JEE Main 2024 April 6 Shift 1 Chemistry Question Paper

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.

Q1. The functional group present in sulphonic acid is:

(1) SO_4H (2) SO_3H (3) $S = O - OH$ (4) -SO_2

Answer: (2)

Solution

Step 1: Structure of sulphonic acid

Sulphonic acid is an organic compound containing the $-SO_3H$ functional group. Its general formula is:

$$R - SO_3H,$$

where R is an alkyl or aryl group.

Step 2: Identify the functional group

The functional group $-SO_3H$ consists of:

- A sulfur atom bonded to three oxygen atoms.
- One of the oxygen atoms is bonded to a hydrogen atom, forming the acidic $-OH$ group.

This functional group is characteristic of sulphonic acids and is responsible for their acidic properties.

Step 3: Correct option

The correct representation of the functional group is:

$$SO_3H.$$

Final Answer: (2) $\mathbf{SO_3H}$.

Quick Tip

Sulphonic acids are characterized by the $-SO_3H$ functional group, which contains a sulfur atom bonded to three oxygen atoms and one acidic $-OH$ group.

Q2. Match List I with List II:

List I (Molecule / Species)	List II (Property / Shape)
A. SO_2Cl_2	I. Paramagnetic
B. NO	II. Diamagnetic
C. NO_2^-	III. Tetrahedral
D. I_3^-	IV. Linear

Choose the correct answer from the options given below:

(1) A-IV, B-I, C-III, D-II (2) A-III, B-I, C-II, D-IV (3) A-III, B-II, C-I, D-IV (4) A-III, B-IV, C-II, D-I

Answer: (2)

Solution

Step 1: Analyze each species

(A) SO_2Cl_2:

- Sulfuryl chloride (SO_2Cl_2) has a tetrahedral geometry around the sulfur atom.
- This is because sulfur is surrounded by four regions of electron density: two oxygen atoms and two chlorine atoms.

A-III (Tetrahedral).

(B) NO:

- Nitric oxide (NO) has an odd number of electrons (11 electrons in total), making it a paramagnetic molecule.

B-I (Paramagnetic).

(C) NO_2^-:

- The nitrite ion (NO_2^-) has a bent geometry and all electrons are paired.
- This makes it a diamagnetic species.

C-II (Diamagnetic).

(D) I_3^-:

- The triiodide ion (I_3^-) is linear due to the arrangement of three iodine atoms with lone pairs on the central iodine atom.

D-IV (Linear).

Step 2: Match the pairs

A - III (Tetrahedral)
B - I (Paramagnetic)
C - II (Diamagnetic)
D - IV (Linear).

The correct option is:

$$(\mathbf{2})\ \mathbf{A-III, B-I, C-II, D-IV}.$$

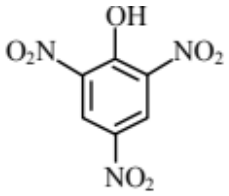
Quick Tip

To solve matching questions involving molecular properties and shapes: 1. Determine the geometry using VSEPR theory for the shape. 2. Identify paramagnetic or diamagnetic properties based on unpaired electrons. 3. Consider lone pairs and bonding pairs for molecular shape determination.

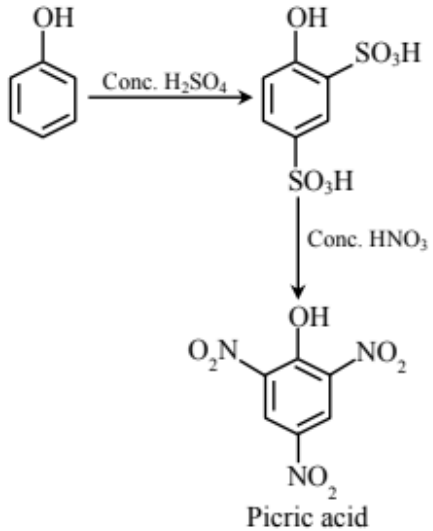
Q3. Given below are two statements:
Statement I: Picric acid is $2,4,6$-trinitrotoluene.
Statement II: Phenol-$2,4$-disulphonic acid is treated with conc. HNO_3 to get picric acid.

In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Statement I is incorrect but Statement II is correct.
(2) Both Statement I and Statement II are incorrect.
(3) Statement I is correct but Statement II is incorrect.
(4) Both Statement I and Statement II are correct.
Answer: (1)

Sol.



picric acid
(2, 4, 6 – trinitrophenol)



Picric acid

Step 1: Analyze Statement I

Picric acid is not $2,4,6$-trinitrotoluene. Instead, it is $2,4,6$-trinitrophenol.

- Picric acid contains a phenol ($-OH$) group attached to a benzene ring with three nitro ($-NO_2$) groups at the 2^{nd}, 4^{th}, and 6^{th} positions.
- $2,4,6$-trinitrotoluene (TNT) is an entirely different compound with a methyl group ($-CH_3$) instead of a hydroxyl group ($-OH$).

Thus, **Statement I is incorrect.**

Step 2: Analyze Statement II

Picric acid can be prepared by treating phenol-2, 4-disulphonic acid with concentrated nitric acid (HNO_3). This reaction introduces nitro groups at the ortho and para positions of the phenol ring, forming 2, 4, 6-trinitrophenol (picric acid).
Thus, **Statement II is correct.**

Step 3: Conclusion

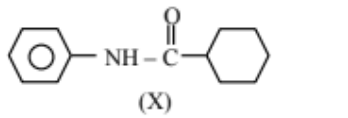
- Statement I is incorrect because picric acid is not 2, 4, 6-trinitrotoluene.
- Statement II is correct because phenol-2, 4-disulphonic acid reacts with concentrated nitric acid to yield picric acid.

Final Answer: (**1**).

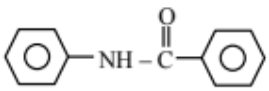
Quick Tip

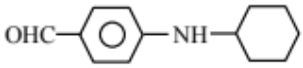
1. Picric acid is 2, 4, 6-trinitrophenol, not trinitrotoluene.
2. It is synthesized by nitrating phenol or its derivatives, such as phenol-2, 4-disulphonic acid.

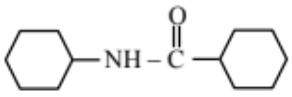
Q4. Which of the following is metamer of the given compound (X) ?

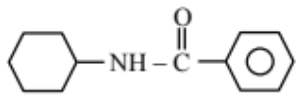


(X)

(1) 

(2) 

(3) 

(4) 

Answer: (4)

Solution

Definition of Metamerism

Metamers are isomers that:

- Have the same molecular formula.

- Contain the same functional group.
- Differ in the alkyl or aryl groups attached to either side of the functional group.

Step 1: Analyze the given compound (X)

The given compound is:

$$C_6H_5 - NH - CO - C_6H_{11}.$$

This compound contains:

- An amide group ($-NHCO-$).
- A phenyl group (C_6H_5) on one side of the amide group.
- A cyclohexyl group (C_6H_{11}) on the other side of the amide group.

Step 2: Identify the metamer

A metamer must:

- Have the same molecular formula as (X).
- Contain the amide group ($-NHCO-$).
- Have different alkyl or aryl groups on either side of the amide group.

Among the given options:

1. ($C_6H_5 - NH - CO - C_6H_5$) is not a metamer because both groups on either side of the functional group are the same (phenyl groups).
2. ($OHCH - CO - NH - C_6H_{11}$) is not a metamer because it does not have the same molecular formula as (X).
3. ($C_6H_{11} - NH - CO - C_6H_{11}$) is not a metamer because both groups on either side of the functional group are the same (cyclohexyl groups).
4. ($C_6H_{11} - NH - CO - C_6H_5$) is a metamer because:
   - It has the same molecular formula as (X).
   - It has the same amide functional group ($-NHCO-$).
   - The groups on either side of the functional group (cyclohexyl and phenyl) are different.

Step 3: Correct answer

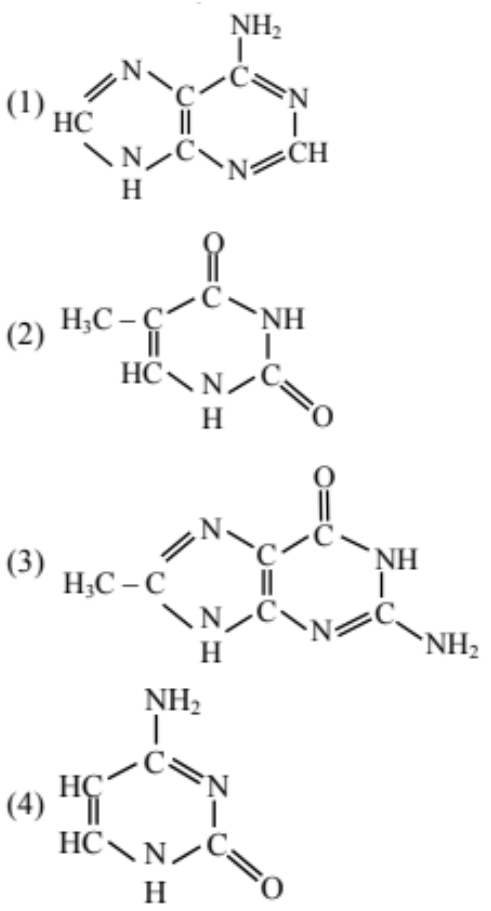
The metamer of the given compound is:

$$C_6H_{11} - NH - CO - C_6H_5.$$

Final Answer: (**4**).

> Quick Tip
>
> Metamers differ in the nature of the alkyl/aryl groups attached to the same functional group. Always verify: 1. The molecular formula. 2. The functional group. 3. The difference in groups attached to the functional group.

Q5. DNA molecule contains 4 bases whoes structure are shown below. One of the structure is not correct, identify the incorrect base structure.



Step 1: Analyze the structure of DNA bases

The four nitrogenous bases in DNA are:

- **Adenine (A):** A purine base with a double-ring structure, including a six-membered and a five-membered ring fused together. It has amine ($-NH_2$) group at position 6.
- **Thymine (T):** A pyrimidine base with a single six-membered ring. It has keto groups (=O) at positions 2 and 4 and a methyl group ($-CH_3$) at position 5.
- **Cytosine (C):** A pyrimidine base with a single six-membered ring. It has a keto group (=O) at position 2 and an amine ($-NH_2$) group at position 4.
- **Guanine (G):** A purine base with a double-ring structure, including keto group (=O) at position 6 and an amine ($-NH_2$) group at position 2.

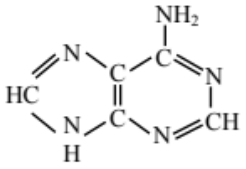
Step 2: Match the given structures

From the diagram:

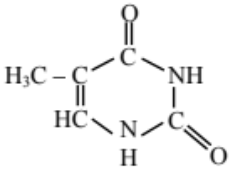
1. Structure (1) corresponds to adenine (correct structure).
2. Structure (2) corresponds to cytosine (correct structure).
3. Structure (3) corresponds to guanine (correct structure).
4. Structure (4) is **not correct for thymine**, because:
    - Thymine should have keto groups (=O) at positions 2 and 4.
    - The given structure has a keto group at position 4 but does not have the keto group at position 2. Instead, it incorrectly shows an amine group ($-NH_2$).

Ans. (3)

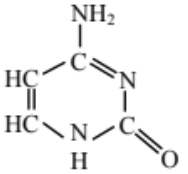
Sol.



⇒ Adenine



⇒ Thymine



⇒ Cytosine

Step 3: Conclusion

The incorrect base structure is:

(**4**) Thymine.

Final Answer: (**4**).

> Quick Tip
>
> To identify nitrogenous bases: 1. Purines (adenine and guanine) have double-ring structures, while pyrimidines (cytosine and thymine) have single-ring structures. 2. Focus on functional groups: keto ($= O$) and amine ($-NH_2$) groups are key to distinguishing the bases. 3. Thymine is unique to DNA and has a methyl group ($-CH_3$) at position 5.

Q6. Match List I with List II:

List I (Hybridization)	List II (Orientation in Space)
A. sp^3	I. Trigonal bipyramidal
B. dsp^2	II. Octahedral
C. sp^3d	III. Tetrahedral
D. sp^3d^2	IV. Square planar

Choose the correct answer from the options given below:

(1) A-III, B-I, C-IV, D-II (2) A-II, B-I, C-IV, D-III(3) A-IV, B-III, C-I, D-II (4) A-III, B-IV, C-I, D-II

Answer: (4)

Solution

Step 1: Understand the hybridizations and their geometries

(A) sp^3: Tetrahedral geometry

- The sp^3 hybridization involves one s-orbital and three p-orbitals.

- This hybridization leads to a tetrahedral geometry, with bond angles of approximately 109.5°.

A-III (Tetrahedral).

(B) dsp^2: Square planar geometry

- The dsp^2 hybridization involves one d-orbital, one s-orbital, and two p-orbitals.
- This hybridization leads to a square planar geometry, common in complexes like $[Ni(CN)_4]^{2-}$.

B-IV (Square planar).

(C) sp^3d: Trigonal bipyramidal geometry

- The sp^3d hybridization involves one s-orbital, three p-orbitals, and one d-orbital.
- This hybridization leads to a trigonal bipyramidal geometry, with three equatorial bonds and two axial bonds.

C-I (Trigonal bipyramidal).

(D) sp^3d^2: Octahedral geometry

- The sp^3d^2 hybridization involves one s-orbital, three p-orbitals, and two d-orbitals.
- This hybridization leads to an octahedral geometry, as seen in complexes like $[SF_6]$.

D-II (Octahedral).

Step 2: Match the pairs

A - III (Tetrahedral)
B - IV (Square planar)
C - I (Trigonal bipyramidal)
D - II (Octahedral).

The correct option is:

$$(4)\ \mathbf{A-III, B-IV, C-I, D-II}.$$

Quick Tip

To determine hybridization geometries: 1. Count the regions of electron density around the central atom to identify the hybridization. 2. Associate common hybridizations (sp^3, sp^3d, etc.) with their geometries: - sp^3: Tetrahedral - dsp^2: Square planar - sp^3d: Trigonal bipyramidal - sp^3d^2: Octahedral.

Q7. Given below are two statements:
Statement I: Gallium is used in the manufacturing of thermometers.
Statement II: A thermometer containing gallium is useful for measuring the freezing point (256 K) of brine solution.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both Statement I and Statement II are false.(2) Statement I is false but Statement II is true.(3) Both Statement I a

Answer: (4)

Solution

Step 1: Analyze Statement I

Gallium has unique properties that make it suitable for use in thermometers:

- It is a liquid metal at temperatures slightly above room temperature (melting point: 29.8°C or 302.95 K).
- Gallium expands as it transitions from solid to liquid, making it useful for accurate temperature measurements.
- Gallium is used in specialized high-temperature thermometers.

Thus, Statement I is true.

Step 2: Analyze Statement II

A thermometer containing gallium cannot be used for measuring the freezing point of brine solution (256 K or -17°C) because:

- The freezing point of brine (256 K) is below the melting point of gallium (302.95 K).
- Gallium remains in a solid state at 256 K and hence cannot function in a thermometer under these conditions.

Thus, Statement II is false.

Step 3: Conclusion

- Statement I is true: Gallium is used in thermometers.
- Statement II is false: Gallium thermometers are not suitable for measuring temperatures below its melting point (302.95 K).

Final Answer: (**4**).

Quick Tip

Gallium is suitable for high-temperature thermometers due to its low melting point and high boiling point. However, it cannot be used at temperatures below its melting point (302.95 K).

Q8. Which of the following statements are correct?

A. Glycerol is purified by vacuum distillation because it decomposes at its normal boiling point.

B. Aniline can be purified by steam distillation as aniline is miscible in water.

C. Ethanol can be separated from ethanol-water mixture by azeotropic distillation because it forms an azeotrope.

D. An organic compound is pure if mixed melting point remains the same.

Choose the most appropriate answer from the options given below:

(1) A, B, C only (2) A, C, D only (3) B, C, D only (4) A, B, D only

Answer: (2)

Solution

Analysis of each statement

(A) Glycerol is purified by vacuum distillation because it decomposes at its normal boiling point:

- True. Glycerol decomposes at high temperatures, so vacuum distillation is used to lower the boiling point and prevent decomposition.

(B) Aniline can be purified by steam distillation as aniline is miscible in water:

- False. Aniline is immiscible in water but can still be purified by steam distillation because it forms a low-boiling azeotrope with water.

(C) Ethanol can be separated from ethanol-water mixture by azeotropic distillation because it forms an azeotrope:

- True. Ethanol and water form an azeotrope, which can be separated by azeotropic distillation.

(D) An organic compound is pure if mixed melting point remains the same:

- True. If a compound's mixed melting point with a known pure sample remains unchanged, it indicates purity.

Correct statements

The correct statements are:

A, C, and D.

Final Answer: (**2**).

Quick Tip

1. Use vacuum distillation for compounds that decompose at high temperatures.
2. Aniline is immiscible in water but forms azeotropes for steam distillation.
3. Azeotropic distillation is useful for separating azeotropes like ethanol-water mixtures.
4. Mixed melting point tests help confirm the purity of organic compounds.

Q9. Match List I with List II:

List I (Compound / Species)	List II (Shape / Geometry)
A. SF_4	I. Tetrahedral
B. BrF_3	II. Pyramidal
C. BrO_3^-	III. See saw
D. NH_4^+	IV. Bent T-shape

Choose the correct answer from the options given below:

(1) A-II, B-III, C-I, D-IV (2) A-III, B-IV, C-II, D-I(3) A-II, B-IV, C-III, D-I (4) A-III, B-II, C-IV, D-I

Answer: (2)

Solution

Step 1: Analyze the shape of each compound/species

(A) SF_4: See-saw geometry

- SF_4 has five regions of electron density around the sulfur atom (four bonding pairs and one lone pair).

- According to VSEPR theory, the geometry is trigonal bipyramidal, but the presence of a lone pair distorts it into a **see-saw shape**.

A-III (See saw).

(B) BrF_3: Bent T-shape

- BrF_3 has five regions of electron density around the bromine atom (three bonding pairs and two lone pairs).
- The lone pairs occupy equatorial positions in a trigonal bipyramidal arrangement, leading to a **bent T-shape**.

B-IV (Bent T-shape).

(C) BrO_3^-: Pyramidal geometry

- BrO_3^- has four regions of electron density around the bromine atom (three bonding pairs and one lone pair).
- The lone pair causes the geometry to be distorted from tetrahedral to **pyramidal**.

C-II (Pyramidal).

(D) NH_4^+: Tetrahedral geometry

- NH_4^+ has four regions of electron density around the nitrogen atom, all bonding pairs.
- The geometry is **tetrahedral**.

D-I (Tetrahedral).

Step 2: Match the pairs

A - III (See saw)
B - IV (Bent T-shape)
C - II (Pyramidal)
D - I (Tetrahedral).

The correct option is:

$$(\mathbf{2})\ \mathbf{A-III, B-IV, C-II, D-I}.$$

Quick Tip

To determine molecular geometry: 1. Count regions of electron density (bonding + lone pairs). 2. Use VSEPR theory to predict the arrangement and adjust for lone pair distortions: - Lone pairs occupy more space and reduce bond angles. - Look for symmetry to confirm the shape.

Q9. Match List I with List II:

List I (Compound / Species)	List II (Shape / Geometry)
A. SF_4	I. Tetrahedral
B. BrF_3	II. Pyramidal
C. BrO_3^-	III. See saw
D. NH_4^+	IV. Bent T-shape

Choose the correct answer from the options given below:

(1) A-II, B-III, C-I, D-IV (2) A-III, B-IV, C-II, D-I(3) A-II, B-IV, C-III, D-I (4) A-III, B-II, C-IV, D-I

Answer: (2)

Solution

Step 1: Analyze each compound and its geometry

(A) SF_4: See-saw geometry

- SF_4 has five regions of electron density around the sulfur atom: four bonding pairs and one lone pair.
- According to VSEPR theory, the lone pair distorts the trigonal bipyramidal structure into a **see-saw** shape.

A-III (See saw).

(B) BrF_3: Bent T-shape

- BrF_3 has five regions of electron density around the bromine atom: three bonding pairs and two lone pairs.
- The lone pairs occupy equatorial positions, resulting in a **bent T-shape**.

B-IV (Bent T-shape).

(C) BrO_3^-: Pyramidal geometry

- BrO_3^- has four regions of electron density: three bonding pairs and one lone pair around the bromine atom.
- The lone pair causes distortion from tetrahedral to **pyramidal**.

C-II (Pyramidal).

(D) NH_4^+: Tetrahedral geometry

- NH_4^+ has four regions of electron density around the nitrogen atom, all bonding pairs.
- The geometry is **tetrahedral**.

D-I (Tetrahedral).

Step 2: Match the pairs

A - III (See saw)
B - IV (Bent T-shape)
C - II (Pyramidal)
D - I (Tetrahedral).

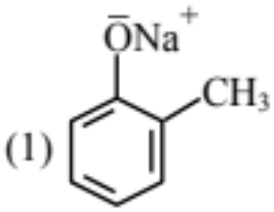
The correct option is:

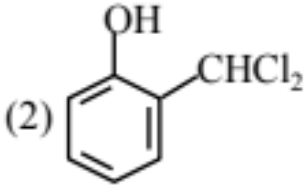
$$(\mathbf{2})\ \mathbf{A-III, B-IV, C-II, D-I}.$$

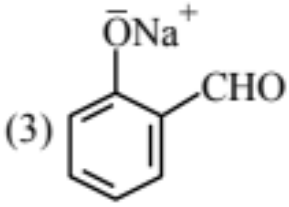
Quick Tip

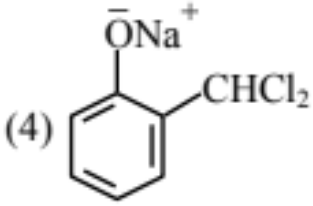
To determine molecular geometries: 1. Count regions of electron density (bonding and lone pairs). 2. Apply VSEPR theory to predict shapes: - Lone pairs occupy more space, causing distortions. - Symmetry helps confirm final geometry.

Q 10. In Reimer - Tiemann reaction, phenol is converted into salicyladehyde through an intermediate. The structure of intermediate is

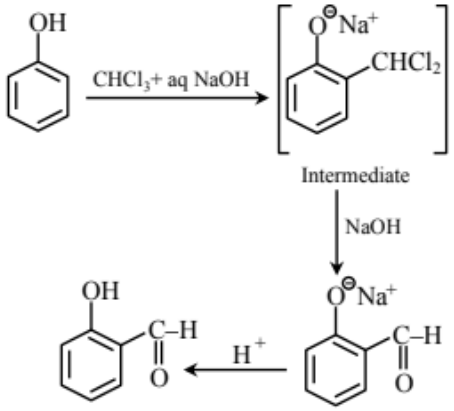
(1) 

(2) 

(3) 

(4) 

Ans. (4)

Sol. 

Reimer-Tiemann Reaction Mechanism

The Reimer-Tiemann reaction converts phenol into salicylaldehyde. The key steps in this reaction are:

- **Phenol reacts with chloroform ($CHCl_3$) in the presence of a strong base (e.g., NaOH).**
- **This reaction generates the reactive dichlorocarbene intermediate (CCl_2).**

- **The dichlorocarbene electrophile attacks the ortho position of the phenoxide ion ($C_6H_5O^-$).**
- **This forms an intermediate compound where the ortho position is substituted with $CHCl_2$ (dichloromethyl group).**
- **Subsequent hydrolysis of the dichloromethyl group yields salicylaldehyde (C_6H_4CHO).**

Intermediate Structure

The intermediate in this reaction is the phenoxide ion with a dichloromethyl group ($CHCl_2$) at the ortho position. Its structure is:

$$C_6H_4O^- \, CHCl_2.$$

Correct Answer

The correct option is:

$$(4)\, C_6H_4O^- \, CHCl_2.$$

Quick Tip

In the Reimer-Tiemann reaction: 1. Phenoxide ion ($C_6H_5O^-$) is the reactive species. 2. The intermediate is formed by electrophilic substitution at the ortho position by dichlorocarbene (CCl_2). 3. Hydrolysis of the intermediate gives the final product, salicylaldehyde.

Q11. Which of the following materials is not a semiconductor?

(1) Germanium (2) Graphite (3) Silicon (4) Copper oxide

Answer: (2)

Solution

Step 1: Understand Semiconductors

Semiconductors are materials whose electrical conductivity lies between conductors and insulators. Examples include:

- **Germanium (Ge): A widely used intrinsic semiconductor.**
- **Silicon (Si): The most common semiconductor used in electronic devices.**
- **Copper oxide (CuO): Can behave as a p-type semiconductor due to its band structure.**

Step 2: Graphite is not a semiconductor

Graphite:

- **Is a good conductor of electricity due to the delocalized π-electrons in its structure.**
- **Does not exhibit the properties of a semiconductor because it does not have an energy bandgap characteristic of semiconductors.**

Correct Answer

Graphite (2) is not a semiconductor.

Quick Tip

To identify semiconductors, look for materials with a small energy bandgap that allows controlled electrical conductivity. Examples include silicon, germanium, and certain metal oxides like copper oxide. Conductors like graphite, which have no bandgap, are not semiconductors.

Q12. Consider the following complexes:

(A) $[\mathbf{CoCl(NH_3)_5}]^{2+}$, **(B)** $[\mathbf{Co(CN)_6}]^{3-}$, **(C)** $[\mathbf{Co(NH_3)_5(H_2O)}]^{3+}$, **(D)** $[\mathbf{Cu(H_2O)_4}]^{2+}$.

The correct order of A, B, C, and D in terms of wavenumber of light absorbed is:

$$(1) C < D < A < B$$
$$(2) D < A < C < B$$
$$(3) A < C < B < D$$
$$(4) B < C < A < D.$$

Answer: (2)

Solution

Step 1: Understand Crystal Field Splitting and Wavenumber

- The wavenumber of light absorbed is directly proportional to the crystal field splitting energy (Δ).
- The splitting energy depends on the ligand field strength as determined by the spectrochemical series:
$$CN^- > NH_3 > H_2O > Cl^-.$$
- Strong field ligands cause a larger crystal field splitting (Δ), which corresponds to higher energy and higher wavenumber absorption.

Step 2: Analyze the given complexes

(A) $[CoCl(NH_3)_5]^{2+}$: Contains a mix of weak (Cl^-) and strong (NH_3) ligands, resulting in moderate crystal field splitting.
(B) $[Co(CN)_6]^{3-}$: Contains strong field ligands (CN^-), resulting in the highest crystal field splitting and highest wavenumber absorption.
(C) $[Co(NH_3)_5(H_2O)]^{3+}$: Contains strong field ligands (NH_3) and a moderate field ligand (H_2O), leading to greater splitting than (A) but less than (B).
(D) $[Cu(H_2O)_4]^{2+}$: Contains weak field ligands (H_2O), resulting in the lowest crystal field splitting and lowest wavenumber absorption.

Step 3: Arrange the complexes by wavenumber

From weakest to strongest crystal field splitting:

$$D < A < C < B.$$

Final Answer: (**2**).

> Quick Tip
>
> To determine the order of wavenumber absorption in complexes: 1. Refer to the spectrochemical series ($CN^- > NH_3 > H_2O > Cl^-$). 2. Stronger field ligands increase crystal field splitting (Δ) and result in higher wavenumber absorption. 3. Analyze the ligand field strength in the given coordination complexes.

Q13. Match List I with List II:

List I (Precipitating reagent and conditions)	List II (Cation)
A. $NH_4Cl + NH_4OH$	I. Mn^{2+}
B. $NH_4OH + Na_2CO_3$	II. Pb^{2+}
C. $NH_4OH + NH_4Cl + H_2S$ gas	III. Al^{3+}
D. dilute HCl	IV. Sr^{2+}

Choose the correct answer from the options given below:

(1) A-IV, B-III, C-II, D-I (2) A-IV, B-II, C-I, D-II (3) A-III, B-IV, C-I, D-II (4) A-III, B-IV, C-II, D-I.

Answer: (3)

Solution

Step 1: Analyze the precipitation reactions and their respective cations

(A) $NH_4Cl + NH_4OH$: Aluminum (Al^{3+}) cation

- Aluminum hydroxide ($Al(OH)_3$) precipitates when ammonium chloride (NH_4Cl) and ammonium hydroxide (NH_4OH) react with Al^{3+}.
- Reaction:
$$Al^{3+} + 3NH_4OH \rightarrow Al(OH)_3 \downarrow + 3NH_4^+.$$
- Match: A-III.

(B) $NH_4OH + Na_2CO_3$: Strontium (Sr^{2+}) cation

- Strontium carbonate ($SrCO_3$) is precipitated when ammonium hydroxide and sodium carbonate react with Sr^{2+}.
- Reaction:
$$Sr^{2+} + Na_2CO_3 \rightarrow SrCO_3 \downarrow + 2Na^+.$$
- Match: B-IV.

(C) $NH_4OH + NH_4Cl + H_2S$ gas: Manganese (Mn^{2+}) cation

- Manganese sulfide (MnS) precipitates under these conditions.
- Reaction:
$$Mn^{2+} + H_2S \rightarrow MnS \downarrow + 2H^+.$$

- Match: C-I.

(D) dilute HCl: Lead (Pb^{2+}) cation

- Lead chloride ($PbCl_2$) precipitates when dilute HCl reacts with Pb^{2+}.
- Reaction:
$$Pb^{2+} + 2Cl^- \rightarrow PbCl_2 \downarrow .$$
- Match: D-II.

Step 2: Final Matches

$$\text{A - III } (Al^{3+}), \quad \text{B - IV } (Sr^{2+}), \quad \text{C - I } (Mn^{2+}), \quad \text{D - II } (Pb^{2+}).$$

The correct option is:

$$(\mathbf{3})\ \mathbf{A-III, B-IV, C-I, D-II}.$$

> Quick Tip
>
> To match precipitating reagents with cations: 1. Use solubility rules to predict precipitation. 2. Ammonium hydroxide with chloride precipitates hydroxides of Al. 3. Carbonate reagents often precipitate group 2 metal carbonates. 4. Dilute HCl is used to precipitate chlorides like $PbCl_2$.

Q14. The electron affinity value is negative for:

- **A.** $Be \rightarrow Be^-$
- **B.** $N \rightarrow N^-$
- **C.** $O \rightarrow O^{2-}$
- **D.** $Na \rightarrow Na^-$
- **E.** $Al \rightarrow Al^-$

Choose the most appropriate answer from the options given below:

(1) D and E only (2) A, B, D and E only(3) A and D only (4) A, B and C only.

NTA Answer: (1)

Solution

Step 1: Understanding Electron Affinity

- Electron affinity is the energy change when an electron is added to an atom or ion in the gaseous phase.
- A **negative electron affinity value** implies that energy is absorbed (not released) when an electron is added.
- Generally, adding an electron to elements with a stable electronic configuration or to a negatively charged ion results in a negative electron affinity value.

Step 2: Analyzing the Given Options

(A) Be $\rightarrow$ Be^-: Beryllium has a stable electronic configuration ($1s^2 2s^2$). Adding an electron requires energy, making its electron affinity value negative.
(B) N $\rightarrow$ N^-: Nitrogen has a half-filled $2p$-orbital ($1s^2 2s^2 2p^3$), making it stable. Adding an electron disrupts this stability, resulting in a negative electron affinity value.
(C) O $\rightarrow$ O^{2-}: Adding the first electron to oxygen releases energy, but adding a second electron to O^- leads to repulsion, making the electron affinity for O $\rightarrow$ O^{2-} negative.
(D) Na $\rightarrow$ Na^-: Sodium has a stable electronic configuration ($1s^2 2s^2 2p^6 3s^1$). Adding an electron disrupts this, requiring energy, and hence the electron affinity is negative.
(E) Al $\rightarrow$ Al^-: Aluminum's configuration is not exceptionally stable, but adding an electron increases repulsion, making the electron affinity slightly negative.

Step 3: Correct Answer

- NTA Answer: **D and E only (1)**

> Quick Tip
>
> For electron affinity: 1. Elements with stable configurations (e.g., noble gases, half-filled, or fully filled orbitals) have low or negative electron affinity. 2. Adding electrons to negatively charged ions or elements with stable configurations usually results in negative values. 3. Analyze trends across periods and groups for a better understanding.

Q15. The number of elements from the following that do not belong to lanthanoids is:

Eu, Cm, Er, Tb, Yb and Lu.

(1) 3 (2) 4 (3) 1 (4) 5

Answer: (3)

Solution

Step 1: Analyze the given elements

- Europium (Eu), Erbium (Er), Terbium (Tb), Ytterbium (Yb), and Lutetium (Lu) are part of the lanthanoid series.
- Curium (Cm) belongs to the actinoid series.

Step 2: Count the non-lanthanoid elements

Only Cm (Curium) does not belong to lanthanoids.

Final Answer: (3)

> Quick Tip
>
> Lanthanoids range from La ($Z = 57$) to Lu ($Z = 71$). Actinoids include elements like Th, U, and Cm.

Q16. The density of 'x' M solution (x molar) of NaOH is 1.12 g/mL, while in molality, the concentration of the solution is 3 m (3 molal). Then x is:

(1) 3.5 (2) 3.0 (3) 3.8 (4) 2.8

Answer: (2)

Solution

Step 1: Formula for molality

$$\text{Molality (m)} = \frac{1000 \times M}{1000 \times d - M \times (\text{Mw})_{\text{solute}}}.$$

Here:

- $M = x$ molarity
- $d = 1.12$ g/mL (density)
- $(\text{Mw})_{\text{solute}} = 40$ g/mol (molar mass of NaOH).
- m = 3 molal.

Step 2: Substituting the values

$$3 = \frac{1000 \times x}{1000 \times 1.12 - x \times 40}.$$

Step 3: Solve for x

$$3 \times (1000 \times 1.12 - x \times 40) = 1000 \times x.$$
$$3 \times 1120 - 120x = 1000x.$$
$$3360 = 1120x.$$
$$x = 3.0.$$

Final Answer: $x = 3.0$ (2)

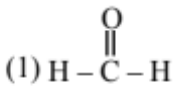
Quick Tip

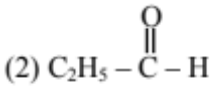
To solve for molarity (M) or molality (m), use the relationship:

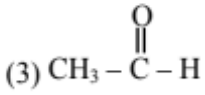
$$m = \frac{1000 \times M}{1000 \times d - M \times \text{Mw}}.$$

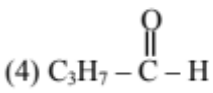
Substitute the values carefully to avoid calculation errors.

Q17. Which among the following aldehydes is most reactive towards nucleophilic addition reactions?

(1) 

(2) 

(3) 

(4) 

Answer: (1)

Solution

Step 1: Factors affecting nucleophilic addition

Nucleophilic addition to an aldehyde depends on:

- **Steric hindrance:** Smaller groups attached to the carbonyl carbon increase reactivity.
- **Partial positive charge:** Higher partial positive charge on the carbonyl carbon makes it more susceptible to nucleophilic attack.

Step 2: Analysis of the given aldehydes

- **Formaldehyde (H–C==O) (Option 1):** No alkyl groups attached, so minimal steric hindrance and maximum partial positive charge on the carbonyl carbon. Most reactive.
- **Other aldehydes (Options 2, 3, 4):** Increasing steric hindrance due to alkyl groups decreases reactivity towards nucleophilic addition.

Final Answer: (1)

Quick Tip

Formaldehyde is the most reactive aldehyde towards nucleophilic addition because it has no alkyl groups, leading to low steric hindrance and a highly electrophilic carbonyl carbon.

Q18. At -20°C and 1 atm pressure, a cylinder is filled with equal number of H_2, I_2 and HI molecules for the reaction:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g), \quad K_P = x \times 10^{-1}.$$

Given: $R = 0.082\,\text{L atm K}^{-1}\text{mol}^{-1}$. The value of x is:

(1) 2 (2) 1 (3) 10 (4) 0.01

Answer: (3)

Solution

Step 1: Expression for equilibrium constant (K_P)

$$K_P = \frac{(P_{HI})^2}{P_{H_2} \cdot P_{I_2}},$$

where:

- P_{HI}, P_{H_2}, P_{I_2} are the partial pressures of HI, H_2, I_2.

Step 2: Equal number of moles assumption

Let the number of moles of H_2, I_2, HI each be n.

- Total pressure $P = 1\,\text{atm}$.
- Mole fraction of each gas:

$$\chi_{H_2} = \chi_{I_2} = \chi_{HI} = \frac{n}{3n} = \frac{1}{3}.$$

- Partial pressure:

$$P_{H_2} = P_{I_2} = P_{HI} = \frac{1}{3}\,\text{atm}.$$

Step 3: Substituting into K_P

$$K_P = \frac{(P_{\text{HI}})^2}{P_{\text{H}_2} \cdot P_{\text{I}_2}} = \frac{\left(\frac{1}{3}\right)^2}{\frac{1}{3} \cdot \frac{1}{3}}.$$

$$K_P = \frac{\frac{1}{9}}{\frac{1}{9}} = 1.0 \times 10.$$

Final Answer: (3)

> Quick Tip
>
> When partial pressures are equal, use mole fractions to calculate K_P. For equilibrium problems, ensure you correctly simplify the ratio of pressures in the equilibrium expression.

Q19. Match List I with List II:

List I (Compound)	List II (Uses)
A. Iodoform	III. Antiseptic
B. Carbon tetrachloride	I. Fire extinguisher
C. CFC	IV. Refrigerants
D. DDT	II. Insecticide

Choose the correct answer from the options given below:

(1) A-I, B-II, C-III, D-IV (2) A-III, B-II, C-IV, D-I (3) A-III, B-I, C-IV, D-II (4) A-II, B-IV, C-I, D-III.

Answer: (3)

Solution

Step 1: Match each compound with its specific use

- **A. Iodoform ($\mathbf{CHI_3}$)**: Known for its antiseptic properties, it is used in medical applications to disinfect wounds.

  Match: III (Antiseptic).

- **B. Carbon tetrachloride ($\mathbf{CCl_4}$)**: Historically used as a fire extinguisher because of its non-flammable properties.

  Match: I (Fire extinguisher).

- **C. CFC (Chlorofluorocarbon)**: Widely used as a refrigerant in cooling systems like air conditioners and refrigerators.

  Match: IV (Refrigerants).

- **D. DDT (Dichlorodiphenyltrichloroethane)**: A well-known insecticide used for controlling mosquitoes and pests.

  Match: II (Insecticide).

Step 2: Final Matching

A-III, B-I, C-IV, D-II.

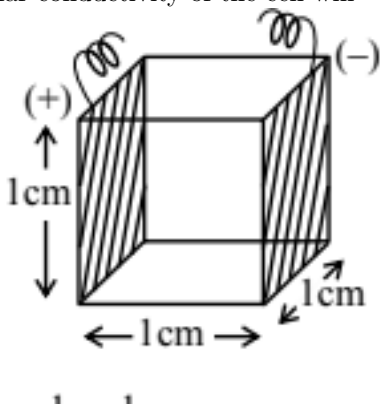
The correct option is:

(**3**).

Quick Tip

To match compounds with their uses: 1. Recall common applications of each compound. 2. Iodoform is used as an antiseptic. 3. Carbon tetrachloride is associated with fire extinguishers. 4. CFCs are refrigerants, while DDT is a well-known insecticide.

Q20. A conductivity cell with two electrodes (dark side) are half-filled with an infinitely dilute aqueous solution of a weak electrolyte. If volume is doubled by adding more water at constant temperature, the molar conductivity of the cell will -



(1) Increase sharply (2) Remain same or cannot be measured accurately (3) Decrease sharply (4) Depend upon the

Answer: (2)

Solution

Step 1: Concept of Molar Conductivity

- **Molar conductivity (Λ_m)** is defined as:

$$\Lambda_m = \frac{\kappa}{c},$$

where κ is the specific conductivity, and c is the molar concentration.

- For weak electrolytes, the molar conductivity increases with dilution due to an increase in ionization of the weak electrolyte.

Step 2: Effect of Doubling the Volume

- When the volume is doubled, the concentration of the electrolyte is halved.
- For infinitely dilute solutions of a weak electrolyte, κ (specific conductivity) becomes very low and cannot be measured accurately.
- Therefore, the molar conductivity (Λ_m) cannot be determined accurately under these conditions.

Final Answer: (2)

Quick Tip

For infinitely dilute solutions, molar conductivity increases with dilution, but specific conductivity decreases. At extreme dilution, accurate measurements become challenging due to very low κ.

SECTION - B

Q21. Consider the dissociation of the weak acid HX as given below:

$$\mathrm{HX(aq)} \rightleftharpoons \mathrm{H^+(aq) + X^-(aq)}, \quad K_a = 1.2 \times 10^{-5}.$$

The osmotic pressure of 0.03 M aqueous solution of HX at 300 K is $\_ \times 10^{-2}$ bar (nearest integer).

[Given: $R = 0.083$ L bar $\mathrm{mol^{-1}K^{-1}}$].

Answer: (76)

Solution

Step 1: Degree of dissociation (α) of the weak acid

The degree of dissociation for a weak acid is calculated using the expression:

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

where:

- $K_a = 1.2 \times 10^{-5}$ (dissociation constant),
- $C = 0.03\,\mathrm{M}$ (initial concentration of HX).

Substitute the values:

$$\alpha = \sqrt{\frac{1.2 \times 10^{-5}}{0.03}} = \sqrt{4 \times 10^{-4}} = 0.02.$$

Step 2: Total concentration of particles in solution

The total concentration of particles after dissociation is:

$$C_{\text{total}} = C(1 - \alpha) + C\alpha + C\alpha = C(1 + \alpha).$$

Substitute $C = 0.03\,\mathrm{M}$ and $\alpha = 0.02$:

$$C_{\text{total}} = 0.03(1 + 0.02) = 0.03 \times 1.02 = 0.0306\,\mathrm{M}.$$

Step 3: Calculate osmotic pressure (π)

The osmotic pressure is given by:

$$\pi = C_{\text{total}} \cdot R \cdot T,$$

where:

- $C_{\text{total}} = 0.0306\,\mathrm{M}$,
- $R = 0.083$ L bar $\mathrm{mol^{-1}K^{-1}}$,
- $T = 300\,\mathrm{K}$.

Substitute the values:

$$\pi = 0.0306 \cdot 0.083 \cdot 300 = 0.76134\,\mathrm{bar}.$$

Step 4: Express osmotic pressure in the given format

The osmotic pressure is approximately:

$$\pi \approx 76 \times 10^{-2}\,\text{bar}.$$

Final Answer: (76)

Quick Tip

For weak electrolytes, calculate the degree of dissociation (α) to find the effective concentration of particles. Use the formula for osmotic pressure:

$$\pi = C_{\text{total}} \cdot R \cdot T,$$

where $C_{\text{total}} = C(1 + \alpha)$ accounts for dissociation.

Q22. The difference in the 'spin-only' magnetic moment values of KMnO and the manganese product formed during titration of $KMnO_4$ against oxalic acid in acidic medium is _BM. (nearest integer)

Answer: (6)

Solution

Step 1: Oxidation state of Mn in $KMnO_4$

- In $KMnO_4$, the oxidation state of Mn is +7. Since there are no unpaired electrons, the spin-only magnetic moment is 0 BM.

Step 2: Manganese product formed

- In the acidic medium during titration, Mn^{+7} in $KMnO_4$ is reduced to Mn^{+2}.
- Mn^{+2} has 5 unpaired electrons ($3d^5$ configuration), giving a spin-only magnetic moment:

$$\mu = \sqrt{n(n+2)}\,\text{BM},$$

where $n = 5$.

$$\mu = \sqrt{5(5+2)} = \sqrt{35} \approx 6\,\text{BM}.$$

Final Answer: $\mu_{\textbf{difference}} = 6 - 0 = 6\,\textbf{BM}$.

Quick Tip

The spin-only magnetic moment depends on the number of unpaired electrons (n):

$$\mu = \sqrt{n(n+2)}\,\text{BM}.$$

For Mn^{+2} ($3d^5$), the value is ≈ 6 BM.

Q23. Time required for 99.9% completion of a first-order reaction is _ times the time required for completion of 90% reaction. (nearest integer)

Answer: (3)

Solution

Step 1: First-order reaction time formula

For a first-order reaction:

$$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]}.$$

Step 2: Time for 99.9% and 90% completion

- For 99.9% completion:

$$t_{99.9\%} = \frac{2.303}{k} \log \frac{100}{0.1} = \frac{2.303}{k} \log(10^3).$$

- For 90% completion:

$$t_{90\%} = \frac{2.303}{k} \log \frac{100}{10} = \frac{2.303}{k} \log(10).$$

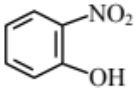
Step 3: Ratio of times

$$\frac{t_{99.9\%}}{t_{90\%}} = \frac{\log(10^3)}{\log(10)} = \frac{3}{1}.$$

Final Answer: 3.

> Quick Tip
>
> For first-order reactions, the time ratio for 99.9% to 90% completion is always 3 : 1, as $\log(10^3) = 3 \cdot \log(10)$.

Q24. Number of molecules from the following which can exhibit hydrogen bonding is . (nearest integer)

$CH_3OH, H_2O, C_2H_6, C_6H_6,$  HF, NH_3

Answer: (5)

Solution

Step 1: Criteria for hydrogen bonding

Hydrogen bonding occurs in molecules containing:

- A hydrogen atom attached to an electronegative atom (O, N, F).
- Lone pairs on the electronegative atom capable of forming a hydrogen bond.

Step 2: Analyze each molecule

- CH_3OH: Contains O–H, so it exhibits hydrogen bonding.
- H_2O: Contains O–H, so it exhibits hydrogen bonding.
- C_2H_6: No O, N, F, so no hydrogen bonding.
- C_6H_6: No O, N, F, so no hydrogen bonding.

- HF: Contains H–F, so it exhibits hydrogen bonding.
- NH_3: Contains N–H, so it exhibits hydrogen bonding.

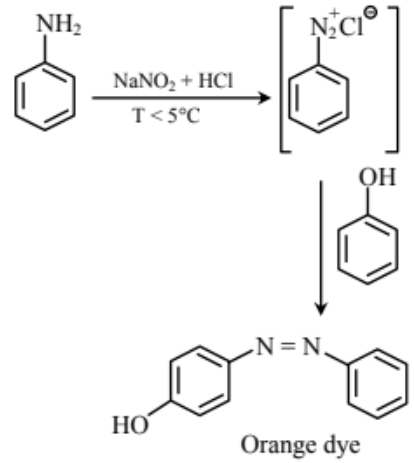
Step 3: Total count

Molecules capable of hydrogen bonding: CH_3OH, H_2O, HF, NH_3 (5 molecules).
Final Answer: 5.

> Quick Tip
>
> For hydrogen bonding, look for O–H, N–H, or H–F bonds. Lone pairs on O, N, F atoms are essential for forming hydrogen bonds.

Q25. 9.3 g of pure aniline upon diazotisation followed by coupling with phenol gives an orange dye. The mass of orange dye produced (assume 100% yield/conversion) is _ g. (nearest integer)
Answer: (20)

Sol.



Orange dye

Solution

Step 1: Write the reaction

The reaction involves:

$$C_6H_5NH_2 \xrightarrow{HNO_2/HCl} C_6H_5N_2^+Cl^- + C_6H_5OH \rightarrow \text{Orange Dye.}$$

Step 2: Molar masses of reactants and products

- Molar mass of aniline ($C_6H_5NH_2$) = 93 g/mol.
- Molar mass of orange dye = 186 g/mol (as it is a 1:1 coupling product of aniline and phenol).

Step 3: Conversion calculation

- Moles of aniline:

$$\text{Moles of aniline} = \frac{\text{Mass of aniline}}{\text{Molar mass of aniline}} = \frac{9.3}{93} = 0.1\,\text{mol}.$$

- Since the reaction has 100% yield, the moles of orange dye formed = moles of aniline = 0.1 mol.

- Mass of orange dye:

$$\text{Mass of orange dye} = \text{Moles of dye} \times \text{Molar mass of dye} = 0.1 \times 186 = 18.6\,\text{g}.$$

- Nearest integer:

$$\text{Mass of orange dye} \approx 20\,\text{g}.$$

Final Answer: 20 g.

> Quick Tip
>
> To calculate the mass of the product: 1. Determine the moles of limiting reagent. 2. Use the stoichiometry of the reaction. 3. Multiply the moles of the product by its molar mass.

Q26. The major product of the following reaction is P:

$$CH_3C \equiv C\text{–}CH_3 \xrightarrow{\text{(i) Na/liq. } NH_3 \text{ (ii) dil. } KMnO_4,\,273\,K} P.$$

Number of oxygen atoms present in product P is _. (nearest integer)

Answer: (2)

Solution

Step 1: Reaction mechanism

- Step (i): Reduction of the alkyne ($CH_3C \equiv C\text{–}CH_3$) with Na/liq. NH_3 converts it to the trans-alkene:

$$CH_3C \equiv C\text{–}CH_3 \xrightarrow{\text{Na/liq. } NH_3} CH_3CH = CHCH_3.$$

- Step (ii): Oxidation of the alkene with dil. $KMnO_4$ at 273 K (cold and dilute conditions) forms a glycol:

$$CH_3CH = CHCH_3 \xrightarrow{\text{dil. } KMnO_4} CH_3CH(OH)\text{–}CH(OH)CH_3.$$

Step 2: Analyze the product

- The product P is a diol (glycol): $CH_3CH(OH)\text{–}CH(OH)CH_3$.
- Each hydroxyl group (OH) contains one oxygen atom.
- The total number of oxygen atoms in P is:

$$\text{Number of oxygen atoms} = 2.$$

Final Answer: 2.

> Quick Tip
>
> Oxidation of alkenes with cold, dilute $KMnO_4$ produces diols. Count the hydroxyl (OH) groups to determine the number of oxygen atoms.

Q27. Frequency of the de-Broglie wave of an electron in Bohr's first orbit of hydrogen atom is ____ $\times 10^{13}$ Hz (nearest integer).

[Given: R_H (Rydberg constant) $= 2.18 \times 10^{-18}$ J, h (Planck's constant) $= 6.6 \times 10^{-34}$ Js.]

NTA Ans: (658)

Solution

Step 1: Relation between wavelength and frequency

The de-Broglie wavelength is:

$$\lambda = \frac{h}{mv}.$$

The frequency is given by:

$$\nu = \frac{v}{\lambda} = \frac{v^2}{h}.$$

Step 2: Kinetic energy relation

The kinetic energy of the electron in the first orbit is:

$$\text{K.E.} = \frac{1}{2}mv^2 = R_H = 2.18 \times 10^{-18}\,\text{J}.$$

Solve for v^2:

$$mv^2 = 2 \cdot \text{K.E.} = 4.36 \times 10^{-18}.$$

Step 3: Calculate frequency

Substitute v^2 and h into the formula for frequency:

$$\nu = \frac{4.36 \times 10^{-18}}{6.6 \times 10^{-34}}.$$

Simplify:

$$\nu = 6.606 \times 10^{14}\,\text{Hz}.$$

Convert to 10^{13} Hz:

$$\nu \approx 658 \times 10^{13}\,\text{Hz}.$$

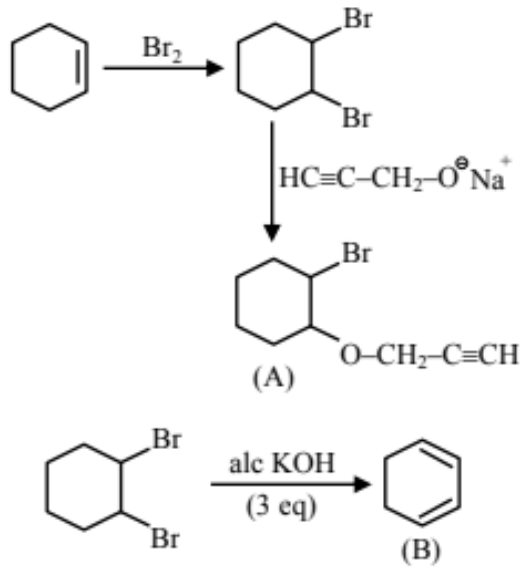
Final Answer: 658×10^{13} **Hz**.

> Quick Tip
>
> To calculate the de-Broglie frequency: 1. Relate $\lambda = h/mv$. 2. Use kinetic energy K.E. $= \frac{1}{2}mv^2$ to find v^2. 3. Combine results to find $\nu = v^2/h$.

Q28. The major products from the following reaction sequence are product A and product B. The total sum of π-electrons in product A and product B are ____ (nearest integer).

Reaction: Benzene $\xrightarrow{Br_2/FeBr_3}$ Bromobenzene $\xrightarrow{\text{Alcoholic KOH (3 eq.)}}$ Phenylacetylene $\xrightarrow{NaNH_2}$ Sodium Phenylacetylide.

Solution



Step 1: Bromination of Benzene

Benzene reacts with Br_2 in the presence of $FeBr_3$ to form bromobenzene.

Step 2: Reaction with Alcoholic KOH

Bromobenzene reacts with 3 equivalents of alcoholic KOH, resulting in the elimination reaction. The product is phenylacetylene.

Step 3: Reaction with Sodium Amide

Phenylacetylene reacts with $NaNH_2$ to form sodium phenylacetylide by deprotonation of the terminal alkyne.

Step 4: Calculate Total π-Electrons

- **Product A (Phenylacetylene):**
  - The benzene ring contributes 6π-electrons.
  - The triple bond in the acetylene group contributes 2π-electrons.
  - Total: $6 + 2 = 8\pi$-electrons.
- **Product B (Sodium Phenylacetylide):**
  - The benzene ring contributes 6π-electrons.
  - The triple bond in the acetylide group contributes 2π-electrons.
  - Total: $6 + 2 = 8\pi$-electrons.

Final Answer: 8.

Quick Tip

For aromatic systems, count the π-electrons in the ring (6 for benzene) and include any additional contributions from double or triple bonds in attached groups.

Q29. Among CrO, Cr O and CrO , the sum of spin-only magnetic moment values of basic and amphoteric oxides is _ $\times 10^{-2}$ BM (nearest integer).

(Given atomic number of Cr is 24).

Solution

Step 1: Oxidation States of Chromium in the Oxides

- **CrO:** Oxidation state of Cr is +2, electronic configuration is $[Ar]3d^4$, unpaired electrons = 4.
- **Cr_2O_3:** Oxidation state of Cr is +3, electronic configuration is $[Ar]3d^3$, unpaired electrons = 3.
- **CrO_3:** Oxidation state of Cr is +6, electronic configuration is $[Ar]$, unpaired electrons = 0.

Step 2: Spin-Only Magnetic Moment Formula

The magnetic moment is calculated using:

$$\mu = \sqrt{n(n+2)}\,\text{BM},$$

where n is the number of unpaired electrons.

- **For CrO ($n = 4$):**
$$\mu = \sqrt{4(4+2)} = \sqrt{24} \approx 4.9\,\text{BM}.$$
- **For Cr_2O_3 ($n = 3$):**
$$\mu = \sqrt{3(3+2)} = \sqrt{15} \approx 3.9\,\text{BM}.$$
- **For CrO_3 ($n = 0$):**
$$\mu = \sqrt{0(0+2)} = 0\,\text{BM}.$$

Step 3: Total Magnetic Moment

Basic and amphoteric oxides: CrO (basic) and Cr_2O_3 (amphoteric).

$$\mu_{\text{total}} = 4.9 + 3.9 = 8.8\,\text{BM}.$$

Convert to nearest integer in 10^{-2}:

$$\boxed{877}.$$

Quick Tip

When calculating magnetic moments: 1. Identify unpaired electrons using oxidation states and electronic configurations. 2. Use the formula $\mu = \sqrt{n(n+2)}$ for spin-only magnetic moments. 3. Sum moments for the required species.

Q30. An ideal gas, C = $\frac{5}{2}R$, is expanded adiabatically against a constant pressure of 1 atm until it doubles in volume. If the initial temperature and pressure are 298 K and 5 atm, respectively, then the final temperature is _ K (nearest integer).

[Given: $\bar{C_v}$ is the molar heat capacity at constant volume.]

??????Solution

Step 1: Determine the adiabatic relation

For an adiabatic process, the relation between temperature and volume is:

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}.$$

Here:

$$\gamma = \frac{C_p}{C_v}, \quad C_p = C_v + R, \quad C_v = \frac{5}{2}R.$$

$$\gamma = \frac{\frac{7}{2}R}{\frac{5}{2}R} = \frac{7}{5}, \quad \gamma - 1 = \frac{2}{5}.$$

Step 2: Substitute known values

Given:

$$T_1 = 298\,\text{K}, \quad V_2 = 2V_1.$$

Substitute into the temperature-volume relation:

$$298 \cdot V_1^{\frac{2}{5}} = T_2 \cdot (2V_1)^{\frac{2}{5}}.$$

Cancel $V_1^{\frac{2}{5}}$:

$$298 = T_2 \cdot 2^{\frac{2}{5}}.$$

Step 3: Solve for T_2

$$T_2 = \frac{298}{2^{\frac{2}{5}}}.$$

Step 4: Approximate $2^{\frac{2}{5}}$

$$2^{\frac{2}{5}} \approx 1.3195.$$

Thus:

$$T_2 = \frac{298}{1.3195} \approx 274\,\text{K}.$$

Final Answer: $274\,\mathbf{K}$.

> Quick Tip
>
> In adiabatic processes, use the relation $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$. Calculate γ from heat capacities, and simplify step-by-step.
