JEE Main 2024 Chemistry Question Paper Jan 30 Shift 2 with Solutions

1. Why KMnO shows colour?

(1) Due to d-d transition
(2) Due to metal to ligand charge transfer
(3) Due to ligand to metal charge transfer
(4) Due to F-center

Correct Answer: (3) Due to ligand to metal charge transfer

Solution:
Step 1: Understanding the Color Formation.
KMnO (Potassium Permanganate) shows color due to the transition of a nonbonding 2p oxygen electron to the vacant molecular orbital of a tetrahedral complex. This type of transition involves ligand-to-metal charge transfer, which occurs when an electron moves from the ligand (oxygen) to the metal ion (Mn), leading to a characteristic color.
Step 2: Conclusion.
The transition from ligand to metal causes the color in KMnO.

Quick Tip

Color in transition metal compounds is often due to electronic transitions between d-orbitals or ligand to metal charge transfer.

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2. C is added to solution of A and B, find mole fraction of C.

(1) $\frac{n_c}{(n_A+n_B+n_C)}$
(2) $\frac{n_c}{(n_A+n_B+n_C)}$
(3) $\frac{n_c}{(n_A+n_B)}$
(4) $\frac{n_c}{(n_A+n_B+n_C)}$

Correct Answer: (1) $\frac{n_c}{(n_A+n_B+n_C)}$

Solution:
Step 1: Mole Fraction Formula.
The mole fraction is given by the formula:

$$\text{Mole fraction of component} = \frac{\text{moles of one component}}{\text{Total moles of all components}}.$$

In this case, for component C:

$$x_C = \frac{n_C}{n_A + n_B + n_C}.$$

Step 2: Conclusion.
The mole fraction of C is $\frac{n_C}{n_A+n_B+n_C}$, which is the correct answer.

Quick Tip

The mole fraction of a component in a solution is the ratio of the moles of that component to the total moles of all components.

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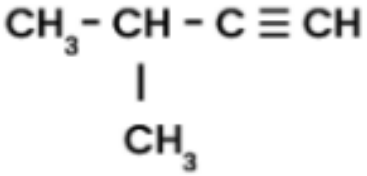
3. IUPAC name of compound:



(1) 2-Methylbutyne
(2) 3-Methylbut-1-yne
(3) 2-Methylbutene
(4) 3-Methylbutane

Correct Answer: (2) 3-Methylbut-1-yne

Solution:
Step 1: Understanding the Structure.
The given compound is $CH_3 - CH = C - CH_3$, which is an alkyne with a triple bond between the second and third carbon atoms. The numbering starts from the left to give the lowest possible number to the triple bond.
Step 2: Naming the Compound.
The compound has 4 carbon atoms, which makes it a butyne. The position of the triple bond is at the 1st carbon (counting from the left). A methyl group is attached to the third carbon.
Step 3: Conclusion.
The correct IUPAC name is 3-Methylbut-1-yne, as the triple bond is at position 1, and the methyl group is at position 3.

Quick Tip

When naming organic compounds, always prioritize giving the lowest number to functional groups like triple or double bonds.

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4. Which reagent on reacting with phenol gives salicylaldehyde?

(1) CO_2, $NaOH$
(2) $CHCl_3$, $NaOH$
(3) CCl_4, $NaOH$
(4) H_2O, H^+

Correct Answer: (2) $CHCl_3$, $NaOH$

Solution:
Step 1: Reaction with Phenol.
When phenol reacts with chloroform ($CHCl_3$) in the presence of sodium hydroxide ($NaOH$), it undergoes the Reimer-Tiemann reaction, which leads to the formation of salicylaldehyde.

Step 2: Mechanism.
In this reaction, the phenol undergoes electrophilic aromatic substitution where chloroform and sodium hydroxide generate a reactive intermediate that reacts with the phenol ring, leading to the formation of salicylaldehyde.
Step 3: Conclusion.
The correct reagent combination for this reaction is $CHCl_3$, $NaOH$.

Quick Tip

The Reimer-Tiemann reaction involves the reaction of phenol with chloroform in the presence of a base to form salicylaldehyde.

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5. Which of the following has a square pyramidal shape?

(1) ClF_3
(2) BrF_5
(3) XeF_4
(4) NH_3

Correct Answer: (2) BrF_5

Solution:
Step 1: Understanding the Molecular Shape.
The square pyramidal shape occurs when there are five bonding pairs of electrons around the central atom, with one atom located above the plane, forming a pyramid. This geometry is associated with compounds like BrF_5, which have 5 bonded atoms and one lone pair.
Step 2: Conclusion.
The correct compound with a square pyramidal shape is BrF_5.

Quick Tip

Square pyramidal geometry occurs in molecules with five bonds and one lone pair, such as BrF_5.

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6. Statement I: NH has lower dipole moment than NF.
Statement II: In NF, the flow of electron is in the same direction.

(1) Both statement I and statement II are false
(2) Statement I is true but statement II is false
(3) Statement I is false but statement II is true
(4) Both statement I and statement II are true

Correct Answer: (1) Both statement I and statement II are false

Solution:
Step 1: Dipole Moment in NH and NF.
In NH, the nitrogen atom has a lone pair of electrons and the dipole moment is directed upwards due to the electronegativity difference between nitrogen and hydrogen. In NF, however, the fluorine atoms, being highly electronegative, pull electron density away from nitrogen, but the molecular shape leads to the cancellation of dipole moments. This results in a lower dipole moment in NF compared to NH, contrary to Statement I.

Step 2: Direction of Electron Flow.
In NF, the electron flow is directed from nitrogen to fluorine because fluorine is more electronegative, not in the same direction as stated in Statement II.
Step 3: Conclusion.
Both statements are false. Statement I is incorrect, and Statement II is also incorrect.

Quick Tip

The dipole moment in molecules depends on both the electronegativity difference and the molecular geometry.

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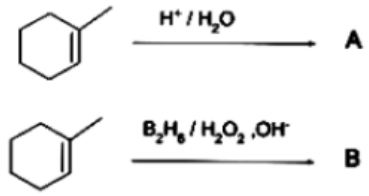
7. Identify A and B.



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

Correct Answer: (2) OH

Solution:
Step 1: Understanding the Reaction.
The first reaction involves the formation of an intermediate in a chemical reaction, likely involving a substitution or addition reaction. The second reaction involves the transformation of the molecule into a different structure with the help of reagents like B_2H_6, which are typical in hydroboration reactions.
Step 2: Identifying the Products.
Both A and B involve hydroboration or related reactions, which typically result in alcohols as the products.
Step 3: Conclusion.
The correct identification for both A and B is OH.

Quick Tip

Reactions involving B_2H_6 typically lead to the formation of alcohols through hydroboration.

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8. What happens when phenol is treated with chloroform in the presence of NaOH at 343 K followed by hydrolysis?

(1) Salicylic Acid
(2) Salicylaldehyde
(3) Benzaldehyde
(4) Benzoic acid

Correct Answer: (3) Benzaldehyde

Solution:
Step 1: Reaction Mechanism.
The reaction between phenol and chloroform in the presence of NaOH at 343 K undergoes a reaction known as the Reimer-Tiemann reaction. This reaction leads to the formation of salicylaldehyde.
Step 2: Hydrolysis.
After the reaction with chloroform and NaOH, the product is subjected to hydrolysis, which results in the formation of salicylaldehyde.
Step 3: Conclusion.
The final product is benzaldehyde, formed after the hydrolysis step.

Quick Tip

The Reimer-Tiemann reaction is commonly used to introduce a formyl group (-CHO) into an aromatic compound, particularly phenols.

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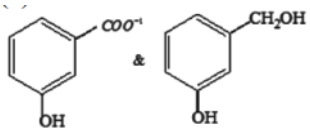
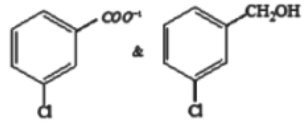
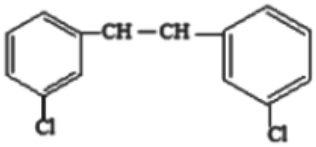
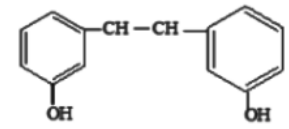
9. When m-chlorobenzaldehyde is treated with 50% KOH solution, the product(s) obtained is:

(1) 

(2) 

(3) 

(4) 

Correct Answer: (2) Product b

Solution:
Step 1: Reaction with KOH.
When m-chlorobenzaldehyde reacts with a strong base like KOH, a condensation reaction takes place, leading to the formation of a product known as a stilbene derivative.
Step 2: Identification of Products.
In this case, the product formed is a compound where two phenyl groups are connected through a double bond. This is typical of the Aldol condensation reaction.
Step 3: Conclusion.
The correct product formed is the one corresponding to option (2), which is the stilbene derivative.

Quick Tip

Aldol condensation is a key reaction where a carbonyl compound reacts with a strong base to form a -hydroxy ketone or aldehyde, which can further undergo dehydration to form an α, β-unsaturated compound.

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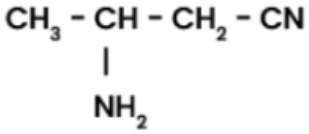
10. Correct IUPAC name the given compound is:



(1) 3-aminobutanenitrile
(2) 3-amino cyano butane
(3) 2-aminobutanenitrile
(4) 1-aminobutanenitrile

Correct Answer: (1) 3-aminobutanenitrile

Solution:
Step 1: Identifying the Structure.
The given structure consists of a butane chain with an amino group (-NH_2) at the third position and a nitrile group (-CN) at the end of the chain.
Step 2: Naming the Compound.
The compound is named based on the IUPAC rules: the base name is 'butanenitrile', the amino group is at position 3, so the correct name is 3-aminobutanenitrile.
Step 3: Conclusion.
The correct IUPAC name is 3-aminobutanenitrile.

Quick Tip

In IUPAC nomenclature, functional groups are given priority based on their position, and the longest chain containing the functional group is selected as the parent chain.

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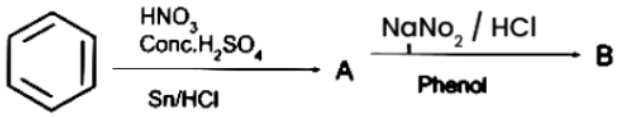
11. Find B:



(1) p-hydroxy azobenzene
(2) o-hydroxy azobenzene
(3) m-hydroxy azobenzene
(4) Azodye

Correct Answer: (1) p-hydroxy azobenzene

Solution:

Step 1: Reaction Mechanism.
In this reaction, the amine group (-NH_2) of the aniline undergoes diazotization with nitrous acid ($NaNO_2/HCl$) after the nitration of phenol. This leads to the formation of the azobenzene compound.
Step 2: Product Identification.
The reaction conditions lead to the formation of p-hydroxy azobenzene due to the position of the substituents in the aromatic ring.
Step 3: Conclusion.
The correct product formed is p-hydroxy azobenzene.

Quick Tip

In diazotization reactions, an amine group reacts with nitrous acid to form a diazonium ion, which can then undergo further reactions.

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12. In the given reaction A and B respectively are:

$$\mathrm{CrO_3Cl_2 + NaOH \quad \rightarrow \quad A + NaCl + H_2O}$$
$$\mathrm{H_2SO_4 + A + H_2O_2 \quad \rightarrow \quad B}$$

(1) Na_2CrO_4 and CrO_5
(2) CrO_3 and Na_2CrO_3
(3) CrO_4 and $Na_2Cr_2O_7$
(4) $Na_2Cr_2O_7$ and Na_2CrO_4

Correct Answer: (1) Na_2CrO_4 and CrO_5

Solution:
Step 1: Reaction of CrO_3 and NaOH.
When chromium trioxide (CrO_3) reacts with chlorine and sodium hydroxide, sodium chromate (Na_2CrO_4) and sodium chloride are produced along with water.
Step 2: Reaction of Sodium Chromate.
When sodium chromate reacts with sulfuric acid and hydrogen peroxide, chromium pentoxide (CrO_5) is formed.
Step 3: Conclusion.
Thus, the correct answer is Na_2CrO_4 and CrO_5.

Quick Tip

Chromium compounds like CrO_3 and Na_2CrO_4 are important in oxidation reactions, especially in organic synthesis.

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13. _____ is based on the difference in the solubility of different components of a mixture with a solvent.

(1) Filtration
(2) Sublimation
(3) Crystallization
(4) Chromatography

Correct Answer: (4) Chromatography

Solution:
Step 1: Understanding Chromatography.
Chromatography is a technique used to separate components of a mixture based on their different solubilities in a given solvent. It relies on the differential interaction of the components with the stationary phase and the mobile phase.
Step 2: Conclusion.
Thus, chromatography is the method that separates components based on solubility differences.

Quick Tip

Chromatography is used to separate substances in a mixture by passing it through a medium in which components move at different rates.

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14. What is the structure of $Mn_2(CO)_{10}$?

(1) Two square pyramidal units joined by bridging CO ligands
(2) Two square pyramidal units joined by Mn-Mn bond
(3) Two tetrahedral units joined by Mn-Mn bond
(4) Two square planer units joined by Mn-Mn bond

Correct Answer: (2) Two square pyramidal units joined by Mn-Mn bond

Solution:
Step 1: Understanding the Structure.
The compound $Mn_2(CO)_{10}$ consists of two manganese atoms each surrounded by CO ligands. These two units are connected via a Mn-Mn bond and each manganese atom is in a square pyramidal geometry.
Step 2: Conclusion.
Thus, the structure of $Mn_2(CO)_{10}$ consists of two square pyramidal units joined by a Mn-Mn bond.

Quick Tip

Manganese carbonyl compounds often feature bridging CO ligands and can have multiple geometrical structures depending on the number of ligands and metal centers.

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15. Statement I: H_2Te is more acidic than H_2S
Statement II: H_2Te has more BDE than H_2S

(1) Statement I and II both are correct
(2) Statement I and II both are incorrect
(3) Statement I is incorrect and Statement II is correct
(4) Statement I is correct and Statement II is incorrect

Correct Answer: (4) Statement I is correct and Statement II is incorrect

Solution:

Step 1: Understanding the Acidity.
The acidity of hydrides in Group 16 increases as we go down the group. Since H_2Te is in the same group as H_2S, but below it, it is more acidic than H_2S, making Statement I correct.
Step 2: Bond Dissociation Enthalpy (BDE).
The BDE of H_2Te is lower than that of H_2S, meaning Statement II is incorrect.
Step 3: Conclusion.
Thus, Statement I is correct and Statement II is incorrect.

Quick Tip

The acidity of hydrides increases as the atomic size increases because the bond between hydrogen and the heavier element becomes weaker.

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16. Total optically active compound will be shown by these compound:

Solution:
Step 1: Identify the Isomers.
The compound in question is 2, 3-Dichlorobutane. The optical activity of a compound depends on the presence of chiral centers. For 2, 3-Dichlorobutane, the number of diastereoisomers and enantiomers can be calculated.
Step 2: Conclusion.
The total number of optically active compounds in this case is calculated to be 3, considering the number of stereoisomers and meso forms.

Quick Tip

Optically active compounds must have no symmetry elements that lead to internal compensation, such as in meso forms.

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17. Number of spectral lines in the He^+ for transition from $n = 5$ to $n = 1$:

Solution:
Step 1: Formula for Spectral Lines.
The number of spectral lines is given by the formula:

$$\Delta n(\Delta n + 1) \quad \frac{n}{2}$$

For transition from $n = 5$ to $n = 1$:

$$\Delta n = 5 \quad \text{So, total lines are } 10$$

Quick Tip

In the case of spectral lines, the number of lines can be found using the formula for the transition of electrons between energy levels.
