JEE Main 2024 April 6 Shift 2 Chemistry Question Paper with solution

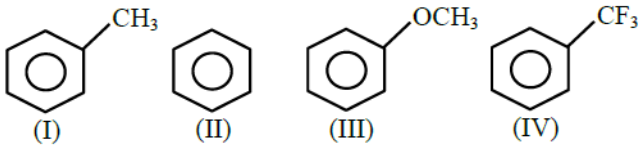
Time Allowed :1 Hour	Maximum Marks :100	Total Questions :30

General Instructions

Read the following instructions very carefully and strictly follow them:

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

1. The correct arrangement for decreasing order of electrophilic substitution for the given compounds is ____.



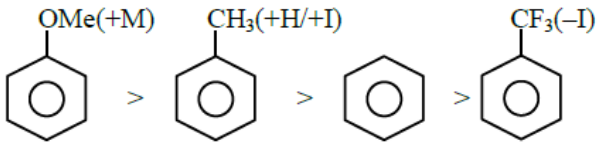
(1) $(IV) > (I) > (II) > (III)$
(2) $(III) > (I) > (II) > (IV)$
(3) $(II) > (IV) > (III) > (I)$
(4) $(III) > (IV) > (II) > (I)$

Correct Answer: (2)

Solution:

The order of electrophilic substitution is determined by the electron-donating or electron-withdrawing effects of the groups attached to the aromatic ring. Compounds with electron-donating groups accelerate electrophilic substitution, whereas compounds with electron-withdrawing

groups slow it down. Based on this, the decreasing order for electrophilic substitution is:



Compound (III) > Compound (I) > Compound (II) > Compound (IV)

Quick Tip

Electron-donating groups increase the rate of electrophilic substitution, while electron-withdrawing groups decrease it.

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2. The molality (m) of a 3 M aqueous solution of NaCl is:
(Given: Density of solution = 1.25 g/mL, Molar mass of Na = 23, Cl = 35.5)

(1) 2.90 m
(2) 2.79 m
(3) 1.90 m
(4) 3.85 m

Correct Answer: (2)

Solution:

To calculate molality, we need to know the mass of the solvent. Since the solution is 3 M, this means 3 moles of NaCl are present in 1 liter of solution. The density of the solution is given as 1.25 g/mL, so the total mass of the solution is:

$$\text{Mass of solution} = 1.25 \times 1000 = 1250\,\text{g}$$

Next, calculate the mass of the solute (NaCl):

$$\text{Mass of solute} = 3 \times 58.5 = 175.5\,\text{g}$$

The mass of the solvent is:

$$\text{Mass of solvent} = 1250 - 175.5 = 1074.5\,\text{g} = 1.0745\,\text{kg}$$

Now, use the formula for molality:

$$\text{molality} = \frac{3 \times 1000}{1074.5} = 2.79\,\text{m}$$

Quick Tip

Molality is calculated as moles of solute per kilogram of solvent, making it temperature-independent.

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3. The incorrect statements regarding enzymes are:
(A) Enzymes are biocatalysts.
(B) Enzymes are non-specific and can catalyse different kinds of reactions.
(C) Most enzymes are globular proteins.
(D) Enzyme - oxidase catalyses the hydrolysis of maltose into glucose.

Choose the correct answer:
(1) (B) and (C)
(2) (B), (C) and (D)
(3) (B) and (D)
(4) (A), (C) and (D)

Correct Answer: (3)

Solution:

Statement (A) is correct as enzymes act as biocatalysts, speeding up biochemical reactions.
Statement (B) is incorrect because enzymes are highly specific and catalyze particular reactions.
Statement (C) is correct as most enzymes are globular proteins.
Statement (D) is incorrect because oxidase enzymes are involved in oxidation-reduction reactions, not in hydrolysis of maltose.

Thus, the incorrect statements are (B) and (D).

Quick Tip

Enzymes are highly specific catalysts that generally catalyze only one type of reaction, often due to the unique structure of their active sites.

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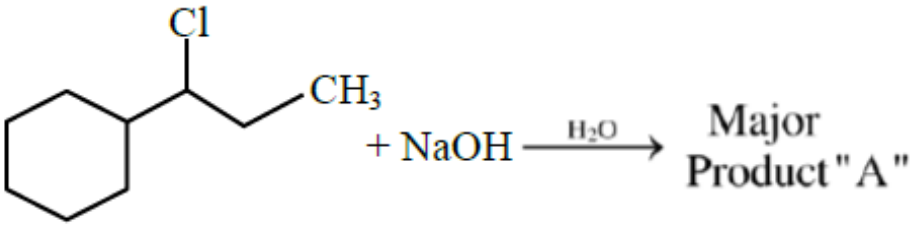
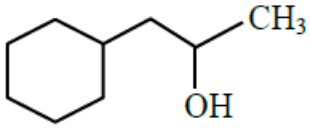
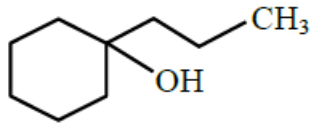
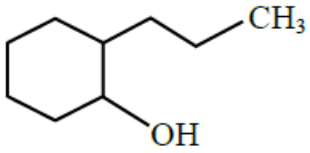
4. Consider the given chemical reaction. Product "A" is:

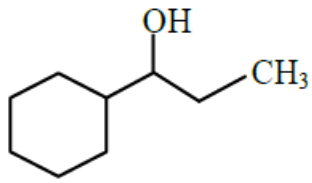


Consider the above chemical reaction. Product "A" is:

(1) 

(2) 

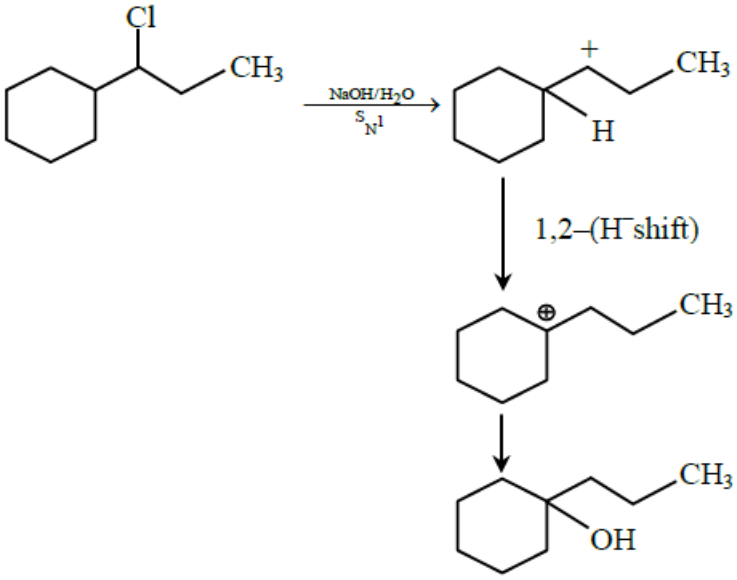
(3) 

(4) 

Correct Answer: (2)

Solution:

The reaction proceeds via an S_N1 mechanism where the leaving group (chlorine) departs first, forming a carbocation. This carbocation undergoes a 1,2-hydride shift, stabilizing the carbocation into a more stable tertiary form. Then, a hydroxide ion (OH^-) attacks the carbocation, leading to the formation of the major product, a tertiary alcohol.



(Major Product)

Quick Tip

In S_N1 reactions, carbocation rearrangements (like hydride or alkyl shifts) often occur to form more stable carbocations before the nucleophile attacks.

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5. During the detection of the acidic radical in a salt, a student observes a pale yellow precipitate, soluble with difficulty in NH_4OH solution when sodium carbonate extract is first acidified with dilute HNO_3 and then $AgNO_3$ solution is added.

This indicates the presence of:

(1) Br^-
(2) CO_3^{2-}
(3) I^-
(4) Cl^-

Correct Answer: (1)

Solution:

When $AgNO_3$ is added to a solution containing halide ions, it forms a precipitate. The colors of these precipitates vary:
- AgI forms a yellow precipitate. - AgCl forms a white precipitate. - AgBr forms a pale yellow precipitate.

$$Ag^+ + I^- \rightarrow AgI \quad \text{(Yellow ppt.)}$$

$$Ag^+ + Cl^- \rightarrow AgCl \quad \text{(White ppt.)}$$

$$Ag^+ + Br^- \rightarrow AgBr \quad \text{(Pale yellow ppt.)}$$

Since a pale yellow precipitate is observed, it indicates the presence of Br^- ions.

Quick Tip

The color of the precipitate formed by silver halides helps identify the halide ions: yellow for AgI, white for AgCl, and pale yellow for AgBr.

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6. How can an electrochemical cell be converted into an electrolytic cell?

(1) Applying an external opposite potential greater than E^0_{cell}
(2) Reversing the flow of ions in the salt bridge.
(3) Applying an external opposite potential lower than E^0_{cell}.
(4) Exchanging the electrodes at anode and cathode.

Correct Answer: (1)

Solution:

To convert an electrochemical cell into an electrolytic cell, an external voltage greater than the standard cell potential E^0_{cell} must be applied in the opposite direction. This will reverse the cell's spontaneous reaction, allowing the cell to perform electrolysis.

Quick Tip

To reverse an electrochemical cell's reaction, apply an external potential greater than the cell's standard potential in the opposite direction.

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7. Arrange the following elements in the increasing order of the number of unpaired electrons in them.
(A) Sc
(B) Cr
(C) V
(D) Ti
(E) Mn

Select the correct answer from the options below:

(1) $(C) < (E) < (B) < (A) < (D)$
(2) $(B) < (C) < (D) < (E) < (A)$
(3) $(A) < (D) < (C) < (B) < (E)$
(4) $(A) < (D) < (C) < (E) < (B)$
Correct Answer: (4)

Solution:

The electronic configurations and corresponding number of unpaired electrons for each element are as follows:

Sc:	$[\text{Ar}]\,4s^2\,3d^1$	(1 unpaired electron)
Cr:	$[\text{Ar}]\,4s^1\,3d^5$	(6 unpaired electrons)
V:	$[\text{Ar}]\,4s^2\,3d^3$	(3 unpaired electrons)
Ti:	$[\text{Ar}]\,4s^2\,3d^2$	(2 unpaired electrons)
Mn:	$[\text{Ar}]\,4s^2\,3d^5$	(5 unpaired electrons)

Thus, arranging these elements in increasing order of unpaired electrons, we get:

$$\text{Sc (A)} < \text{Ti (D)} < \text{V (C)} < \text{Mn (E)} < \text{Cr (B)}$$

Quick Tip

The number of unpaired electrons in transition elements is determined by their electronic configuration, particularly the arrangement of electrons in the *d*-orbitals.

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8. Match List-I with List-II.

List-I	**List-II**
Alkali Metal	Emission Wavelength in nm
(A) Li	(I) 589.2
(B) Na	(II) 455.5
(C) Rb	(III) 670.8
(D) Cs	(IV) 780.0

Select the correct answer from the options below:
(1) (A)-(I), (B)-(IV), (C)-(III), (D)-(II)
(2) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)
(3) (A)-(II), (B)-(I), (C)-(III), (D)-(IV)
(4) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)

Correct Answer: (2)

Solution:

This question asks about the characteristic emission wavelengths of alkali metals, which are known from their flame test results. The correct matches are:

(A) Li $-$(III) 670.8 nm
(B) Na $-$(I) 589.2 nm
(C) Rb $-$(IV) 780.0 nm
(D) Cs $-$(II) 455.5 nm

Quick Tip

The characteristic emission wavelengths of alkali metals are used in flame tests for their identification, with each metal emitting light at a specific wavelength.

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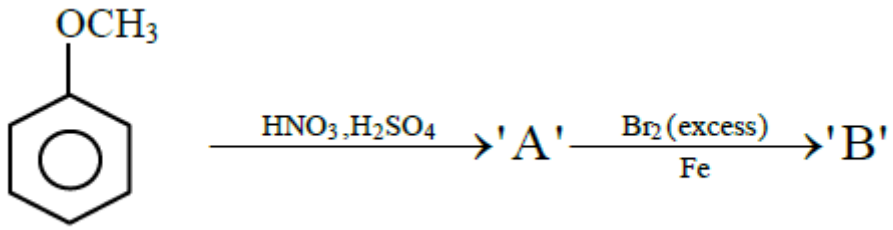
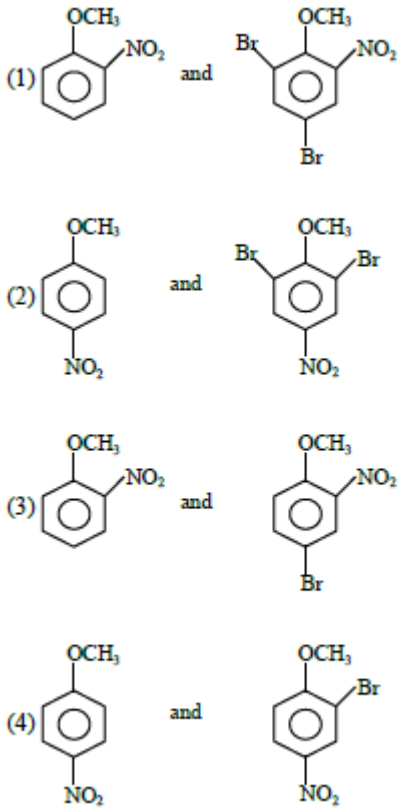
9. The major products formed:



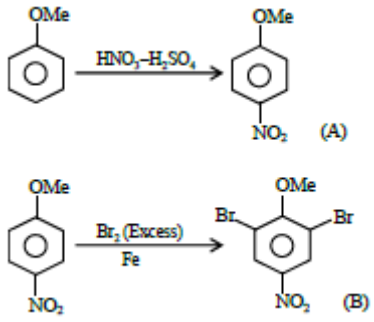
A and B respectively are:



Correct Answer: (2)

Solution:

The reaction sequence proceeds as follows: 1. Anisole (methoxybenzene) undergoes nitration with HNO_3/H_2SO_4 to form 4-nitroanisole (A). 2. The nitrated product undergoes bromination with Br_2 (in the presence of excess iron) to yield 4-bromo-2-nitroanisole (B).



Therefore, the correct products are (A) and (B) as shown in option (2).

Quick Tip

Anisole (OMe-substituted benzene) directs electrophilic substitution reactions to the para and ortho positions, which explains the selective nitration and bromination patterns.

10. The incorrect statement regarding the geometrical isomers of 2-butene is:
(1) cis-2-butene and trans-2-butene are not interconvertible at room temperature.
(2) cis-2-butene has less dipole moment than trans-2-butene.
(3) trans-2-butene is more stable than cis-2-butene.
(4) cis-2-butene and trans-2-butene are stereoisomers.
Correct Answer: (2)

Solution:

The structures of cis-2-butene and trans-2-butene are:

$$\text{cis-2-butene:} \quad CH_3 - CH = CH - CH_3 \quad \text{(Polar)}$$
$$\text{trans-2-butene:} \quad H - CH = CH - CH_3 \quad \text{(Non-Polar)}$$

In terms of dipole moment, cis-but-2-ene has a higher dipole moment than trans-but-2-ene because the substituents are on the same side in the cis form, creating an overall dipole. In contrast, the trans form has a symmetrical arrangement where the dipoles cancel out.

Quick Tip

In geometric isomers, the cis form usually has a higher dipole moment than the trans form due to the unequal distribution of substituents around the double bond.

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11. Given below are two statements:

Statement I: PF_5 and BrF_5 both exhibit sp^3d hybridization.
Statement II: SF_6 and $[Co(NH_3)_6]^{3+}$ both exhibit sp^3d^2 hybridization.

Choose the correct answer from the options below:
(1) Statement I is true but Statement II is false
(2) Both Statement I and Statement II are true
(3) Both Statement I and Statement II are false
(4) Statement I is false but Statement II is true
Correct Answer: (3)

Solution:

The hybridization of the molecules is as follows:

$$\begin{aligned} &PF_5 && : sp^3d \\ &F_5 && : sp^3d^2 \\ &SF_6 && : sp^3d^2 \\ &[Co(NH_3)_6]^{3+} && : d^2sp^3 \end{aligned}$$

Thus, both Statement I and Statement II are incorrect.

Quick Tip

The hybridization of a molecule depends on the number of electron pairs around the central atom. SF_6, with six bonding pairs, has sp^3d^2 hybridization, while PF_5 has sp^3d hybridization with five bonding pairs.

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12. The number of ions from the following that are expected to behave as oxidising agents is:
Sn^{4+}, Sn^{2+}, Pb^{2+}, Tl^{3+}, Pb^{4+}, Tl^{+}

(1) 3
(2) 4
(3) 1
(4) 2
Correct Answer: (4)

Solution:

Only Tl^{3+} and Pb^{4+} are capable of acting as oxidising agents due to the inert pair effect. These ions tend to gain electrons to reach a more stable oxidation state.

Quick Tip

The inert pair effect leads to the instability of higher oxidation states in heavier elements, making ions like Tl^{3+} and Pb^{4+} effective oxidising agents as they readily accept electrons.

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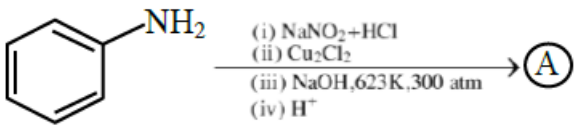
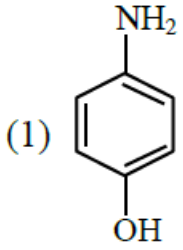
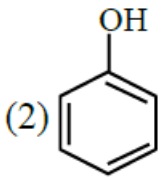
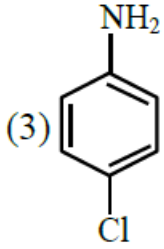
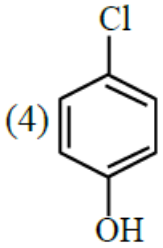
13. Identify the product A in the following reaction.







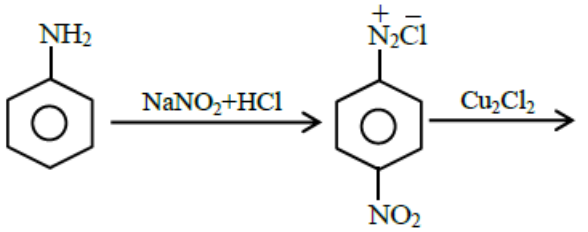


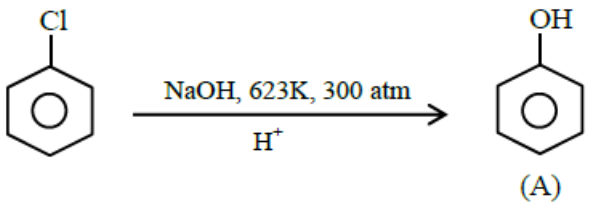


Correct Answer: (2)

Solution:

The reaction begins with diazotization, followed by the Sandmeyer reaction, and concludes with hydrolysis, resulting in product A.





Quick Tip

This sequence demonstrates the transformation of an aromatic amine into a variety of substituted products using diazotization and Sandmeyer's reactions, with the final step being a hydrolysis process.

14. The correct statements among the following, for a "chromatography" purification method is:
(1) Organic compounds run faster than solvent in the thin layer chromatographic plate.
(2) Non-polar compounds are retained at top and polar compounds come down in column chromatography.
(3) R_f of a polar compound is smaller than that of a non-polar compound.
(4) R_f is an integral value.

Correct Answer: (3)

Solution:

In chromatography, non-polar compounds travel further, hence having higher R_f values than polar compounds, which are more attracted to the stationary phase.

Quick Tip

The R_f value in chromatography indicates how far a compound travels relative to the solvent. Polar compounds have lower R_f values because they interact more strongly with the stationary phase.

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15. Evaluate the following statements related to group 14 elements for their correctness.
(A) Covalent radius decreases down the group from C to Pb in a regular manner.
(B) Electronegativity decreases from C to Pb down the group gradually.
(C) Maximum covalence of C is 4 whereas other elements can expand their covalence due to presence of d orbitals.
(D) Heavier elements do not form π-π bonds.
(E) Carbon can exhibit negative oxidation states.

Choose the correct answer from the options given below:
(1) (C), (D) and (E) Only
(2) (A) and (B) Only
(3) (A), (B) and (C) Only
(4) (C) and (D) Only

Correct Answer: (1)

Solution:
(A) Covalent radius increases down the group, not decreases.
(B) Electronegativity does not decrease gradually across the group.
(C) Carbon has a maximum covalence of 4, while heavier elements can expand their covalence due to d-orbitals.
(D) Correct; heavier elements in group 14 do not form π-π bonds.

(E) Carbon can exhibit oxidation states ranging from -4 to +4.

Quick Tip

In Group 14, elements like carbon can form π-π bonds, but this capability diminishes down the group as atomic size increases. Carbon's unique small size also allows it to exhibit a wider range of oxidation states.

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16. Match List-I with the List-II

List-I (Reaction)	**List-II (Type of redox reaction)**
(A) $N_2(g) + O_2(g) \rightarrow 2NO(g)$	(I) Decomposition
(B) $2Pb(NO_3)_{2(s)} \rightarrow 2PbO_{(s)} + 4NO_{2(g)} + O_{2(g)}$	(II) Displacement
(C) $2Na(s) + 2H_2O \rightarrow 2NaOH_{(aq)} + H_2(g)$	(III) Disproportionation
(D) $2NO_2(g) + 2^-OH_{(aq)} \rightarrow NO^-_{2(aq)} + NO^-_{3(aq)} + H_2O_{(l)}$	(IV) Combination

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

Correct Answer: (4)

Solution:

(A) $N_2 + O_2 \rightarrow 2NO$: This is a combination reaction, as two reactants combine to form one product. Thus, $A \rightarrow (IV)$.
(B) $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$: This is a decomposition reaction, where a single compound breaks into multiple products. Thus, $B \rightarrow (I)$.
(C) $2Na + 2H_2O \rightarrow 2NaOH + H_2$: This is a displacement reaction, as sodium displaces hydrogen in water. Thus, $C \rightarrow (II)$.
(D) $2NO_2$+$2OH^- \rightarrow NO_2^-$+NO_3^-+H_2O: This is a disproportionation reaction, as $NO_2 is both oxidized and r$
(III).

Final Matching:

$$A \rightarrow (IV),\ B \rightarrow (I),\ C \rightarrow (II),\ D \rightarrow (III)$$

Quick Tip

Understanding redox reactions involves recognizing whether elements combine (combination), break down (decomposition), replace other elements (displacement), or undergo simultaneous oxidation and reduction (disproportionation).

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17. Consider the given reaction, identify the major product P.

$$CH_3 - COOH \xrightarrow[(iv)\ H_2O/\bar{O}H,\Delta]{(i)\ LiAlH_4 \quad (ii)\ PCC \quad (iii)\ HCN/\bar{O}H} \text{"P"}$$

(1) $CH_3 - CH_2 - CH_2 - OH$

(2) $CH_3 - CH_2 - \overset{\overset{O}{\|}}{C} - NH_2$

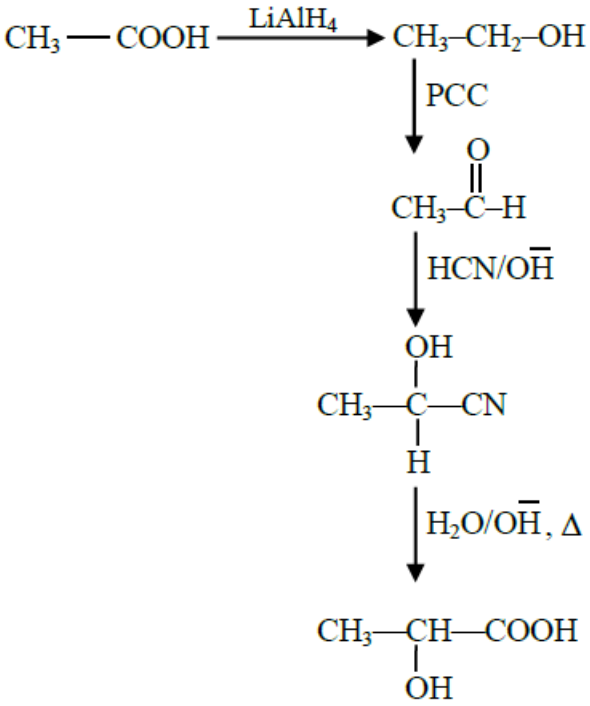
(3) $CH_3 - \overset{\overset{O}{\|}}{C} - CH_2CH_3$

(4) $CH_3 - \overset{\overset{OH}{|}}{CH} - COOH$

Correct Answer: (4)

Solution:

The reaction involves reduction with $LiAlH_4$ followed by oxidation with PCC, resulting in the formation of a primary alcohol as the major product.



Quick Tip

$LiAlH_4$ is a strong reducing agent that reduces carboxylic acids to alcohols, while PCC is a mild oxidant that oxidizes alcohols to aldehydes.

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18. The correct IUPAC name of $[PtBr_2(PMe_3)_2]$ is:

1. bis(trimethylphosphine)dibromoplatinum(II)
2. bis[bromo(trimethylphosphine)]platinum(II)
3. dibromobis(trimethylphosphine)platinum(II)
4. dibromodi(trimethylphosphine)platinum(II)

Correct Answer: (3)

Solution:
The correct IUPAC name is "dibromobis(trimethylphosphine)platinum(II)," where "bis" denotes two ligands, and the ligands are named alphabetically.

Quick Tip

When naming coordination compounds, the prefixes like "bis" are used for multiple identical ligands, and the ligands are listed alphabetically.

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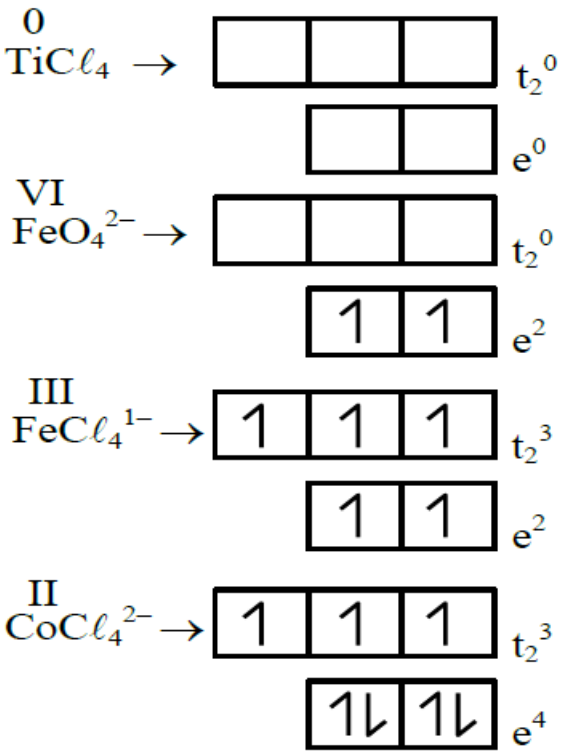
19. Match List-I with List-II

List-I	**List-II**
Tetrahedral Complex	Electronic configuration
(A) $TiCl_4$	(I) e^2, t_2^1
(B) $[FeO_4]^{2-}$	(II) e^4, t_2^2
(C) $[FeCl_4]^{-}$	(III) e^0, t_2^0
(D) $[CoCl_4]^{2-}$	(IV) e^2, t_2^2

Choose the correct answer from the option given below:
(1) (A)-(I), (B)-(III), (C)-(IV), (D)-(II)
(2) (A)-(IV), (B)-(III), (C)-(I), (D)-(II)
(3) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)
(4) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)

Correct Answer: (4)

Solution:
The electronic configurations for the tetrahedral complexes are determined by the number of d-electrons in the metal ion and the splitting of the d-orbitals into e and t_2 sets, resulting in the following configurations:



- $TiCl_4$ → (III) - $[FeO_4]^{2-}$ → (I) - $[FeCl_4]^{-}$ → (II) - $[CoCl_4]^{2-}$ → (IV)

Quick Tip

In tetrahedral complexes, the d-orbitals split into two sets: e (higher energy) and t_2 (lower energy). The electronic configuration depends on the number of d-electrons and the ligand field.

---

20. The ratio $\frac{K_P}{K_C}$ for the reaction:

$$CO_{(g)} + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$$

is:

1. $(RT)^{1/2}$
2. RT
3. 1
4. $\frac{1}{\sqrt{RT}}$

Correct Answer: (4)

Solution:
For the reaction, the change in the number of moles of gas $\Delta n_g = 1 - \left(1 + \frac{1}{2}\right) = -\frac{1}{2}$.

$$CO_{(g)} + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$$

$$\Delta n_g = 1 - \left(1 + \frac{1}{2}\right) = -\frac{1}{2}$$

Therefore, the relationship between K_P and K_C is given by:

$$\frac{K_P}{K_C} = (\mathrm{RT})^{\Delta n_g} = \frac{1}{\sqrt{\mathrm{RT}}}$$

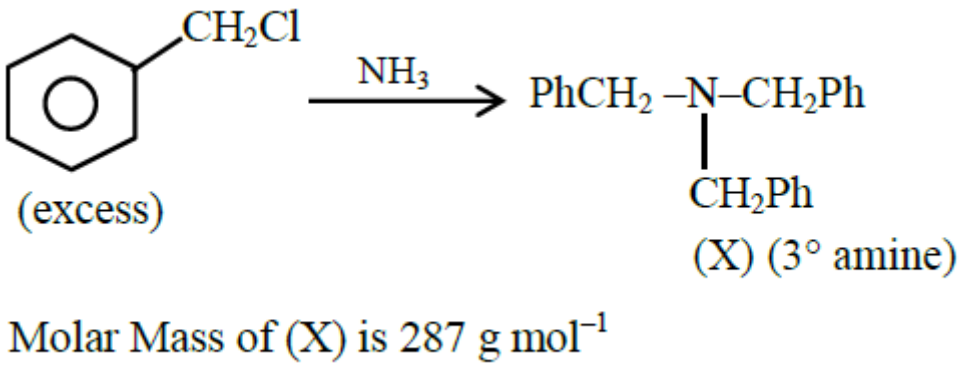
Quick Tip

The relationship between the equilibrium constants K_P and K_C for gas-phase reactions is given by $\frac{K_P}{K_C} = (\mathrm{RT})^{\Delta n_g}$, where Δn_g is the change in the number of gas moles.

---

21. An amine (X) is prepared by ammonolysis of benzyl chloride. On adding p-toluenesulphonyl chloride to it, the solution remains clear. Molar mass of the amine (X) formed is _____ g mol^{-1}.
(Given molar mass in g mol^{-1} C: 12, H: 1, O: 16, N: 14)
Correct Answer: (287)

Solution:



Molar Mass of (X) is 287 g mol^{-1}

The ammonolysis of benzyl chloride results in the formation of a tertiary amine. The reaction with p-toluenesulphonyl chloride does not result in precipitation, indicating that the amine has a relatively large molar mass. The molar mass of the formed amine is 287 g/mol.

Quick Tip

Ammonolysis of benzyl chloride forms a tertiary amine. The p-toluenesulphonyl chloride does not react with tertiary amines, which lack available hydrogen for sulfonation.

---

22. Consider the following reactions

$$NiS + HNO_3 + HCl \rightarrow A + NO + S + H_2O$$

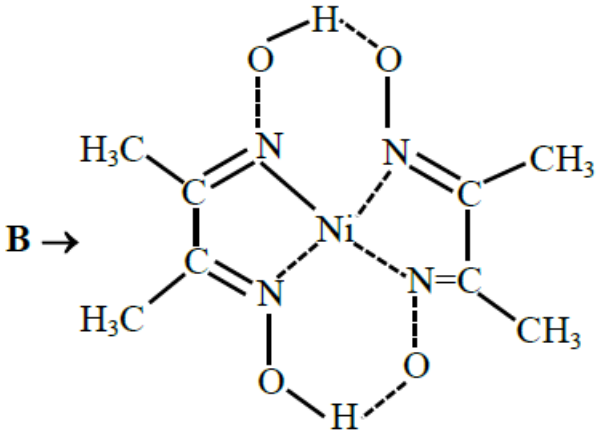
$$A + NH_4OH + \begin{matrix} H_3C - C = N - OH \\ | \\ H_3C - C = N - OH \end{matrix} \longrightarrow B + NH_4Cl + H_2O$$

The number of protons that do not involve in hydrogen bonding in the product B is_____.

Correct Answer: (12)

Solution:

The structure of product B reveals that 12 protons are not involved in hydrogen bonding. These protons are not adjacent to electronegative atoms that would facilitate hydrogen bonding.



$$3NiS + 2HNO_3 + 6HCl \longrightarrow 3NiCl_2 + 2NO + 3S + 4H_2O$$

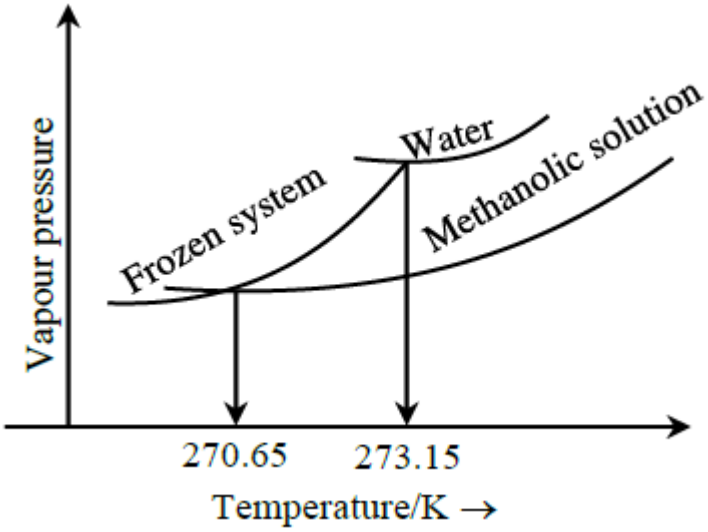
$$NiCl_2 + 2NH_4OH + \begin{matrix} H_3C - C = N - OH \\ | \\ H_3C - C = N - OH \end{matrix} \rightarrow NH_4Cl + H_2O + (B)$$

Quick Tip

In hydrogen bonding, protons attached to electronegative atoms like oxygen or nitrogen participate in the hydrogen bond formation, while those attached to less electronegative atoms do not.

---

23. When $x \times 10^{-2}$ mL methanol (molar mass = 32 g; density = 0.792 g/cm^3) is added to 100 mL water (density = 1 g/cm^3), the following diagram is obtained.



x=_____ = (nearest integer)
[Given: Molal freezing point depression constant of water at 273.15 K is 1.86 K kg mol^{-1}.]
Correct Answer: 543
Solution:

- The freezing point depression (ΔT_f) is calculated as:

$$\Delta T_f = 273.15 - 270.65 = 2.5\,\text{K}$$

- The relationship between freezing point depression and molality is:

$$\Delta T_f = K_f \cdot m = 2.5 = 1.86 \times \frac{n}{0.1}$$

- Solving for the moles of methanol (n):

$$n = 0.1344\,\text{moles}$$

- The mass of methanol is:

$$w = 0.1344 \times 32 = 4.3\,\text{g}$$

- The volume of methanol is:

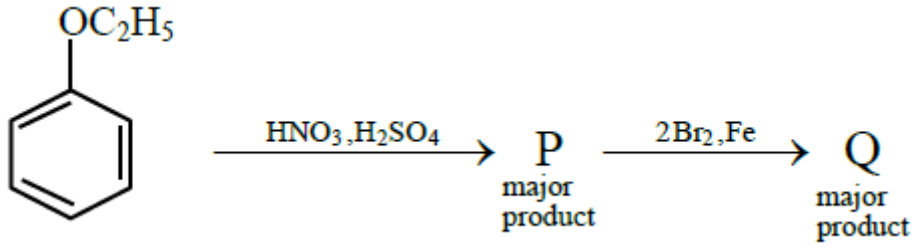
$$\text{Volume} = \frac{4.3}{0.792} = 5.43\,\text{mL} = 543 \times 10^{-2}\,\text{mL}$$

Answer: $x = 543$

Quick Tip

To calculate freezing point depression, subtract the observed freezing point from the normal freezing point of water. Then use the depression constant to find the molality.

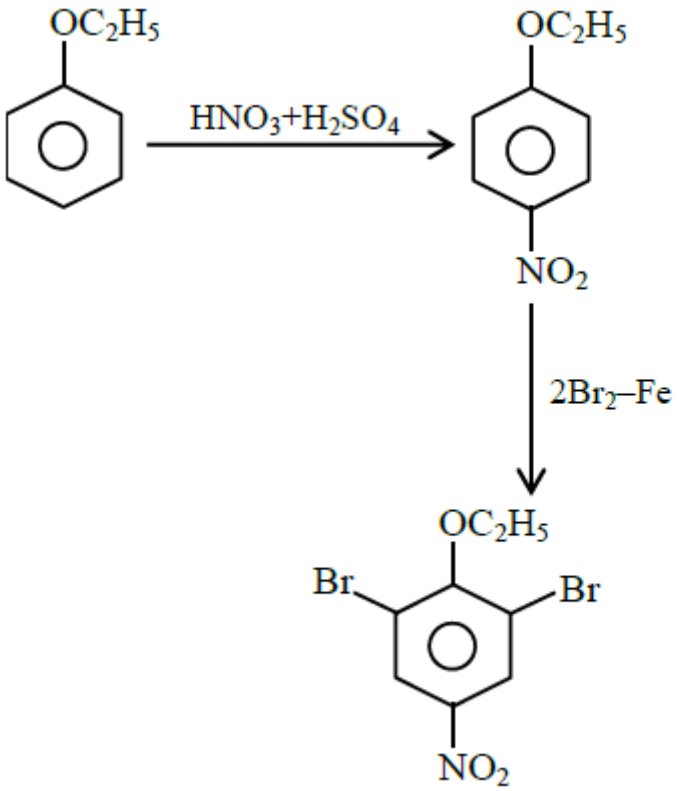
24. The compound with OC_2H_5 group undergoes the following reaction sequence:



The ratio of the number of oxygen atoms to bromine atoms in the product Q is ____.

Correct Answer: 15

Solution:



Answer: 15

Quick Tip

When performing multi-step reactions, carefully track each transformation of functional groups and atoms to determine the final ratio in the product.

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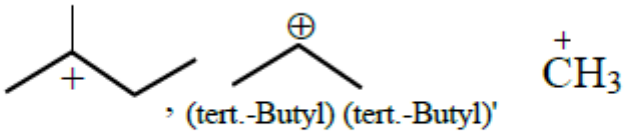
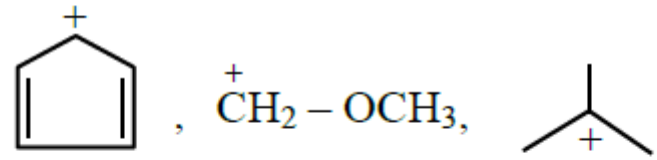
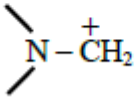
25. Number of carbocations from the following that are not stabilized by hyperconjugation is..... .

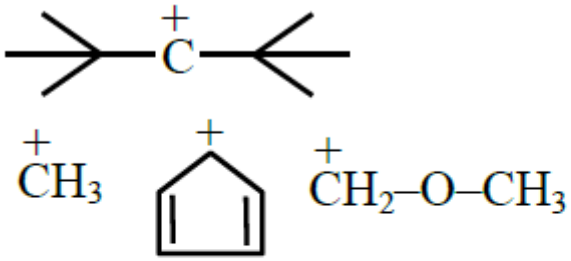


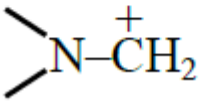




Correct Answer: (5)

Solution:
The carbocations that are not stabilized by hyperconjugation are those that do not have alkyl groups adjacent to them to allow delocalization of electrons. These include the following:





Hence, the number of carbocations that are not stabilized by hyperconjugation is 5.

Quick Tip

Hyperconjugation occurs when carbocations are adjacent to alkyl groups, which donate electron density to stabilize the positive charge. Without such groups, hyperconjugation is not possible.

---

26. For the reaction at 298 K, $2A + B \rightarrow C$. $\Delta H = 400\,\text{kJ mol}^{-1}$ and $\Delta S = 0.2\,\text{kJ mol}^{-1}\,\text{K}^{-1}$. The reaction will become spontaneous above ------ K.

Correct Answer: (2000)

Solution:
To determine the temperature at which the reaction becomes spontaneous, we use the Gibbs free energy equation $\Delta G = \Delta H - T\Delta S$. For spontaneity, $\Delta G = 0$, so:

$$T = \frac{\Delta H}{\Delta S} = \frac{400}{0.2} = 2000\,\text{K}$$

> Quick Tip
>
> A reaction becomes spontaneous when the Gibbs free energy ΔG is negative. You can find the temperature at which this occurs by setting $\Delta G = 0$ and solving for T.

---

27. Total number of species from the following with central atom utilising sp^2 hybrid orbitals for bonding is ...

NH_3, SO_2, SiO_2, $BeCl_2$, C_2H_2, C_2H_4, BCl_3, HCHO, C_6H_6, BF_3, $C_2H_4Cl_2$

Correct Answer: (6)
Solution:
The species with a central atom using sp^2 hybrid orbitals are:

$$SO_2,\ C_2H_4,\ BCl_3,\ HCHO,\ C_6H_6,\ BF_3$$

> Quick Tip
>
> When a central atom undergoes sp^2 hybridization, it forms three regions of electron density, often involving one double bond or lone pair, resulting in a trigonal planar geometry.

---

28. Consider the two different first-order reactions given below:
A + B $\rightarrow$ C (Reaction 1)
P $\rightarrow$ Q (Reaction 2)
The ratio of the half-life of Reaction 1 : Reaction 2 is 5 : 2. If t_1 and t_2 represent the time taken to complete $\frac{2}{3}$ and $\frac{4}{5}$ of Reaction 1 and Reaction 2, respectively, then the value of the ratio $t_1 : t_2$ is ___ $\times 10^{-1}$ (nearest integer).
[**Given:** $\log_{10}(3) = 0.477$ **and** $\log_{10}(5) = 0.699$]
Correct Answer: (17)
Solution:
For first-order reactions:

$$K_1 t_1 = \ln\left(\frac{1}{1-\frac{2}{3}}\right) = \ln 3$$

$$K_2 t_2 = \ln\left(\frac{1}{1-\frac{4}{5}}\right) = \ln 5$$

$$K_1 t_1 = 5 \quad \text{and} \quad K_2 t_2 = 2$$

$$\frac{K_1}{K_2} = \frac{\ln 3}{\ln 5}$$

$$\frac{t_1}{t_2} = \frac{0.477}{0.699} \cdot 5/2 = 1.7 = 17 \times 10^{-1}$$

Quick Tip

For first-order reactions, the time taken to complete a given fraction can be derived using the natural logarithm of the fraction. The half-life ratio can also help relate the rate constants of the reactions.

---

29. For hydrogen atom, energy of an electron in first excited state is - 3.4 eV, K.E. of the same electron of hydrogen atom is x eV. Value of x is ____ $\times 10^{-1}$ eV. (Nearest integer)
Correct Answer: (34)
Solution:
The energy of an electron in a hydrogen atom is given by the formula:

$$E = -\frac{13.6}{n^2}\,\text{eV}$$

For the first excited state ($n = 2$):

$$E = -\frac{13.6}{2^2} = -\frac{13.6}{4} = -3.4\,\text{eV}$$

The total energy (E) of an electron is related to its kinetic energy ($K.E.$) and potential energy (U) by:

$$E = K.E. + U, \quad \text{where} \quad U = 2E$$

Thus:

$$K.E. = -E$$

Substituting $E = -3.4\,\text{eV}$:

$$K.E. = -(-3.4) = 3.4\,\text{eV}$$

The kinetic energy is expressed as $x \times 10^{-1}\,\text{eV}$, so:

$$x = 34$$

Answer: $x = 34$

Quick Tip

For hydrogen-like atoms, the kinetic energy of the electron is always equal to the absolute value of the total energy, with a positive sign.

---

30. Among VO_2^+, MnO_4^- and $Cr_2O_7^{2-}$, the spin-only magnetic moment value of the species with least oxidizing ability is _____ BM (Nearest integer).
[Given atomic number V = 23, Mn = 25, Cr = 24]
Correct Answer: (0)
Solution:
The oxidizing ability follows the trend:

$$V^{+5} < Cr^{+6} < Mn^{+7}$$

For V^{5+} : $[Ar]\,4s^0\,3d^0$, there are no unpaired electrons:

$$\mu = 0\,\text{BM}$$

Quick Tip

The magnetic moment is zero for species with no unpaired electrons. The oxidation state and electron configuration are key to predicting magnetic properties and oxidation power.
