JEE Main 2024 Chemistry Question Paper Jan 27 Shift 2 with Solutions

1. Which of the following cannot act as an oxidising agent?

(1) MnO_4^-
(2) SO_4^{2-}
(3) N_3^-
(4) BrO_3^-

Correct Answer: (3) N_3^-

Solution:
Step 1: Understanding oxidising agents.
An oxidising agent is a species that gains electrons (gets reduced). For this, it must contain an element in a high oxidation state capable of reduction.

Step 2: Evaluating each species.
MnO_4^-, SO_4^{2-} and BrO_3^- all contain elements in high oxidation states and can readily gain electrons, so they act as oxidising agents.

Step 3: Conclusion.
N_3^- (azide ion) contains nitrogen already in a low oxidation state and cannot act as an oxidising agent.

> Quick Tip
>
> Species with high oxidation states usually act as strong oxidising agents.

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2. The quantity which changes with temperature is:

(1) Mole fraction
(2) Mass percentage
(3) Molarity
(4) Molality

Correct Answer: (3) Molarity

Solution:
Step 1: Understanding temperature dependence.
Molarity is defined as moles of solute per litre of solution. It depends on the volume of the solution.

Step 2: Why molarity changes?
When temperature increases, liquid expands and its volume increases. Because volume changes, molarity also changes.

Step 3: Conclusion.
Since molarity varies with temperature, it is the correct answer. Other quantities are independent of temperature.

Quick Tip

Remember: Any concentration unit involving *volume* changes with temperature.

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3. Phenolic group can be identified by a positive:

(1) Lucas test
(2) Carbylamine test
(3) Phthalein test
(4) Tollen's test

Correct Answer: (3) Phthalein test

Solution:
Step 1: Principle of the Phthalein test.
Phenols react with phthalic anhydride in the presence of concentrated H_2SO_4 to form phenolphthalein, which is colourless.

Step 2: Formation of coloured dye.
When excess NaOH is added, phenolphthalein turns pink due to formation of the phenolate ion. This confirms the presence of phenolic –OH group.

Step 3: Conclusion.
Since only phenolic compounds give this dye test, the correct answer is Phthalein test.

Quick Tip

Phenols give a characteristic pink colour in the Phthalein dye test.

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4. Find the longest wavelength in the Paschen series in terms of R.

(1) 144/7R
(2) 123/2R
(3) 170/R
(4) 16/R

Correct Answer: (1) $\frac{144}{7R}$

Solution:
Step 1: Understanding the Paschen series.
Paschen series corresponds to electronic transitions ending at $n = 3$.

Step 2: Longest wavelength = smallest energy difference.
This occurs when the electron falls from $n = 4$ to $n = 3$.

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = R\left(\frac{1}{9} - \frac{1}{16}\right) = R\left(\frac{7}{144}\right)$$

Thus,

$$\lambda = \frac{144}{7R}$$

Quick Tip

For longest wavelength in any series, consider the transition from the nearest higher level.

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5. For a first-order reaction, find the ratio of time for 99.9% completion to its half-life.

(1) 10
(2) 5
(3) 20
(4) 4

Correct Answer: (1) 10

Solution:
For a first-order reaction, the integrated rate law is:

$$t = \frac{2.303}{k} \log \frac{a}{a-x}$$

Step 1: Time for 99.9% completion.
Here, $a = 100$, $x = 99.9$.

$$t_1 = \frac{2.303}{k} \log \frac{100}{0.1} = \frac{2.303}{k} \log 1000 = \frac{2.303}{k} \times 3$$

Step 2: Time for 50% completion (half-life).

$$t_2 = \frac{2.303}{k} \log \frac{100}{50} = \frac{2.303}{k} \log 2 = \frac{2.303}{k} \times 0.3010$$

Step 3: Ratio

$$\frac{t_1}{t_2} = \frac{3}{0.3010} \approx 10$$

Quick Tip

For first-order reactions, high percentage completion times are many times larger than the half-life.

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6. S1: Ce^{4+} is stable because of noble gas configuration.
S2: Ce^{4+} is a good reducing agent as it can go to +3 oxidation state.

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

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

Solution:
Step 1: Evaluating S1.
Ce^{4+} has the configuration of xenon (noble gas), so it is highly stable. Thus, statement I is correct.

Step 2: Evaluating S2.
Ce^{4+} readily gains electrons to get reduced to Ce^{3+}, which means it acts as an *oxidising agent*, not a reducing agent. Hence statement II is incorrect.

Step 3: Final conclusion.
Only statement I is correct.

Quick Tip

Any ion that easily gains electrons acts as an oxidising agent; one that easily loses electrons acts as a reducing agent.

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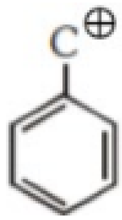
7. Which of the following does NOT undergo SN1 reaction?

(1) $C = C^{\oplus}$
(2) $2° \ C^{\oplus}$
(3) 

(4) $C = C - C^{\oplus}$

Correct Answer: (1) $C = C^{\oplus}$

Solution:
Step 1: Understanding SN1 mechanism.
SN1 reactions proceed through formation of a stable carbocation intermediate.

Step 2: Analysing the options.
Carbocations adjacent to double bonds (vinylic carbocations) are extremely unstable, as the positive charge is directly on the sp^2 carbon.

Step 3: Conclusion.
$C = C^{\oplus}$ does not undergo SN1 because vinylic carbocations are too unstable to form.

Quick Tip

SN1 is favoured by 3° ¿ 2° ¿ 1° carbocations; vinylic carbocations do not form.

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8. For C_2H_6 (ethane), find the incorrect statement regarding the Newman projection.

(1) Infinite conformers
(2) Interconvertible
(3) Dihedral angle in staggered form is 60°
(4) Eclipsed form is more stable

Correct Answer: (4) Eclipsed form is more stable

Solution:
Step 1: Conformations of ethane.
Ethane has infinite conformations due to free rotation around the C–C bond.

Step 2: Staggered vs Eclipsed.
Staggered conformation is most stable because repulsions between H atoms are minimized. Eclipsed conformations have maximum torsional strain and are least stable.

Step 3: Final conclusion.
Therefore, the incorrect statement is that eclipsed form is more stable.

> **Quick Tip**
>
> Staggered conformations are most stable due to minimum torsional strain.

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9. 1 mole of PbS reacts with x moles of O_3 to give y moles of O_2. Find x + y.

(1) 8
(2) 9
(3) 4
(4) 6

Correct Answer: (1) 8

Solution:

$$\mathrm{PbS} + 4\mathrm{O_3} \rightarrow \mathrm{PbSO_4} + 4\mathrm{O_2}$$

Here, $x = 4$ and $y = 4$.

$$x + y = 4 + 4 = 8$$

> **Quick Tip**
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> Ozone often oxidises sulphides to sulphates while releasing oxygen.

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10. Which structure of protein remains intact after coagulation (e.g., boiling egg white)?

(1) Primary
(2) Secondary
(3) Tertiary
(4) Quaternary

Correct Answer: (1) Primary

Solution:
Step 1: Effect of heat on proteins.
Coagulation breaks hydrogen bonds, ionic bonds, and hydrophobic interactions, causing unfolding of secondary and tertiary structures.

Step 2: Primary structure.
The primary structure (sequence of amino acids) is held by peptide bonds, which do not break on heating.

Step 3: Conclusion.
Thus, primary structure remains intact while higher-level structures are destroyed.

> **Quick Tip**
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> Coagulation denatures proteins but does not break peptide bonds.

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11. The molecular formula of the second homologue in the homologous series of monocarboxylic acids is:

(1) CH_3COOH
(2) CH_3CH_2COOH
(3) $CH_3CH(CH_3)COOH$
(4) $CH_3CH_2CH_2COOH$

Correct Answer: (1) CH_3COOH

Solution:
Step 1: General formula.
Monocarboxylic acids follow the formula $C_nH_{2n}O_2$.

Step 2: First and second members.
First member (n = 1): HCOOH
Second member (n = 2): CH_3COOH

Step 3: Conclusion.
Therefore, the second homologue is acetic acid (CH_3COOH).

> **Quick Tip**
>
> Homologues differ by $-CH_2-$ group in any homologous series.

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12. The technique used for purification of steam–volatile, water–immiscible substances is:

(a) Fractional Distillation
(b) Distillation under reduced pressure
(c) Steam Distillation
(d) Simple Distillation

Correct Answer: (c) Steam Distillation

Solution:
Step 1: Understanding the method.
Steam distillation is used for substances that vaporize with steam and do not dissolve in water. Such substances distill at temperatures lower than their boiling points, avoiding decomposition.

Step 2: Why steam distillation works.
When steam passes through the mixture, the combined vapour pressure lowers the boiling point, allowing separation of volatile, water–immiscible compounds.

Step 3: Conclusion.
Therefore, steam distillation is the correct purification technique for steam–volatile and water–immiscible substances.

> **Quick Tip**
> Steam distillation is ideal for separating organic compounds that decompose at high temperatures.

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13. In which of the following options do all elements have d^{10} configuration in their ground state?

(a) Cu, Zn, Cd, Ag
(b) Cd, Au, Hg, Ni
(c) Sc, Ti, Fe, Zn
(d) Fe, Cr, Co, Ni

Correct Answer: (a) Cu, Zn, Cd, Ag

Solution:
Step 1: Writing configurations.
Zn $\rightarrow 3d^{10}4s^2$
Cu $\rightarrow 3d^{10}4s^1$
Cd $\rightarrow 4d^{10}5s^2$
Ag $\rightarrow 4d^{10}5s^1$

Step 2: Evaluating correctness.
All four elements have completely filled d^{10} subshells in their ground state.

Step 3: Conclusion.
Thus, option (a) is correct since all listed elements possess a d^{10} configuration.

Quick Tip

Elements with filled d^{10} shells show high stability due to electronic symmetry.

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14. How many of the following are non–polar molecules?
H_2O, CH_4, SO_2, $CHCl_3$, PF_3, NH_3, SO_2, HF

Correct Answer: 2

Solution:
Step 1: Identify molecular geometry and symmetry.
A non–polar molecule must be symmetric such that dipole moments cancel out.

Step 2: Assessing each molecule.
CH_4 → Tetrahedral, symmetric → non–polar
CO_2 (implied from list repetition) → Linear symmetric → non–polar

Step 3: Conclusion.
Only two molecules in the list are non–polar.

Quick Tip

Symmetry is the most important factor in determining molecular polarity.

15.
(a) $[Co(NH_3)_6]^{3+}$
(b) $[PtCl_6]^{2-}$
(c) SF_6
(d) BrF_2**How many of the following have d^2sp^3 hybridisation?**

(a) $[Co(NH_3)_6]^{3+}$
(b) $[PtCl_6]^{2-}$
(c) SF_6
(d) BrF_2

Correct Answer: 2

Solution:
Step 1: Hybridisation check.
$Co(NH_3)_6$
$^{3+}$ → Inner orbital complex → d^2sp^3
Cl_6
$^{2-}$ → Square planar or octahedral (uses d–orbitals) → d^2sp^3
SF_6 → Uses sp^3d^2 (equivalent to d^2sp^3) → octahedral
BrF_2 → Does not have d^2sp^3; uses sp^3d hybridisation.

Step 2: Conclusion.
Two of the species show d^2sp^3 hybridisation.

Quick Tip

Octahedral geometry corresponds to d^2sp^3 hybridisation in coordination compounds.

16.
(a) Fe^{2+}
(b) Cs^{+}
(c) Sr^{2+}
(d) Pb^{2+}How many of the following have noble gas configuration?

(a) Fe^{2+}
(b) Cs^{+}
(c) Sr^{2+}
(d) Pb^{2+}

Correct Answer: 2

Solution:
Step 1: Checking electronic configurations.
$Cs^{+} \rightarrow$ [Xe] (after losing 1 electron)
$Sr^{2+} \rightarrow$ [Kr] (after losing 2 electrons)

Step 2: Checking remaining ions.
$Fe^{2+} \rightarrow 3d^6$ (not noble gas configuration)
$Pb^{2+} \rightarrow$ [Xe] $4f^{14}5d^{10}6s^2$ (not noble gas configuration)

Step 3: Final conclusion.
Only Cs^{+} and Sr^{2+} attain noble gas configuration, so total = 2.

Quick Tip

Ions that lose electrons to reach s^2p^6 configuration usually achieve noble gas stability.

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17. In a standard hydrogen electrode, pH = 3. What is the EMF of the electrode in this case?

Correct Answer: -0.1773 V

Solution:
The EMF of a hydrogen electrode is given by:

$$E_{\mathbf{H^+/H_2}} = -0.0591 \times \mathbf{pH}$$

Step 1: Substitute pH = 3.

$$E = -0.0591 \times 3 = -0.1773 \text{ V}$$

Step 2: Conclusion.
Thus, the EMF of the hydrogen electrode at pH 3 is -0.1773 V.

Quick Tip

For every increase of 1 unit in pH, hydrogen electrode potential decreases by 0.0591 V.

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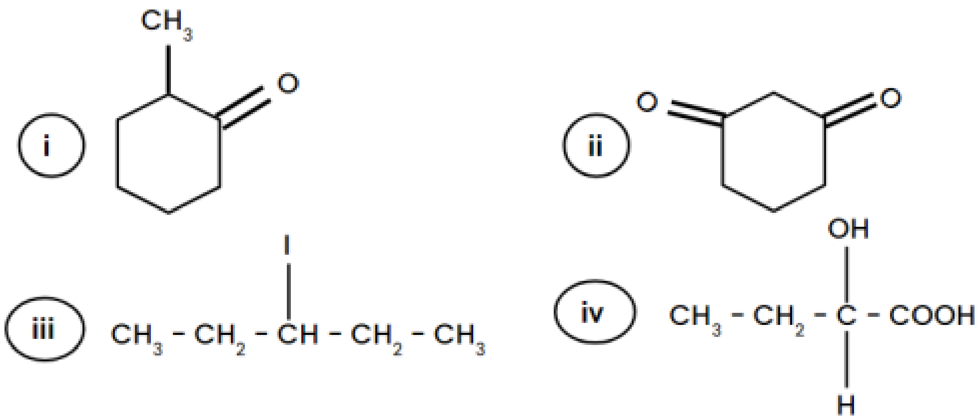
18. How many compounds among the following contain a chiral carbon?



Correct Answer: 2

Solution:
Step 1: Definition of chiral carbon.
A carbon atom bonded to four different substituents is chiral.

Step 2: Analysis of compounds.
(i) The carbon adjacent to the carbonyl has identical substituents → not chiral.
(ii) Symmetrical diketone ring → no chiral centre.
(iii) CH_3–CH_2–CH(I)–CH_2–CH_3: the carbon with I is attached to four different groups → chiral.
(iv) CH_3–CH_2–CH_2–C(OH)(H)–COOH: the central C attached to OH, H, COOH and propyl group → chiral.

Step 3: Conclusion.
Thus, the number of chiral compounds = 2.

Quick Tip

A quick way to detect chirality: look for tetrahedral carbon with all four different groups.

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19. What volume of 3M NaOH solution can be formed using 84 g of NaOH?

Correct Answer: 700 mL

Solution:
Step 1: Calculate moles of NaOH.

$$\text{Moles} = \frac{84}{40} = 2.1$$

Step 2: Use molarity formula.

$$M \times V = \textbf{moles}$$
$$3 \times V = 2.1$$
$$V = 0.7 \textbf{ L}$$

Step 3: Convert to mL.

$$0.7 \textbf{ L} = 700 \textbf{ mL}$$

Quick Tip

Always convert the final molarity volume to litres before converting to mL.
