Organic Chemistry JEE Main PYQ - 2

Total Time: 1 Hour : 15 Minute **Total Marks:** 120

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

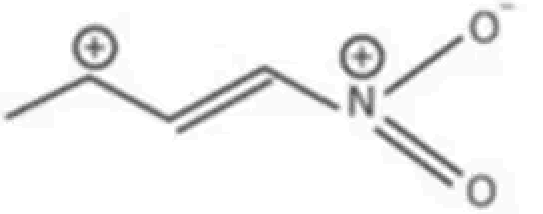
Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Organic Chemistry

1. Which of the following resonating structure is the most stable? (+4, -1)

(1)



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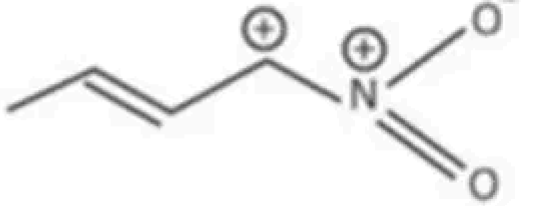

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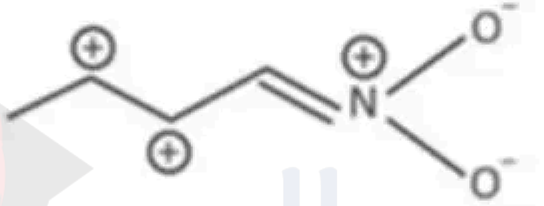

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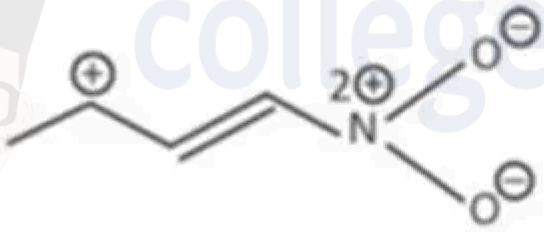

a. 1

b. 2

c. 3

d. 4

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2. 80 mL of an organic compound is mixed with 264 mL of O_2 and ignited. It gives 224 mL of gaseous mixture at NTP. After passing through KOH, 64 mL of gas remains. The organic compound is: (+4, -1)

a. C_2H_6

b. C_2H_2

c. C_4H_{10}

d. C_6H_6

---

3. **In Sulphur estimation, 0.7 g of an organic compound gives 1 g of $BaSO_4$ by Carius method. What is the % of 'S' in the compound?** **(+4, -1)**

a. 19.61

b. 23.85

c. 27.93

d. 14.57

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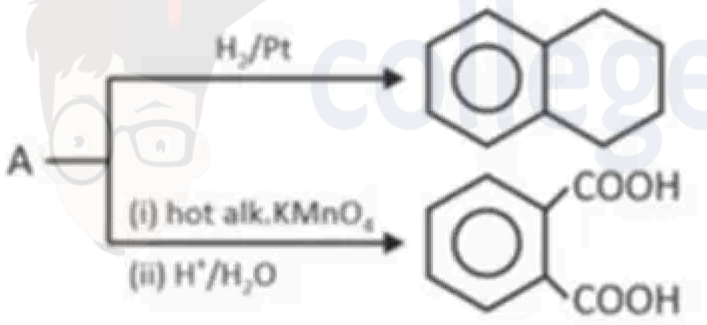
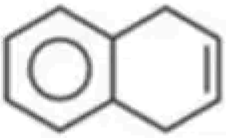
4. **Consider the following reaction:** **(+4, -1)**



Then 'A' will be:

(1)



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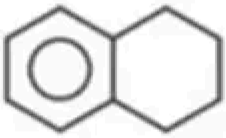

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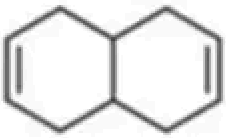

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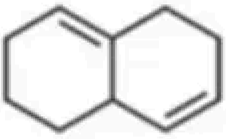

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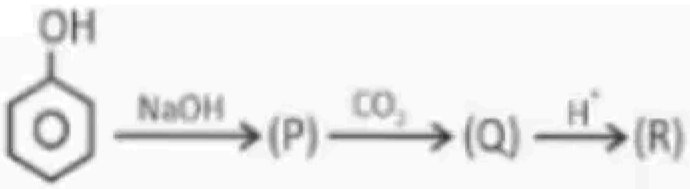
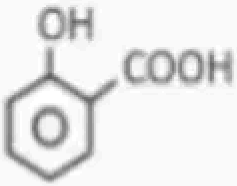
5. In the following reaction sequence, identify compound (R). **(+4, -1)**



(1)



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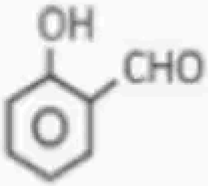

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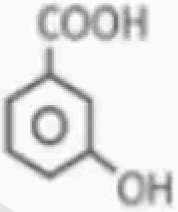

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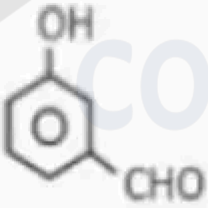

a. 1

b. 2

c. 3

d. 4

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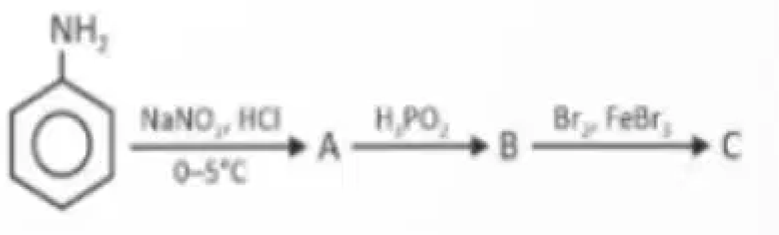
6. Consider the following sequence of reactions and identify A, B, and C respectively. **(+4, -1)**



a. $C_6H_5OH,\ C_6H_6,\ C_6H_4Br_2$

b. $C_6H_5N_2^+,\ C_6H_6,\ C_6H_5Br$

c. $C_6H_5NO_2,\ C_6H_6OH,\ C_6H_5Br$

d. $C_6H_5Cl,\ C_6H_6OH,\ C_6H_5Cl$

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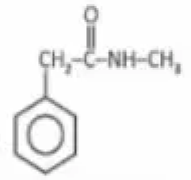
7. A compound 'A' with molecular formula $C_9H_{11}NO$ reacts with $Br_2/NaOH$ to give (X). On reaction with $NaNO_2$ in dilute HCl, it gives compound (Y). When (Y) is treated with CuCN, followed by hydrolysis, it gives (Z). The compound (A) on hydrolysis also gives compound (Z). Identify compound (A). **(+4, -1)**

(1)



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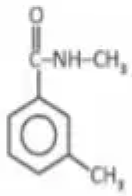

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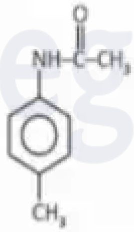
(4)



a. 1

b. 2

c. 3

d. 4

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8. Reactivity of the following on the basis of S_N1 mechanism. **(+4, -1)**

a. IV>III>I>II

b. II>IV>III>I

c. III>IV>I>II

d. IV>III>II>I

---

9. Which of the following is the correct order of the reactivity of given nucleophiles when treated with CH_3Br in methanol? F^-, I^-, $C_2H_5O^-$, $C_6H_5O^-$ **(+4, -1)**

a. $I^- > C_2H_5O^- > C_6H_5O^- > F^-$

b. $I^- > F^- > C_2H_5O^- > C_6H_5O^-$

c. $C_2H_5O^- > F^- > I^- > C_6H_5O^-$

d. $C_6H_5O^- > I^- > F^- > C_2H_5O^-$

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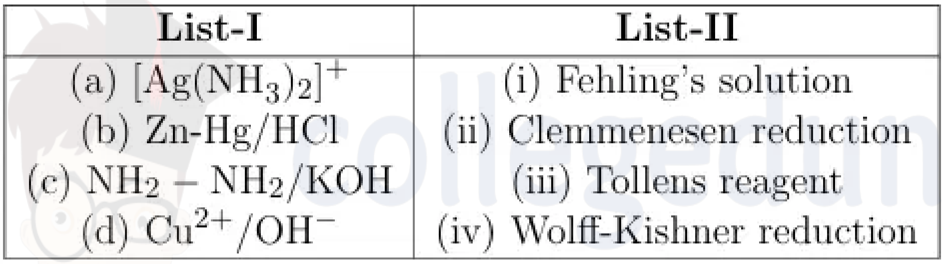
10. Match the following and choose the correct option. **(+4, -1)**



List-I	List-II
(a) $[Ag(NH_3)_2]^+$	(i) Fehling's solution
(b) Zn-Hg/HCl	(ii) Clemmenesen reduction
(c) NH_2-NH_2/KOH	(iii) Tollens reagent
(d) Cu^{2+}/OH^-	(iv) Wolff-Kishner reduction

a. a(i), b(ii), c(iii), d(iv)

b. a(iv), b(iii), c(ii), d(i)

c. a(iii), b(ii), c(iv), d(i)

d. a(i), b(ii), c(iv), d(iii)

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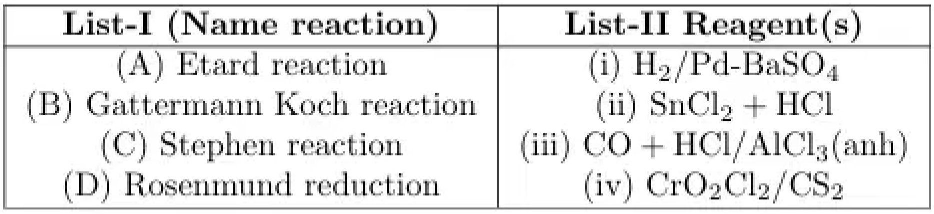
11. Match the two columns: **(+4, -1)**



List-I (Name reaction)	List-II Reagent(s)
(A) Etard reaction	(i) $H_2/Pd\text{-}BaSO_4$
(B) Gattermann Koch reaction	(ii) $SnCl_2 + HCl$
(C) Stephen reaction	(iii) $CO + HCl/AlCl_3$(anh)
(D) Rosenmund reduction	(iv) CrO_2Cl_2/CS_2

Choose the correct answer:

a. A–iv, B–ii, C–iii, D–i

b. A–iv, B–iii, C–ii, D–i

c. A–iv, B–iii, C–ii, D–ii

d. A–iv, B–ii, C–iii, D–i

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12. Which compound is optically inactive out of the following? n-propyl chloride, secondary butyl chloride, tert-butyl chloride, isopropyl chloride. **(+4, -1)**

a. Only I, III, IV

b. Only IV

c. Only I, II, III

d. Only II, III, IV

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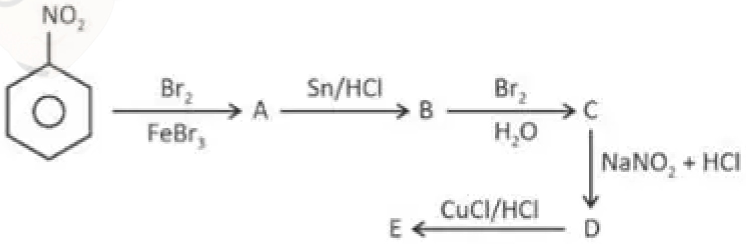
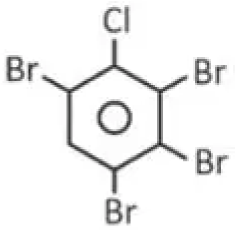
13. Observe the following reaction sequence: **(+4, -1)**



The final product E is:

(1)



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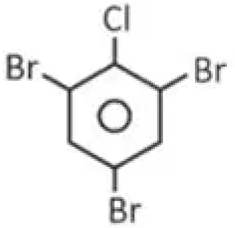

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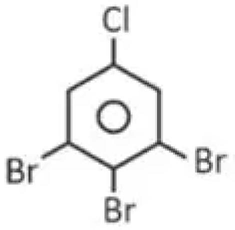

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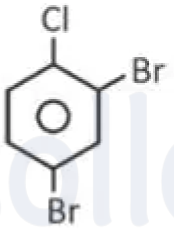

a. 1

b. 2

c. 3

d. 4

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14. Order of reactivity of nucleophiles given below, OH^-, CH_3COO^-, PhO^-, ClO_4^- **(+4, -1)**

a. $PhO^- > OH^- > ClO_4^- > CH_3COO^-$

b. $OH^- > PhO^- > CH_3COO^- > ClO_4^-$

c. $ClO_4^- > OH^- > PhO^- > CH_3COO^-$

d. $CH_3COO^- > OH^- > PhO^- > ClO_4^-$

15. **On combustion, $0.210\,\mathrm{g}$ of an organic compound containing C, H and O gave $0.127\,\mathrm{g}$ of $\mathrm{H_2O}$ and $0.307\,\mathrm{g}$ of $\mathrm{CO_2}$. The percentages of hydrogen and oxygen in the given organic compound respectively are:** **(+4, -1)**

a. $53.41,\ 39.6$

b. $6.72,\ 53.41$

c. $7.55,\ 43.85$

d. $6.72,\ 39.87$

---

16. **Consider the following reaction:** **(+4, -1)**

$$\mathrm{CH_3{-}C{\equiv}C{-}CH_3}$$

$$\xrightarrow[\mathrm{Pd/C}]{H_2} X \qquad \xrightarrow[\text{liq. } NH_3]{Na} Y$$

Choose the correct option.

a. $X \Rightarrow \mathrm{CH_3CH_2CH_2CH_3}$
\hspace*{1.3cm} $Y \Rightarrow \mathrm{CH_3{-}CH{=}CH{-}CH_3\ (cis)}$

b. $X \Rightarrow \mathrm{CH_3{-}CH{=}CH{-}CH_3\ (cis)}$
\hspace*{1.3cm} $Y \Rightarrow \mathrm{CH_3{-}CH{=}CH{-}CH_3\ (trans)}$

c. $X \Rightarrow \mathrm{CH_3{-}CH{=}CH{-}CH_3\ (cis)}$
\hspace*{1.3cm} $Y \Rightarrow \mathrm{CH_3{-}CH{=}CH{-}CH_3\ (cis)}$

d. $X \Rightarrow \mathrm{CH_3{-}CH{=}CH{-}CH_3\ (trans)}$
\hspace*{1.3cm} $Y \Rightarrow \mathrm{CH_3{-}CH{=}CH{-}CH_3\ (cis)}$

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17. **Which of the following is a mixed oxide?** **(+4, -1)**

a. $\mathrm{Fe_2O_3}$

b. $\mathrm{PbO_2}$

c. $\mathrm{Pb_3O_4}$

d. BaO_2

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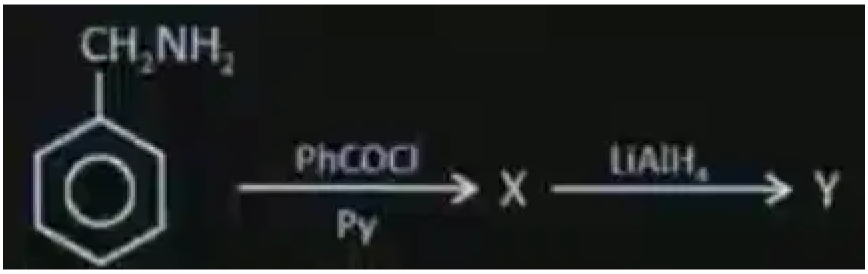
18. **Consider the following reaction:** **(+4, -1)**

$$Ph-CH_2NH_2 \xrightarrow[Py]{PhCOCl} X \xrightarrow{LiAlH_4} Y$$

The correct structure of Y **is:**



a. $PhCH_2NHCOPh$

b. $Ph-CH_2NHCH_2Ph$

c. $PhNH_2CH_2Ph$

d. $PhCH_3$

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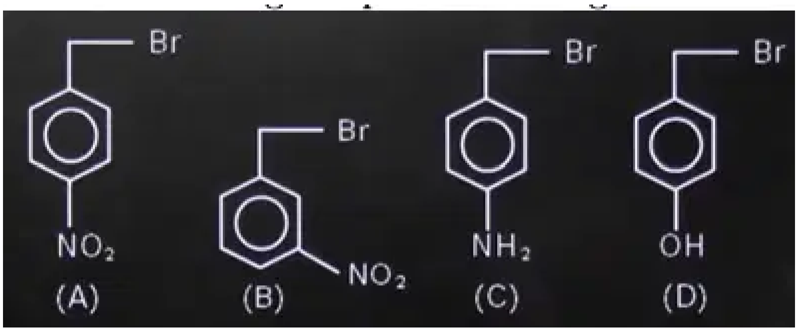
19. **The following compounds undergo SN2 reaction. What is the correct order of SN2 reactivity?** **(+4, -1)**



a. $D > C > B > A$

b. $A > B > D > C$

c. $A > B > C > D$

d. $D > A > C > B$

20. **Which of the following is the correct order of nucleophilic nature for the following reaction?** **(+4, -1)**

$$CH_3Br + Nu^- \longrightarrow CH_3Nu + Br^-$$

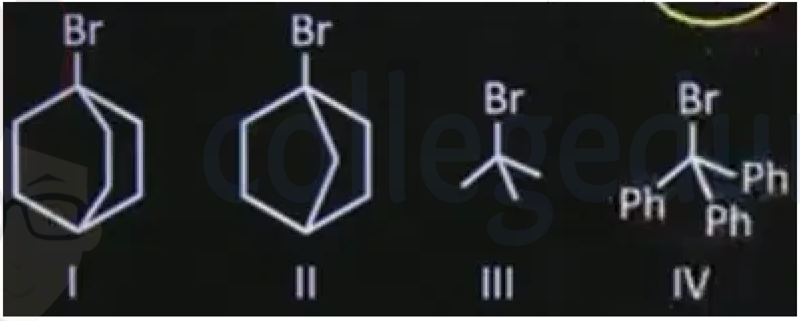
a. $HO^{\rightarrow}PhO^{\rightarrow}CH_3COO^{\rightarrow}ClO_4^-$

b. $PhO^{\rightarrow}HO^{\rightarrow}CH_3COO^{\rightarrow}ClO_4^-$

c. $CH_3COO^{\rightarrow}HO^{\rightarrow}PhO^{\rightarrow}ClO_4^-$

d. $HO^{\rightarrow}ClO_4^{\rightarrow}PhO^{\rightarrow}CH_3COO^-$

21. **The reactivity of the following compounds on the basis of the S_N1 mechanism is** **(+4, -1)**



(I), (II), (III), (IV) as shown in the figure.

a. $IV > III > I > II$

b. $II > IV > III > I$

c. $III > IV > I > II$

d. $IV > III > II > I$

22. **Which of the following is the correct order of reactivity of the given nucleophiles when treated with CH_3Br in methanol?** **(+4, -1)**

$$F^-,\ I^-,\ C_2H_5O^-,\ C_6H_5O^-$$

a. $I^{\rightarrow}C_2H_5O^{\rightarrow}C_6H_5O^{\rightarrow}F^-$

b. $I^{\rightarrow}F^{\rightarrow}C_2H_5O^{\rightarrow}C_6H_5O^-$

c. $I^{\rightarrow}C_2H_5O^{\rightarrow}F^{\rightarrow}C_6H_5O^-$

d. $C_6H_5O^{\rightarrow}F^{\rightarrow}I^{\rightarrow}C_2H_5O^-$

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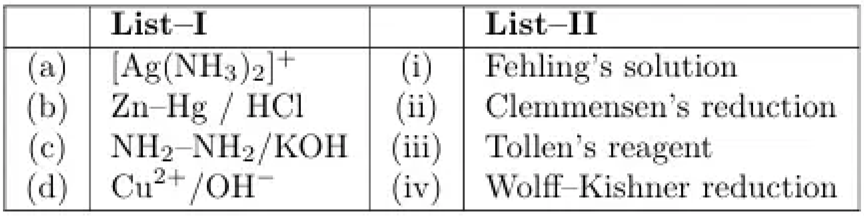
23. Match the following (List–I with List–II) and choose the correct option. **(+4, -1)**



	List–I		List–II
(a)	$[Ag(NH_3)_2]^+$	(i)	Fehling's solution
(b)	Zn–Hg / HCl	(ii)	Clemmensen's reduction
(c)	$NH_2–NH_2/KOH$	(iii)	Tollen's reagent
(d)	Cu^{2+}/OH^-	(iv)	Wolff–Kishner reduction

a. a(i), b(ii), c(iii), d(iv)

b. a(iv), b(iii), c(ii), d(i)

c. a(iii), b(ii), c(iv), d(i)

d. a(i), b(ii), c(iv), d(iii)

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24. In phosphorus estimation, 0.5 g of an organic compound gives 0.75 g of $Mg_2P_2O_7$. The percentage of phosphorus (P) in the compound is (nearest integer): **(+4, -1)**

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25. 1 g of an organic compound produces 1.49 g of $Mg_2P_2O_7$. Determine the percentage of phosphorus (P). **(+4, -1)**

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26. Consider the following statements: **(+4, -1)**

[(A)] Propanal and propanone are functional isomers
[(B)] Ethoxyethane and methoxypropane are metamers
[(C)] But-2-ene shows optical isomerism
[(D)] But-1-ene and but-2-ene are functional isomers
[(E)] Pentane and 2,2-dimethylpropane are chain isomers **The correct statements are:**

a. A, B, D only

b. B, C, D only

c. A, B, E only

d. A, B, D, E only

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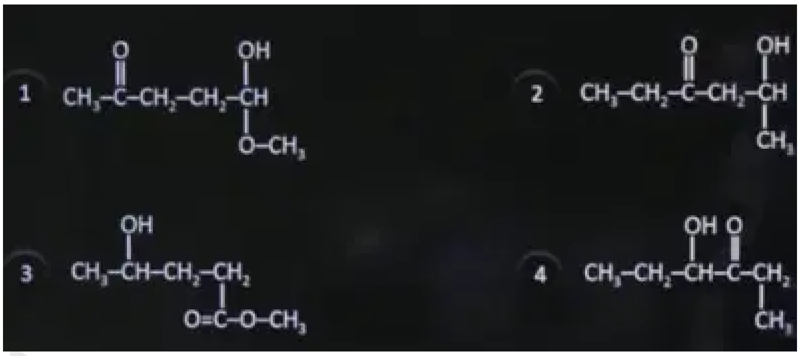
27. $C_6H_{12}O_3$ **gives positive iodoform test. On hydrolysis with dilute acid, the product formed gives both Tollens' test and iodoform test. Find the correct structure of** $C_6H_{12}O_3$. **(+4, -1)**



a. $CH_3COCH_2CH_2CH(OH)OCH_3$

b. $CH_3CH_2COCH_2CH(OH)CH_3$

c. $CH_3CH(OH)CH_2CH_2COOCH_3$

d. $CH_3CH_2CH(OH)COCH_2CH_3$

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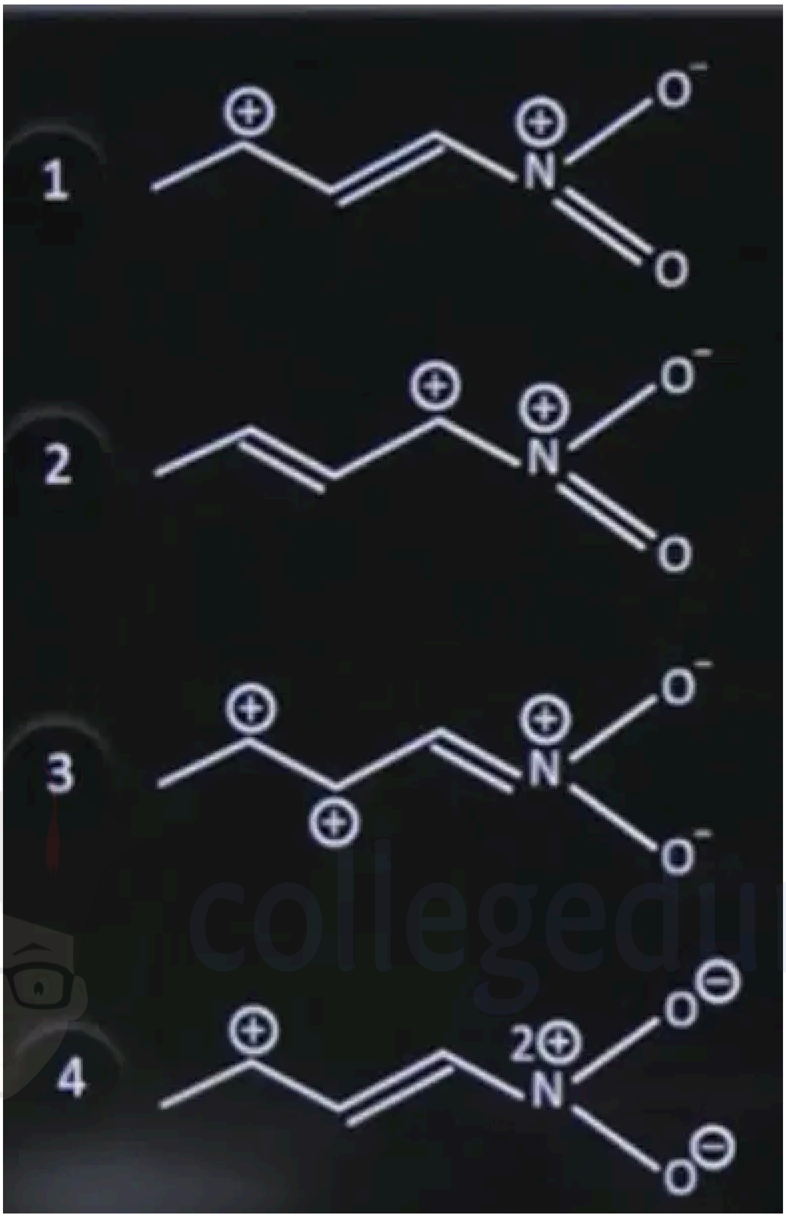
28. **Which of the following resonating structures is the most stable?** **(+4, -1)**



a. Structure 1

b. Structure 2

c. Structure 3

d. Structure 4

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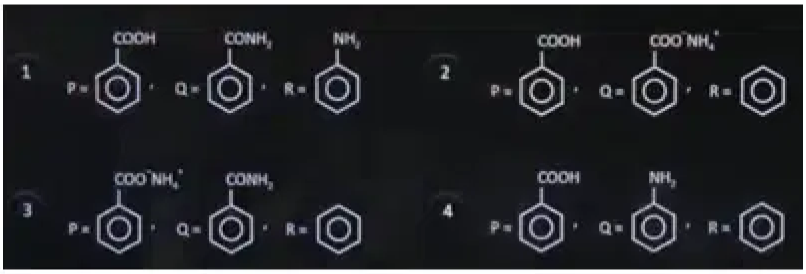
29. Observe the following reaction sequence: **(+4, -1)**

$$(P) \xrightarrow[\Delta]{NH_3} (Q) \xrightarrow{Br_2/KOH} (R)$$

Which of the following is the correct structure for P, Q and R?



a. $P =$ Benzoic acid $(-COOH)$, $Q =$ Benzamide $(-CONH2)$, $R =$ Aniline $(-NH2)$

b. $P =$ Benzoic acid, $Q =$ Ammonium benzoate, $R =$ Benzene

c. $P =$ Ammonium benzoate, $Q =$ Benzamide, $R =$ Benzene

d. $P =$ Benzoic acid, $Q =$ Aniline, $R =$ Benzene

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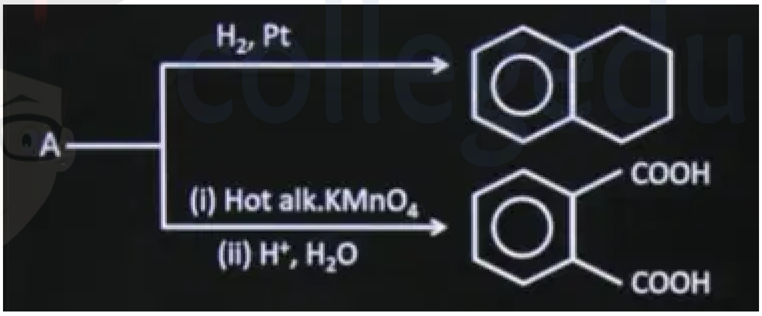
30. An organic compound (A) undergoes the following reactions: **(+4, -1)**



Which of the following is compound (A)?

a. Structure 1

b. Structure 2

c. Structure 3

d. Structure 4

Answers

1. **Answer: a**

Explanation:

Step 1: Understanding resonance structures.
In resonance structures, the most stable structure is the one with the least charge separation and with negative charges on more electronegative atoms. The structure in option (1) has the most stable charge distribution, where the nitrogen atom holds the negative charge and the carbon atoms bear partial positive charges.
Step 2: Conclusion.
The correct answer is **(1)** as it represents the most stable resonating structure.

2. **Answer: b**

Explanation:

Step 1: Understanding the reaction.
The reaction involves the combustion of the organic compound with oxygen, producing a gaseous mixture. The gas remaining after passing through KOH is the unreacted oxygen.
Step 2: Calculation of gas volumes.
- Volume of gas after reaction: $224\,\text{mL}$
- Volume of gas left after passing through KOH (unreacted O_2): $64\,\text{mL}$
- Volume of CO_2 formed = $224\,\text{mL} - 64\,\text{mL} = 160\,\text{mL}$

Now, applying stoichiometric relations:
Let the volume of C_2H_2 be $x\,\text{mL}$, and the volume of O_2 used in the reaction is $x + \frac{y}{4}$.
Using the relation:

$$\frac{80}{200} = \frac{2}{2 + \frac{y}{4}}$$

Solving for y, we get that $y = 2$, hence the organic compound is $\mathrm{C_2H_2}$.
Step 3: Conclusion.
The correct answer is **(2) C_2H_2**.

3. **Answer: a**

Explanation:

Step 1: Understanding the Carius method.
In the Carius method, the organic compound reacts with an oxidizing agent to form $BaSO_4$, which is used to estimate the amount of sulfur present in the compound.
Step 2: Calculation of sulfur percentage.
From the problem:

$$\text{Percentage of Sulfur} = \frac{1 \times 32}{233 \times 0.7} \times 100 = 19.61$$

Step 3: Conclusion.
The correct answer is **(1) 19.61%** as calculated above.

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4. **Answer: 1 - 1**

Explanation:

Step 1: Understanding the reaction.
The given reaction shows the oxidation of a benzene derivative using potassium permanganate ($KMnO_4$) under hot alkaline conditions. The compound is then reduced in the presence of hydrogen (H_2) over platinum (Pt), converting the molecule to the corresponding carboxylic acid.
Step 2: Analyzing the options.
(1) This option matches the expected structure after oxidation of the side chain and reduction to a carboxylic acid.
(2) This is not correct as it represents a different ring structure.
(3) This option shows a structure with a substituent at the wrong position.
(4) This structure does not reflect the desired product from the reaction.
Step 3: Conclusion.
The correct answer is **(1)** as it is the product after oxidation and reduction.

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5. **Answer: a**

Explanation:

Step 1: Reaction with $NaOH$.
The first step involves the phenol reacting with sodium hydroxide, which converts the phenol group into a phenoxide ion (P). **Step 2: Reaction with CO_2.**
The phenoxide ion then reacts with carbon dioxide under basic conditions, resulting in the formation of a carboxylate anion (Q), which then undergoes protonation in acidic conditions to form a carboxylic acid group (R). **Step 3: Conclusion.**
Thus, compound (R) is a carboxylic acid, $COOH$. **Final Answer:**

$$\boxed{COOH}$$

---

6. Answer: b

Explanation:

Step 1: Reaction with $NaNO_2$ and HCl.
The reaction of an amine group with nitrous acid $(NaNO_2)$ in dilute HCl produces a diazonium salt. Hence, compound A will be $C_6H_5N_2^+$. **Step 2: Reaction with H_3PO_4.**
The diazonium salt undergoes further transformation to form benzene, so compound B will be C_6H_6. **Step 3: Reaction with Br_2 and $FeBr_3$.**
Bromination of benzene with $FeBr_3$ gives bromobenzene, so compound C will be C_6H_5Br. **Step 4: Conclusion.**
Thus, the correct compounds are $A = C_6H_5N_2^+$, $B = C_6H_6$, and $C = C_6H_5Br$. **Final Answer:**

$$\boxed{C_6H_5N_2^+,\ C_6H_6,\ C_6H_5Br}$$

---

7. Answer: a

Explanation:

Step 1: Reaction with $Br_2/NaOH$.
The given molecular formula suggests an amine group, which reacts with bromine and sodium hydroxide (the Hofmann bromamide reaction) to give a primary amine. The compound (A) contains a benzylic amine group, suggesting it undergoes this reaction. **Step 2: Reaction with $NaNO_2$ and dilute HCl.**
The reaction of the amine group with nitrous acid gives diazonium salt, confirming

the structure of A. **Step 3: Treatment with CuCN and hydrolysis.**
The treatment of diazonium salts with copper cyanide forms a substituted aromatic compound, and hydrolysis gives the corresponding phenyl group. **Step 4: Conclusion.**
Thus, compound (A) is $\mathrm{C_6H_5C\,(NH_2)\,CH_3}$. **Final Answer:**

$$\boxed{\mathrm{C_6H_5C\,(NH_2)\,CH_3}}$$

8. **Answer: a**

Explanation:

Step 1: $S_\mathrm{N}1$ reaction mechanism.
In the $S_\mathrm{N}1$ mechanism, the reactivity depends on the stability of the carbocation formed during the reaction. More stable carbocations lead to faster reactions. The order of stability for carbocations generally follows the trend:

$$\text{Tertiary} > \text{Secondary} > \text{Primary} > \text{Methyl}$$

Step 2: Analyze the compounds.
- Compound IV has a tertiary carbocation, which is the most stable and thus most reactive. - Compound III has a secondary carbocation, making it next in reactivity. - Compound I has a primary carbocation, so it is less reactive. - Compound II has a methyl carbocation, the least stable and reactive. **Step 3: Conclusion.**
The reactivity order is:

$$\mathrm{IV} > \mathrm{III} > \mathrm{I} > \mathrm{II}$$

Final Answer:

$$\boxed{\mathrm{IV} > \mathrm{III} > \mathrm{I} > \mathrm{II}}$$

9. **Answer: a**

Explanation:

Step 1: Reactivity of nucleophiles.
The reactivity of nucleophiles follows the trend of their basicity and polarizability. A larger, more polarizable anion or nucleophile will be more reactive in nucleophilic

substitution reactions like S_N2. **Step 2: Conclusion.**
The reactivity order of the given nucleophiles in methanol is:

$$I^- > C_2H_5O^- > C_6H_5O^- > F^-$$

Final Answer:

$$\boxed{I^- > C_2H_5O^- > C_6H_5O^- > F^-}$$

---

10. Answer: c

Explanation:

Step 1: Identify the reactions.
- (a) $[Ag(NH_3)_2]^+$ is used in the Tollens reagent, which is used for the detection of aldehydes. - (b) $Zn\text{-}Hg/HCl$ is used in the Clemmenesen reduction for converting carbonyl compounds to alkanes. - (c) $NH_2 - NH_2/KOH$ is used in the Wolff-Kishner reduction for reducing aldehydes or ketones to alkanes. - (d) Cu^{2+}/OH^- is used in Fehling's solution for the detection of reducing sugars. **Step 2: Conclusion.**
Thus, the correct match is:

$$a(iii), b(ii), c(iv), d(i)$$

Final Answer:

$$\boxed{a(iii), b(ii), c(iv), d(i)}$$

---

11. Answer: b

Explanation:

Step 1: Match Etard reaction (A).
The Etard reaction involves the oxidation of aldehydes to acids, and it requires H_2 in the presence of palladium and barium sulfate ($Pd\text{-}BaSO_4$) as the catalyst. Thus, A matches with (iv).
Step 2: Match Gattermann Koch reaction (B).
The Gattermann Koch reaction involves the formylation of aromatic compounds using carbon monoxide and hydrochloric acid in the presence of anhydrous

aluminum chloride ($\mathrm{AlCl_3}$). Thus, B matches with (iii).

Step 3: Match Stephen reaction (C).

The Stephen reaction involves the reduction of aldehydes to alkyl groups using tin chloride and hydrochloric acid. Thus, C matches with (ii).

Step 4: Match Rosenmund reduction (D).

The Rosenmund reduction is the partial catalytic hydrogenation of acyl chlorides to aldehydes using palladium on barium sulfate, which fits D matching with (i). Thus, the correct match is A-iv, B-iii, C-ii, D-i.

---

12. Answer: a

Explanation:

Step 1: Understand optical activity.

A compound is optically active if it contains a chiral center, i.e., a carbon atom bonded to four different groups. If a compound lacks a chiral center, it will be optically inactive.

Step 2: Analyze each compound.

- n-propyl chloride (I): The structure of n-propyl chloride is $\mathrm{CH_3CH_2CH_2Cl}$, where the central carbon is attached to two hydrogen atoms, making it non-chiral. Hence, it is optically inactive. - Secondary butyl chloride (II): The structure is $\mathrm{CH_3CH_2CHCl}$, where the central carbon is attached to two identical groups, making it non-chiral. Therefore, it is optically inactive. - Tert-butyl chloride (III): The structure is $\mathrm{(CH_3)_3CCl}$, where the central carbon is bonded to three identical methyl groups. This makes it non-chiral, and it is optically inactive. - Isopropyl chloride (IV): The structure is $\mathrm{CH_3CHClCH_3}$, where the central carbon is attached to two identical methyl groups, making it non-chiral. Therefore, it is optically inactive.

Step 3: Conclusion.

All of the compounds, except for isopropyl chloride, are optically inactive because they lack a chiral center. Therefore, the correct answer is (1) Only I, III, IV.

---

13. Answer: a

Explanation:

Step 1: Analyze the reaction sequence.
- The starting compound is nitrobenzene (NO_2-C6H5). - Step 1 (Reaction with Br2/FeBr3): This is an electrophilic aromatic substitution reaction where Br_2 and $FeBr_3$ generate the electrophilic bromine ion (Br^+), leading to the substitution of a hydrogen atom on the benzene ring with a bromine atom, resulting in the compound A, which is 1-bromo-2-nitrobenzene.
- Step 2 (Reaction with Sn/HCl): Tin and hydrochloric acid are used to reduce the nitro group (NO_2) to an amine group (NH_2). This results in compound B, which is 1-bromo-2-aminobenzene.
- Step 3 (Reaction with Br2/H2O): Bromine and water introduce a second bromine atom at the para position to the amino group, resulting in compound C, which is 1,4-dibromo-2-aminobenzene.
- Step 4 (Reaction with NaNO2/HCl): Sodium nitrite and hydrochloric acid cause the conversion of the amine group into a diazonium ion, which can undergo further substitution.
- Step 5 (Reaction with CuCl/HCl): The diazonium ion undergoes replacement with a chlorine atom, resulting in the final product E, which is 1,4,6-tribromo-2-chlorobenzene.
Step 2: Identify the final product.
The final product is $C_6H_3(Br)_3Cl$, which corresponds to option (1).

---

14. Answer: b

Explanation:

Step 1: Understand the reactivity of nucleophiles.
Nucleophilicity is a measure of the reactivity of a nucleophile in a substitution or addition reaction. The order of nucleophilicity is influenced by factors such as charge, size, and electronegativity. - Hydroxide ion OH^-: A strong nucleophile because it has a negative charge and is small. - Phenoxide ion PhO^-: A strong nucleophile, but slightly weaker than hydroxide, because the negative charge is delocalized over the aromatic ring, reducing its nucleophilicity. - Acetate ion CH_3COO^-: A weaker nucleophile than OH^- and PhO^-, as the negative charge is stabilized by resonance with the carbonyl group. - Perchlorate ion ClO_4^-: A very weak nucleophile because the negative charge is highly delocalized over the oxygen atoms, making it less reactive.
Step 2: Compare nucleophilicity.

From the above reasoning, the order of nucleophilicity is:

$$\mathrm{OH^-} > \mathrm{PhO^-} > \mathrm{CH_3COO^-} > \mathrm{ClO_4^-}$$

Thus, the correct order of reactivity is given by option (2).

---

15. Answer: b

Explanation:

Concept:

From the mass of $\mathrm{CO_2}$, carbon content is calculated.
From the mass of $\mathrm{H_2O}$, hydrogen content is calculated.
Oxygen content is obtained by difference.
Step 1: Calculate mass of hydrogen.

$$\text{Mass of H} = \frac{2}{18} \times 0.127 = 0.01411\,\text{g}$$

Step 2: Calculate mass of carbon.

$$\text{Mass of C} = \frac{12}{44} \times 0.307 = 0.08373\,\text{g}$$

Step 3: Calculate mass of oxygen in the compound.

$$\text{Mass of O} = 0.210 - (0.08373 + 0.01411)$$

$$\text{Mass of O} = 0.11216\,\text{g}$$

Step 4: Calculate percentage of hydrogen.

$$\%H = \frac{0.01411}{0.210} \times 100 = 6.72\%$$

Step 5: Calculate percentage of oxygen.

$$\%O = \frac{0.11216}{0.210} \times 100 = 53.41\%$$

---

16. **Answer: a**

Explanation:

Concept:

Alkynes undergo different types of reduction depending on the reagent used.
Catalytic hydrogenation with $H_2/Pd{-}C$ leads to **complete reduction**.
Reduction with $Na/NH_3(l)$ gives **anti-addition**, forming a **trans-alkene**.
Step 1: Nature of the starting compound.

$$CH_3{-}C{\equiv}C{-}CH_3 = \text{2-butyne}$$

Step 2: Reaction with $H_2/Pd{-}C$. This reagent causes **complete hydrogenation** of alkynes to alkanes.

$$X = CH_3CH_2CH_2CH_3 \quad (\text{butane})$$

Step 3: Reaction with $Na/NH_3(l)$. This is a dissolving metal reduction causing **anti-addition** of hydrogen.

$$Y = CH_3{-}CH{=}CH{-}CH_3\ (\text{trans-2-butene})$$

Conclusion:

$$X = \text{butane}, \quad Y = \text{trans-2-butene}$$

---

17. **Answer: c**

Explanation:

Concept: A **mixed oxide** is an oxide that can be considered as a combination of two different oxides of the same metal, usually involving different oxidation states.
Typical representation:

$$\text{Mixed oxide} = \text{Lower oxide} + \text{Higher oxide}$$

Step 1: Analyze each option.
Fe_2O_3: Simple oxide of iron (only Fe^{3+})
PbO_2: Simple oxide of lead (only Pb^{4+})
BaO_2: Peroxide, contains O_2^{2-}
Step 2: Examine Pb_3O_4.

$$Pb_3O_4 = 2PbO + PbO_2$$

Here:
Pb exists in both +2 and +4 oxidation states
It is a combination of two oxides of lead Hence, Pb_3O_4 is a mixed oxide.

$$\boxed{Pb_3O_4 \text{ is a mixed oxide}}$$

---

18. Answer: b

Explanation:

Concept:
Acid chlorides react with amines to form amides.
$LiAlH_4$ reduces amides to amines by converting the CO group into a CH_2 group.
Step 1: Identify the starting compound. The given compound is benzylamine:

$$Ph{-}CH_2NH_2$$

Step 2: Reaction with benzoyl chloride ($PhCOCl$) in presence of pyridine. This is an acylation reaction, forming an amide:

$$Ph{-}CH_2NH_2 \xrightarrow{PhCOCl/Py} Ph{-}CH_2NHCOPh$$

Thus,

$$X = Ph{-}CH_2NHCOPh$$

Step 3: Reduction with $LiAlH_4$. Lithium aluminium hydride reduces amides as:

$$RCONHR' \xrightarrow{LiAlH_4} RCH_2NHR'$$

Applying this:

$$\mathrm{Ph{-}CH_2NHCOPh} \xrightarrow{\mathrm{LiAlH_4}} \mathrm{Ph{-}CH_2NHCH_2Ph}$$

Step 4: Final product.

$$\boxed{Y = \mathrm{Ph{-}CH_2NHCH_2Ph}}$$

---

19. Answer: c

Explanation:

Concept: In an **SN2 reaction**, the rate depends on:
Nature of the substrate
Steric hindrance near the reacting carbon
Electronic effects of substituents For **benzylic halides**:
Electron-withdrawing groups (EWG) **increase** SN2 rate by stabilizing the transition state
Electron-donating groups (EDG) **decrease** SN2 rate by destabilizing the transition state
Para-substituted EWGs are more effective than meta-substituted EWGs
Step 1: Identify the substituents in each compound.
(A): Para-$\mathrm{NO_2}$ group Strong **electron-withdrawing group** (−I and −M effect)
(B): Meta-$\mathrm{NO_2}$ group Electron-withdrawing only by **−I effect**; resonance effect is absent at meta position
(C): Para-$\mathrm{NH_2}$ group Strong **electron-donating group** due to +M effect
(D): Para-OH group Electron-donating group, but weaker than $\mathrm{NH_2}$
Step 2: Compare the effect of substituents on SN2 reactivity.
Strong EWG $\Rightarrow$ maximum SN2 rate
Meta EWG<Para EWG
EDGs reduce SN2 rate
$\mathrm{NH_2}$ donates electrons more strongly than OH Thus, SN2 reactivity decreases in the order:

$$\text{Para-NO}_2 > \text{Meta-NO}_2 > \mathrm{OH} > \mathrm{NH_2}$$

Step 3: Assign compounds accordingly:

$$A > B > D > C$$

Among the given options, this corresponds to:

$$\boxed{A > B > C > D}$$

---

20. Answer: a

Explanation:

Concept: The given reaction is an **SN2 reaction**, as methyl bromide (CH_3Br) undergoes nucleophilic substitution via a single-step backside attack mechanism.
For nucleophilicity in SN2 reactions:
Higher **electron density** increases nucleophilicity
Resonance stabilization decreases nucleophilicity
Weakly basic and highly stabilized anions are poor nucleophiles
Step 1: Analyze each nucleophile.
\(**HO^-**\): Small size, high charge density, and no resonance stabilization. Hence, it is a very strong nucleophile.
\(**PhO^-**\) (Phenoxide ion): The negative charge is delocalized over the aromatic ring through resonance, reducing its availability for nucleophilic attack. Thus, it is weaker than HO^-.
\(**CH_3COO^-**\) (Acetate ion): The negative charge is delocalized over two oxygen atoms due to resonance, making it less nucleophilic than phenoxide.
\(**ClO_4^-**\) (Perchlorate ion): Highly resonance-stabilized with extensive charge delocalization. It is an extremely weak nucleophile.
Step 2: Compare nucleophilic strength based on availability of lone pair.

$$HO^{\rightarrow}PhO^{\rightarrow}CH_3COO^{\rightarrow}ClO_4^-$$

Step 3: Match the order with the given options. This order corresponds to **Option (1)**.

---

21. Answer: a

Explanation:

Concept: In an S_N1 reaction, the **rate-determining step** is the formation of a carbocation. Hence, the reactivity order depends on the **stability of the carbocation** formed after the leaving group departs. Carbocation stability increases due to:
Greater degree of substitution $(3^\circ > 2^\circ > 1^\circ)$
Resonance stabilization (benzylic, allylic)
Hyperconjugation
Step 1: Analyze compound (IV). Compound (IV) forms a **tertiary benzylic carbocation** with **two phenyl rings**. The positive charge is extensively stabilized by:
Resonance with both phenyl rings
Hyperconjugation Thus, (IV) forms the **most stable carbocation** and reacts fastest.
Step 2: Analyze compound (III). Compound (III) is a **tertiary alkyl bromide**. It forms a tertiary carbocation stabilized by hyperconjugation, but **no resonance stabilization** is present. Hence, its reactivity is less than (IV) but greater than secondary carbocations.
Step 3: Analyze compounds (I) and (II). Both (I) and (II) are **secondary cyclohexyl bromides**. However:
In (I), the carbocation formed is relatively more stable due to better structural accommodation.
In (II), the carbocation is less stable due to poorer overlap and higher ring strain. Thus,

$$\text{Stability: I} > \text{II}$$

Step 4: Write the overall order based on carbocation stability.

$$\boxed{\text{IV} > \text{III} > \text{I} > \text{II}}$$

This matches **Option (1)**.

---

22. Answer: a

Explanation:

Concept: The reaction of methyl bromide (CH_3Br) with nucleophiles proceeds via an **SN2 mechanism**. Since the solvent is **methanol (polar protic)**, nucleophilicity is strongly influenced by:
Solvation effects
Size of the nucleophile

Resonance stabilization In **polar protic solvents**, nucleophilicity generally follows:

$$\text{Larger, more polarizable ions} > \text{smaller ions}$$

Step 1: Compare halide ions.
\(**I**^-\): Large size, weak solvation, highly polarizable
\(**F**^-\): Very small size, strongly solvated by methanol Thus,

$$I^- \gg F^-$$

Step 2: Compare alkoxide and phenoxide ions.
\(**C**_2**H**_5**O**^-\) (ethoxide): Negative charge is localized on oxygen → stronger nucleophile.
\(**C**_6**H**_5**O**^-\) (phenoxide): Negative charge is delocalized into the benzene ring due to resonance → reduced nucleophilicity. Hence,

$$C_2H_5O^{\rightarrow}C_6H_5O^-$$

Step 3: Overall comparison in methanol (polar protic solvent).
I^-: Least solvated, most polarizable → strongest nucleophile
$C_2H_5O^-$: Strong base and good nucleophile
$C_6H_5O^-$: Resonance-stabilized → weaker nucleophile
F^-: Strongly solvated → weakest nucleophile
Step 4: Final order of nucleophilic reactivity.

$$\boxed{I^{\rightarrow}C_2H_5O^{\rightarrow}C_6H_5O^{\rightarrow}F^-}$$

This matches **Option (1)**.

---

23. Answer: c

Explanation:

Concept: This question tests knowledge of **important qualitative reagents and named organic reactions**. Each reagent in List–I has a well-known composition and specific use, which helps in direct identification.

Step 1: Analyze item (a).

$$[Ag(NH_3)_2]^+$$

This is the **diamminesilver(I) complex**. It is the active species present in **Tollen's reagent**, which is used to test aldehydes and produces a silver mirror.

$$(a) \to \text{Tollen's reagent} \to (iii)$$

Step 2: Analyze item (b).

$$\text{Zn–Hg / HCl}$$

This reagent is used to reduce aldehydes and ketones to hydrocarbons under **strongly acidic conditions**. This reaction is known as **Clemmensen's reduction**.

$$(b) \to \text{Clemmensen's reduction} \to (ii)$$

Step 3: Analyze item (c).

$$NH_2–NH_2/KOH$$

Hydrazine in the presence of strong base converts aldehydes and ketones into hydrocarbons under **basic conditions**. This reaction is known as the **Wolff–Kishner reduction**.

$$(c) \to \text{Wolff–Kishner reduction} \to (iv)$$

Step 4: Analyze item (d).

$$Cu^{2+}/OH^-$$

Alkaline copper(II) ions form the basis of **Fehling's solution**, which is used to detect aliphatic aldehydes by forming a red precipitate of Cu_2O.

$$(d) \to \text{Fehling's solution} \to (i)$$

Step 5: Write the complete matching.

$$a(iii),\ b(ii),\ c(iv),\ d(i)$$

This corresponds to **Option (3)**.

---

24. Answer: 42 - 42

Explanation:

Concept: This question is based on the **gravimetric estimation of phosphorus**. In this method, phosphorus present in the organic compound is quantitatively converted into a stable compound, **magnesium pyrophosphate** $Mg_2P_2O_7$. Knowing the mass of this precipitate allows us to calculate the mass and percentage of phosphorus using stoichiometry.

Step 1: Calculate the molar mass of $Mg_2P_2O_7$ Atomic masses:

$$\mathrm{Mg} = 24, \quad \mathrm{P} = 31, \quad \mathrm{O} = 16$$

$$\text{Molar mass of } \mathrm{Mg_2P_2O_7} = 2(24) + 2(31) + 7(16)$$

$$= 48 + 62 + 112 = 222 \text{ g mol}^{-1}$$

Step 2: Calculate the mass of phosphorus in one mole of $Mg_2P_2O_7$ From the formula, one mole of $Mg_2P_2O_7$ contains:

$$2 \text{ atoms of phosphorus}$$

$$\text{Mass of phosphorus} = 2 \times 31 = 62 \text{ g}$$

Step 3: Determine the fraction of phosphorus in $Mg_2P_2O_7$

$$\text{Fraction of P} = \frac{62}{222}$$

Step 4: Calculate the mass of phosphorus in 0.75 g of $Mg_2P_2O_7$

$$\text{Mass of P} = 0.75 \times \frac{62}{222}$$

$$= 0.75 \times 0.2793$$

$$= 0.209 \text{ g}$$

Step 5: Calculate the percentage of phosphorus in the organic compound Given mass of organic compound = 0.5 g

Step 6: Nearest integer value

---

25. Answer: 41.6 - 41.6

Explanation:

Concept: This problem is based on **gravimetric analysis of phosphorus**. In gravimetric estimation, an element present in a compound is converted quantitatively into a stable compound of known composition. Here, phosphorus present in the organic compound is finally obtained as **magnesium pyrophosphate**, $\mathrm{Mg_2P_2O_7}$. Once the mass of this compound is known, the mass of phosphorus can be calculated using stoichiometry.

Step 1: Write the formula and calculate molar mass of $\mathrm{Mg_2P_2O_7}$

$$\mathrm{Mg_2P_2O_7}$$

Molar masses:

$$\mathrm{Mg} = 24, \quad \mathrm{P} = 31, \quad \mathrm{O} = 16$$

$$\text{Molar mass of } \mathrm{Mg_2P_2O_7} = 2(24) + 2(31) + 7(16)$$

$$= 48 + 62 + 112 = 222 \text{ g mol}^{-1}$$

Step 2: Determine how much phosphorus is present in one mole of $\mathrm{Mg_2P_2O_7}$ From the formula, each mole of $\mathrm{Mg_2P_2O_7}$ contains:

$$2 \text{ atoms of phosphorus}$$

$$\text{Mass of phosphorus} = 2 \times 31 = 62 \text{ g}$$

Step 3: Find the mass fraction of phosphorus in $\mathrm{Mg_2P_2O_7}$

$$\text{Fraction of P} = \frac{\text{Mass of P}}{\text{Molar mass of } \mathrm{Mg_2P_2O_7}} = \frac{62}{222}$$

Step 4: Calculate the mass of phosphorus in 1.49 g of $\mathrm{Mg_2P_2O_7}$

$$\text{Mass of P} = 1.49 \times \frac{62}{222}$$

$$= 1.49 \times 0.2793$$

$$= 0.416 \text{ g}$$

Step 5: Calculate the percentage of phosphorus in the given sample Given mass of organic compound = 1 g

Final Answer: \[\boxed{41.6%} \]

---

26. **Answer: c**

Explanation:

[(A)] **Correct** — Propanal (aldehyde) and propanone (ketone) have the same molecular formula but different functional groups.
[(B)] **Correct** — Ethoxyethane and methoxypropane are ethers differing in alkyl group distribution, hence metamers.
[(C)] **Incorrect** — But-2-ene shows geometrical (cis–trans) isomerism, not optical isomerism.
[(D)] **Incorrect** — But-1-ene and but-2-ene are positional isomers, not functional isomers.
[(E)] **Correct** — Pentane and 2,2-dimethylpropane differ in carbon chain arrangement, hence chain isomers.

---

27. **Answer: a**

Explanation:

Step 1: A positive iodoform test indicates the presence of either:

$$\mathrm{CH_3CO{-}or CH_3CH(OH){-}}$$

Step 2: On hydrolysis with dilute acid, the product gives:
Tollens' test $\Rightarrow$ aldehyde group ($-\mathrm{CHO}$)
Iodoform test $\Rightarrow$ methyl ketone group
Step 3: Therefore, the hydrolysis product must contain both:

$$-\mathrm{CHO and CH_3CO}-$$

Step 4: Option (A) is a hemiacetal. On acid hydrolysis, it yields:

$$\mathrm{CH_3COCH_2CH_2CHO}$$

which contains:
Aldehyde group $\Rightarrow$ Tollens' test positive
Methyl ketone group $\Rightarrow$ Iodoform test positive **Hence, option (A) is correct.**

---

28. Answer: b

Explanation:

The stability of resonance structures depends on the following factors:
Minimum charge separation
Maximum number of atoms having complete octet
Negative charge on more electronegative atoms
Positive charge on less electronegative atoms

Analysis of options:
Option (1): Contains unnecessary charge separation and a carbocation not well stabilised.

Option (2): Has:
Minimum charge separation
Positive charge delocalised and stabilised by resonance
Negative charge located on oxygen (more electronegative) Hence, it is the most stable.

Option (3): Contains two adjacent positive charges, leading to strong electrostatic repulsion.

Option (4): Shows excessive charge separation and a highly unstable dicationic nitrogen.

---

29. Answer: a

Explanation:

Step 1: Benzoic acid reacts with ammonia on heating to form benzamide:

$$C6H5COOH + NH3 -> [\Delta] C6H5CONH2 + H2O$$

Thus,

$$P = \text{Benzoic acid}, Q = \text{Benzamide}$$

Step 2: Benzamide undergoes Hofmann bromamide reaction with $Br2/KOH$, forming aniline:

$$C6H5CONH2 -> [Br2/KOH] C6H5NH2$$

Thus,

$$R = \text{Aniline}$$

---

30. Answer: a

Explanation:

Given reactions:

- Reaction 1: $\mathrm{H_2, Pt}$ (Hydrogenation)
- Reaction 2: $\mathrm{Hot\ alk.\ KMnO_4}$ (Oxidation to Carboxylic acid)
- Reaction 3: $\mathrm{H^+, H_2O}$ (Acidic Hydrolysis)

The compound (A) undergoes these reactions:

$$H_2,\ Pt \rightarrow \text{Saturated compound}$$

$$\text{Hot alk. } KMnO_4 \rightarrow \text{Carboxylation of the methyl group}$$

$$H^+,\ H_2O \rightarrow \text{Carboxylic acid formation}$$

Step-by-Step Analysis:

Let's consider the structure of compound (A). The first reaction with hydrogen (H_2) and platinum (Pt) suggests that the compound contains a double bond or an unsaturation. Hydrogenation would reduce the unsaturation to a saturated structure. The second reaction with hot alkaline $KMnO_4$ is a strong oxidizing reaction that cleaves the methyl group ($-CH_3$) in methylbenzene (toluene) and oxidizes it to a carboxyl group ($-COOH$), forming benzoic acid. The final acidic hydrolysis ensures the formation of carboxylic acid as the final product.

Conclusion: Compound (A) is likely to be **toluene (methylbenzene)**, and after the reactions, the product will be **benzoic acid**.

Therefore, compound (A) corresponds to: Option 1 (Toluene), and the final product is **benzoic acid**.