute the rate ratio.

Question 28: The product C in the following sequence of reactions has _____ π bonds:



Answer: (4)

Solution:
The reaction sequence proceeds as follows:

Step 1: Oxidation of $C_6H_5CH_2CH_3$ with $KMnO_4$ and KOH The side chain ethyl group of ethylbenzene is oxidized to a carboxylate salt:

$$C_6H_5CH_2CH_3 -> [KMnO_4, KOH, \Delta]C_6H_5COOK(A).$$

Here, A is C_6H_5COOK, potassium benzoate.
Step 2: Acidification with H_3O^+ The carboxylate salt is acidified to form benzoic acid:

$$C_6H_5COOK + H_3O^+ -> C_6H_5COOH(B).$$

Here, B is C_6H_5COOH, benzoic acid.
Step 3: Bromination with $Br_2/FeBr_3$ Bromination occurs at the para-position of the benzene ring relative to the carboxylic acid group, yielding:

$$C_6H_5COOH -> [Br_2, FeBr_3]p - BrC_6H_4COOH(C).$$

Here, C is para-bromobenzoic acid ($p - BrC_6H_4COOH$).
Step 4: Count the π-bonds in C - The benzene ring contributes 3 π-bonds. - The $C = O$ group in the carboxylic acid contributes 1 π-bond.
Thus, the total number of π-bonds in C is:

$$\pi\text{-bonds} = 3 + 1 = 4.$$

Final Answer: 4.

Quick Tip

Oxidation of alkyl side chains on aromatic rings with $KMnO4$ results in carboxylate salts. Bromination selectively occurs at the para-position when activating groups like $-COOH$ are present.

Question 29: Considering acetic acid dissociates in water, its dissociation constant is 6.25×10^{-5}. If 5 mL of acetic acid is dissolved in 1 litre of water, the solution will freeze at $-x \times 10^{-2}\,^\circ$C, provided pure water freezes at 0°C.
Given:

- **K_f of water $= 1.86$ K kg mol^{-1},**
- **Density of acetic acid $= 1.2$ g cm^{-3},**

- **Molar mass of water** $= 18\,\mathbf{g\ mol^{-1}}$,
- **Molar mass of acetic acid** $= 60\,\mathbf{g\ mol^{-1}}$,
- **Density of water** $= 1\,\mathbf{g\ cm^{-3}}$.

Acetic acid dissociates as:

$$CH_3COOH <=> CH_3COO^- + H^+.$$

Answer: (19)

Solution:
The depression in freezing point ΔT_f is calculated using the formula:

$$\Delta T_f = i \cdot K_f \cdot m,$$

where:

- i is the van 't Hoff factor,
- K_f is the cryoscopic constant ($1.86\,\mathrm{K\ kg\ mol^{-1}}$),
- m is the molality of the solution.

Step 1: Calculate the molality of the solution The mass of acetic acid dissolved is:

$$\text{Mass of acetic acid} = \text{Volume} \times \text{Density} = 5\,\text{mL} \times 1.2\,\text{g/mL} = 6\,\text{g}.$$

The number of moles of acetic acid is:

$$\text{Moles of acetic acid} = \frac{\text{Mass of acetic acid}}{\text{Molar mass of acetic acid}} = \frac{6}{60} = 0.1\,\text{mol}.$$

The molality of the solution is:

$$m = \frac{\text{Moles of solute}}{\text{Mass of solvent (kg)}} = \frac{0.1}{1} = 0.1\,\text{mol/kg}.$$

Step 2: Calculate the van 't Hoff factor (i) The dissociation constant (K_a) of acetic acid is:

$$K_a = 6.25 \times 10^{-5}.$$

The degree of dissociation (α) is given by:

$$\alpha = \sqrt{\frac{K_a}{C}},$$

where C is the molarity of the solution. The molarity is:

$$C = \frac{\text{Moles of solute}}{\text{Volume of solution (L)}} = \frac{0.1}{1} = 0.1\,\text{mol/L}.$$

$$\alpha = \sqrt{\frac{6.25 \times 10^{-5}}{0.1}} = \sqrt{6.25 \times 10^{-4}} = 0.025.$$

The van 't Hoff factor is:

$$i = 1 + \alpha = 1 + 0.025 = 1.025.$$

Step 3: Calculate ΔT_f

$$\Delta T_f = i \cdot K_f \cdot m = 1.025 \cdot 1.86 \cdot 0.1 = 0.19065\,\text{K}.$$

Converting to $-x \times 10^{-2}$:

$$x = 19.$$

Final Answer: $x = 19$.

Quick Tip

When calculating freezing point depression for weak acids, account for partial dissociation using the van 't Hoff factor i, which includes the degree of dissociation α.

Question 30: The number of compounds from the following with zero dipole moment is _____:

$$HF, H_2, H_2S, CO_2, NH_3, BF_3, CH_4, CHCl_3, SiF_4, H_2O, BeF_2.$$

Answer: (6)

Solution:
A molecule has a zero dipole moment if it is symmetric, and the bond dipoles cancel each other out. Let us analyze each compound:
1. H_2: - Diatomic, nonpolar, symmetric. - Dipole moment = 0.
2. CO_2: - Linear molecule, symmetric. - Dipole moment = 0.
3. BF_3: - Planar triangular structure, symmetric. - Dipole moment = 0.
4. CH_4: - Tetrahedral geometry, symmetric. - Dipole moment = 0.
5. SiF_4: - Tetrahedral geometry, symmetric. - Dipole moment = 0.
6. BeF_2: - Linear molecule, symmetric. - Dipole moment = 0.
Molecules with nonzero dipole moments: - HF: Polar molecule, asymmetric. - H_2S: Bent structure, asymmetric. - NH_3: Trigonal pyramidal structure, asymmetric. - $CHCl_3$: Tetrahedral, but asymmetric due to Cl. - H_2O: Bent structure, asymmetric.
Conclusion The compounds with zero dipole moment are:

$$H_2, CO_2, BF_3, CH_4, SiF_4, BeF_2.$$

The number of such compounds is:

$$6.$$

Final Answer: 6.

Quick Tip

Symmetry in molecular geometry is key to identifying molecules with zero dipole moment. Linear, planar triangular, and tetrahedral geometries often exhibit this property.
