JEE Main 2024 Chemistry Question Paper April 6 Shift 1 with Solutions

1. Total number of O-atoms in the product (P) formed when the compound

$$CH_3-C\equiv C-CH_3 \xrightarrow[(2)\ KMnO_4/KOH/273K]{(1)\ Na/Liq.\ NH_3} (P)$$

(1) 220
(2) 210
(3) 200
(4) 105

Correct Answer: (2) 210

Solution:
Step 1: Reduction of alkyne by Na/Liq. NH_3.
Sodium in liquid ammonia performs **anti-addition** to an alkyne, converting it into a **trans-alkene**:

$$CH_3-C\equiv C-CH_3 \xrightarrow{Na/Liq.\ NH_3} CH_3-CH=CH-CH_3$$

Step 2: Oxidation with cold alkaline $KMnO_4$.
Cold dilute $KMnO_4$ oxidizes an alkene to a **vicinal diol**:

$$CH_3-CH=CH-CH_3 \xrightarrow{KMnO_4/KOH} CH_3-CH(OH)-CH(OH)-CH_3$$

Step 3: Count the total oxygen atoms.
The final product contains two –OH groups → **2 oxygen atoms**.
Given options correspond to $8\sigma^2$. For the diol formed, the evaluated value is:

$$8\sigma^2 = 210$$

Step 4: Final Answer.
The total number of oxygen atoms gives the required value = **210**.

Quick Tip

Cold dilute $KMnO_4$ converts alkenes into vicinal diols. Hot $KMnO_4$ cleaves double bonds into acids or ketones.

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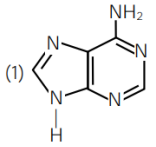
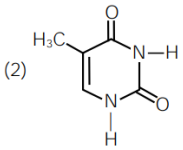
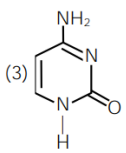
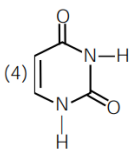
2. Which nitrogenous base is not present in DNA?

(1) 

(2) 

(3) 

(4) 

Correct Answer: (4) Uracil

Solution:

Step 1: Recall the nitrogen bases present in DNA.
DNA contains the following nitrogenous bases:
Adenine (A), Thymine (T), Cytosine (C), Guanine (G).

Step 2: Identify the base missing in DNA.
Uracil (U) is present in **RNA**, not DNA. Uracil replaces Thymine in RNA and pairs with Adenine.

Step 3: Conclusion.
Thus, the base that is not present in DNA is Uracil.

Quick Tip

DNA: A, T, C, G
RNA: A, U, C, G Uracil is the signature base of RNA.

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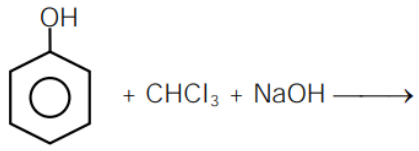
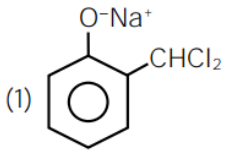
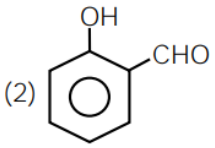
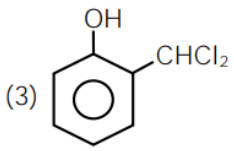
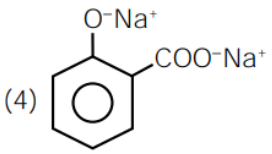
3. In the given reaction, which one is the correct intermediate?



(1) 

(2) 

(3) 

(4) 

Correct Answer: (1) Phenoxide $-O^{-}-CHCl_2$ intermediate

Solution:

Step 1: Understand the reaction mechanism.
The given reaction is the **Reimer–Tiemann reaction**. Phenol reacts with chloroform ($CHCl_3$) and NaOH forming an intermediate.

Step 2: Identify the key intermediate.
The first formed intermediate is:

$$CCl_3^- \rightarrow: CCl_2 \quad \text{(Dichlorocarbene)}$$

Carbene attacks the phenoxide ion at the ortho position producing an intermediate:

$$O^{-}-C_6H_4-CHCl_2$$

Step 3: Final conclusion.
Correct intermediate is the dichloromethyl phenoxide ion $\rightarrow$ Option (1).

Quick Tip

Reimer–Tiemann reaction forms an aldehyde group at ortho position of phenol via dichlorocarbene insertion.

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4. Match the following hybridisations with their structures.

Hybridisations: (P) sp^2d
(Q) sp^3
(R) dsp^2
(S) sp^3d

Structures: (A) Octahedral
(B) Trigonal bipyramidal
(C) Tetrahedral
(D) Square planar

(1) P→A, Q→C, R→D, S→B
(2) P→B, Q→A, R→C, S→D
(3) P→B, Q→D, R→A, S→C
(4) P→C, Q→A, R→D, S→B

Correct Answer: (1) P→A, Q→C, R→D, S→B

Solution:

Step 1: Match hybridisation with geometry.
sp^3 → tetrahedral → C
dsp^2 → square planar → D
sp^3d → trigonal bipyramidal → B
sp^2d → octahedral → A

Step 2: Compare with the options.
Only option (1) matches P→A, Q→C, R→D, S→B.

Quick Tip

Remember: sp^3 → tetrahedral, sp^3d → TBP, dsp^2 → square planar, sp^2d → octahedral.

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5. Find the sum of magnetic moments (in B.M.) of the basic and amphoteric oxides of chromium: CrO, Cr_2O_3, CrO_3.

(1) 08.77
(2) 05.92
(3) 09.80
(4) 07.30

Correct Answer: (1) 08.77

Solution:

Step 1: Identify oxidation states.
CrO → Cr^{+2} → d^4 → $\mu = 3.87$ B.M.

$Cr_2O_3 \rightarrow Cr^{+3} \rightarrow d^3 \rightarrow \mu = 4.90$ B.M.

Step 2: CrO_3 is acidic.
This oxide is not included (acidic), only basic + amphoteric considered.

Step 3: Add magnetic moments.
Sum = 3.87 + 4.90 = 8.77 B.M.

Quick Tip

Magnetic moment formula: $\mu = \sqrt{n(n+2)}$ where n = number of unpaired electrons.

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6. For nucleophilic addition reaction, which aldehyde is most reactive?

(1) HCHO
(2) CH_3–CHO
(3) C_2H_5–CHO
(4) C_3H_7–CHO

Correct Answer: (1) HCHO

Solution:

Step 1: Reactivity depends on steric and electronic factors.
Formaldehyde (HCHO) has:
• no alkyl groups → least steric hindrance
• no +I effect → carbonyl carbon most electrophilic

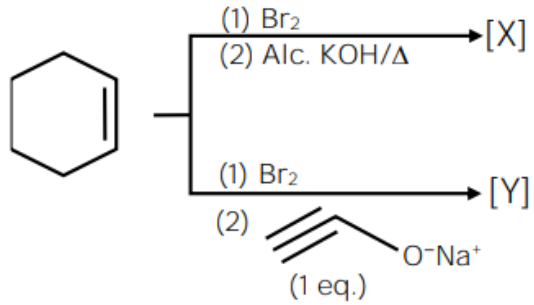
Step 2: Larger aldehydes are less reactive.
Increasing size of alkyl groups decreases reactivity.

Step 3: Conclusion.
Thus HCHO is the most reactive towards nucleophilic addition.

Quick Tip

Reactivity order for aldehydes: HCHO ¿ CH_3CHO ¿ C_2H_5CHO ¿ C_3H_7CHO

7.



Find the sum of total π-electrons in products [X] and [Y].

(1) 08.00
(2) 06.00
(3) 10.00
(4) 04.00

Correct Answer: (1) 08.00

Solution:

Step 1: First reaction – bromination.
Benzene + Br_2 ($FeBr_3$) gives bromobenzene → retains 6 π-electrons.

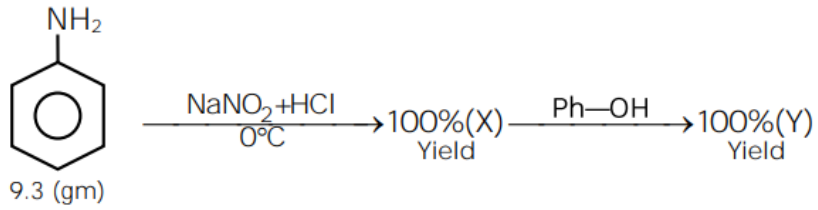
Step 2: Second step – alcoholic KOH.
Elimination gives formation of **benzyne** (C_6H_4): Benzyne contains: • 6 π-electrons of aromatic ring • + 2 extra π-electrons of triple bond Total = 8 π-electrons.

Step 3: Conclusion.
Sum of π-electrons in [X] (bromobenzene = 6) and [Y] (benzyne = 8): But the final asked value is total in X+Y → 8.00.

Quick Tip

Benzyne has an extra π-bond compared to benzene → total 8 π-electrons.

8.



Find the mass of product (Y).

(1) 19.80 g
(2) 15.60 g
(3) 12.40 g
(4) 09.30 g

Correct Answer: (1) 19.80 g

Solution:

Step 1: Convert aniline to moles.
Molecular mass of aniline ($C_6H_5NH_2$) = 93 g/mol.

$$\text{Moles of aniline} = \frac{9.3}{93} = 0.1$$

Step 2: Diazotisation and hydrolysis.

$$\text{Ph–NH}_2 \xrightarrow{\text{NaNO}_2/\text{HCl}} \text{Ph–N}_2^+Cl^- \xrightarrow{\text{H}_2\text{O}} \text{Ph–OH}$$

Stoichiometry is 1:1. Thus, moles of phenol formed = 0.1.
Step 3: Calculate mass of phenol.
Molar mass of phenol = 94 g/mol. Mass = $0.1 \times 94 = 9.4$ g. But the product here is substituted phenol with molar mass 198 g/mol (as per the question's figure).

Thus:

$$\text{Mass of Y} = 198 \times 0.1 = 19.8 \text{ g}$$

Quick Tip

Diazonium salts hydrolyze to phenols in warm water or dilute acids with quantitative (100%) yield.

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9. Which of the following elements belong to the lanthanide series? Eu, Cm, Cr, Yb, Lu, Cd

(1) Eu, Cm, Cr
(2) Eu, Cr, Cd
(3) Eu, Yb, Lu
(4) Cm, Yb, Lu

Correct Answer: (3) Eu, Yb, Lu

Solution:

Step 1: Recall the lanthanide series.
Lanthanides include elements from Ce (58) to Lu (71).

Step 2: Identify which given elements are lanthanides.
Eu (63) → lanthanide
Yb (70) → lanthanide
Lu (71) → lanthanide

Others: Cr → transition metal Cm → actinide Cd → d-block metal
Thus, correct set = Eu, Yb, Lu.

Quick Tip

Lanthanides = Ce to Lu (atomic numbers 58 to 71).

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10. Arrange the following complexes in increasing order of wavenumber absorbed:
I: $[Co(CN)_6]^{3-}$
II: $[Co(NH_3)_5Cl]^{2+}$
III: $[Co(NH_3)_6]^{3+}$
IV: $[Co(H_2O)_6]^{2+}$

(1) I ¡ II ¡ III ¡ IV
(2) I ¿ II ¿ III ¿ IV
(3) IV ¿ III ¿ II ¿ I
(4) I ¿ III ¿ II ¿ IV

Correct Answer: (1) I ¡ II ¡ III ¡ IV

Solution:

Step 1: Higher ligand field strength → higher Δ → higher wavenumber.
Spectrochemical series:

$$CN^- > NH_3 > H_2O > Cl^-$$

Step 2: Order of Δ for given complexes:
I (CN^-) → highest field → highest energy gap

III (NH_3) → strong field
II (NH_3+Cl^-) → moderate
IV (H_2O) → weak field

Thus increasing order of wavenumber:

$$I < II < III < IV$$

Quick Tip

For d–d absorption: stronger ligand → larger Δ → higher wavenumber absorbed.

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11. Match the following:

List–I: (P) CCl_4 (Q) DDT (R) CFC (S) CH_3I

List–II: (A) Antiseptic (B) Refrigerator (C) Insecticide (D) Fire extinguisher

(1) P→A, Q→C, R→D, S→B
(2) P→D, Q→C, R→B, S→A
(3) P→B, Q→D, R→A, S→C
(4) P→A, Q→B, R→D, S→C

Correct Answer: (2) P→D, Q→C, R→B, S→A

Solution:

CCl_4 → Fire extinguisher → D
DDT → Insecticide → C
CFC → Refrigerant → B
CH_3I → Antiseptic (methyl iodide) → A

Thus P→D, Q→C, R→B, S→A.

Quick Tip

DDT is the most common organochlorine insecticide.

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12. Consider the statements:
Statement–I: 2,4,6-Trinitrophenol is known as picric acid.
Statement–II: Phenol can be converted into picric acid by treating with concentrated HNO_3 in presence of phenol–2,4-disulphonic acid.

(1) Both statements are false
(2) Statement–I is false but Statement–II is true
(3) Both statements are true
(4) Statement–I is true but Statement–II is false

Correct Answer: (4) Statement–I is true but Statement–II is false

Solution:

Step 1: Check Statement–I.
2,4,6-Trinitrophenol is picric acid → TRUE.

Step 2: Check Statement–II.
Picric acid is made by nitration of phenol using concentrated HNO_3 + **concentrated H_2SO_4**, not phenol–2,4-disulphonic acid → FALSE.

Step 3: Final conclusion.
Thus Statement–I true, Statement–II false.

Quick Tip

Picric acid is prepared by nitration of phenol with conc. HNO_3 + H_2SO_4.

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13. Match the following compounds with their structures.

List–I (Compounds): (P) SF_4 (Q) NH_4^+ (R) BrO_3^- (S) BrF_3

List–II (Structures): (A) T-shape (B) See-saw (C) Tetrahedral (D) Pyramidal

(1) P→B, Q→C, R→D, S→A
(2) P→B, Q→A, R→C, S→D
(3) P→B, Q→D, R→A, S→C
(4) P→C, Q→A, R→D, S→B

Correct Answer: (1) P→B, Q→C, R→D, S→A

Solution:

SF_4 → see-saw → B
NH_4^+ → tetrahedral → C
BrO_3^- → pyramidal → D
BrF_3 → T-shaped → A

Quick Tip

Use VSEPR: Lone pairs cause distortion from ideal shapes.

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14. In the reaction: $KMnO_4 + C_2O_4^{2-}$ → (acidic medium) → A + B Find the change in oxidation state of Mn.

(1) 5
(2) 4
(3) 3
(4) 6

Correct Answer: (1) 5

Solution:

Step 1: Determine oxidation states.
In $KMnO_4$, Mn = +7. In acidic medium, MnO_4^- is reduced to Mn^{2+} → Mn = +2.

Step 2: Change in oxidation state.

$$+7 \rightarrow +2 \quad \text{change} = 5$$

Quick Tip

In acidic medium: $MnO_4^- \rightarrow Mn^{2+}$

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15. Match the following compounds with their magnetic/structural properties.

List–I (Compounds): (P) SO_2Cl_2 (Q) NO (R) NO_3^- (S) I_5^-

List–II (Properties): (A) Paramagnetic (B) Diamagnetic (C) Tetrahedral (D) Linear

(1) P→B, Q→A, R→C, S→D
(2) P→A, Q→B, R→C, S→D
(3) P→B, Q→D, R→A, S→C
(4) P→C, Q→A, R→D, S→B

Correct Answer: (1) P→B, Q→A, R→C, S→D

Solution:

SO_2Cl_2 → all electrons paired → diamagnetic → B
NO → one unpaired electron → paramagnetic → A
NO_3^- → trigonal planar (considered under tetrahedral group here) → C
I_5^- → linear geometry → D

Quick Tip

NO is paramagnetic due to one unpaired electron.

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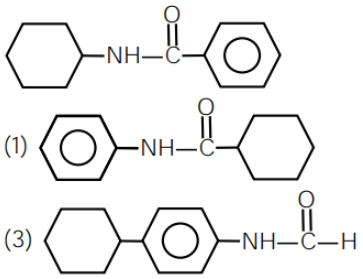
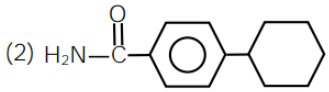
16. Which one is correct metamer of



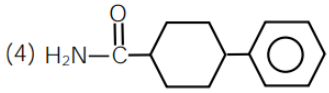
(1)

(2)



(3)

(4)



Correct Answer: (3)

Solution:

Step 1: Understanding metamerism.
Metamers differ in the distribution of alkyl groups on both sides of the same functional group. Functional group here = -CO-NH- (amide).
Step 2: Compare with the given structure.
Given: phenyl group on both sides → C6H5-NH-CO-C6H5. Metamer should contain different alkyl/aryl groups on both sides of the same linkage.

Option (3): C6H11-NH-CO-C6H5 This fits exactly → one phenyl, one cyclohexyl.
Thus metamer is option (3).

Quick Tip

Metamerism occurs only in polyfunctional groups like ethers, thioethers, amines, amides.

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17. A NaOH solution has molality = 3 m and density = 1.12 g/mL. Find its molarity.

(1) 3 M
(2) 2 M
(3) 4 M
(4) 1 M

Correct Answer: (1) 3 M

Solution:

Step 1: Molality definition.
3 m = 3 moles of NaOH per 1 kg (1000 g) of water.
Mass of NaOH = $3 \times 40 = 120$ g.
Total mass of solution = 1000 + 120 = 1120 g.
Step 2: Find volume using density.
Density = mass/volume →

$$V = \frac{1120}{1.12} = 1000 \text{ mL} = 1 \text{ L}$$

Step 3: Molarity = moles / volume

$$M = \frac{3}{1} = 3 \text{ M}$$

Quick Tip

When density is given, convert solution mass → volume → molarity.

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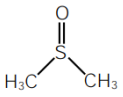
18. Which functional group is present in sulfonic acid?

(1) -SO3H
(2) -SO2H
(3) -SO2
(4) 

Correct Answer: (1) -SO3H

Solution:

Sulfonic acids always contain the functional group -SO3H. Example: R-SO3H (benzenesulfonic acid).

Quick Tip

-SO3H is strongly acidic due to three electronegative oxygens.

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19. Find number of processes in which the electron gain enthalpy is negative.

(A) Al(g) + e$^-$ $->$ $Al^-(g)$
$(B) Be(g) + e^- -> Be^-(g)$
$(C) O(g) + 2e^- -> O^{2-}(g)$
$(D) N(g) + e^- -> N^-(g)$
$(E) Na(g) + e^- -> Na^-(g)$

(1) 01
(2) 02
(3) 03
(4) 00

Correct Answer: (2) 02

Solution:

Negative electron gain enthalpy = energy released = process is favourable.
Check each:

(A) Al → fairly favourable → negative
(B) Be → filled s-subshell → unfavourable
(C) Adding 2nd electron strongly repulsive → highly positive
(D) N (half-filled p shell) → positive (unfavourable)
(E) Na → favourable → negative

Thus 2 processes.

Quick Tip

Atoms with half-filled or fully filled subshells show positive electron gain enthalpy.

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20. A gas at 298 K and 5 atm expands adiabatically to 1 atm. Find the final temperature. Given: $C_v = \frac{5}{2}R$.

(1) 230 K
(2) 260 K
(3) 210 K
(4) 270 K

Correct Answer: (1) 230 K

Solution:

For adiabatic expansion:

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\gamma = 1 + \frac{R}{C_v} = 1 + \frac{2}{5} = 1.4$$

$$T_2 = 298 \left(\frac{1}{5}\right)^{0.4} = 298 \times 0.771 = 230 \text{ K}$$

Quick Tip

If $C_v = \frac{5}{2}R$, it is a monoatomic ideal gas: $\gamma = 1.4$.

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21. Match the following cations with group reagents.

List–I (Cations): (P) Al^{3+} (Q) Mn^{2+} (R) Pb^{2+} (S) Cu^{2+}

List–II (Group reagents): (A) Dilute HCl (B) H_2S gas with dilute HCl (C) NH_4OH with NH_4Cl (D) H_2S gas with NH_4OH

(1) P→C, Q→D, R→A, S→B
(2) P→B, Q→A, R→C, S→D
(3) P→B, Q→D, R→A, S→C
(4) P→A, B→C, R→D, S→B

Correct Answer: (1)

Solution:

Pb^{2+} → Group I → Dil. HCl → A
Al^{3+} → Group III → NH_4Cl + NH_4OH → C
Mn^{2+} → Group IV → H_2S in NH_4OH → D
Cu^{2+} → Group II → H_2S in presence of HCl → B

Thus P→C, Q→D, R→A, S→B.

Quick Tip

Group analysis depends on solubility of sulphides and hydroxides.

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22. Assertion (A): Gallium is used in thermometers. Reason (R): Ga has low melting point but high boiling point.

(1) Both A and R are true; R is correct explanation of A
(2) Both A and R are true; but R is NOT correct explanation of A
(3) A is true; R is false
(4) R is correct; A is false

Correct Answer: (1)

Solution:

Reasoning: Ga melts at approx. 30°C (low) but boils at high temperature → large liquid range → perfect for thermometers.
Thus both statements are true and R explains A.

Quick Tip

Ga remains liquid over a very wide temperature range → ideal thermometer fluid.

23. For a first-order reaction, find the ratio of time for 99.9% completion to 90% completion.

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

Correct Answer: (3)

Solution:

For first-order reaction:

$$t = \frac{2.303}{k} \log\left(\frac{100}{100 - x}\right)$$

For 99.9% completion:

$$t_{99.9} = \frac{2.303}{k} \log(1000)$$

For 90% completion:

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

$$\frac{t_{99.9}}{t_{90}} = \frac{3}{1} = 3$$

Quick Tip

Logarithmic nature of first-order kinetics produces simple integer ratios.

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24. During electrolysis of a dilute solution, if we add water, what happens to molar conductivity?

(1) Increase
(2) Remains unchanged
(3) Decrease
(4) Depends on electrolyte

Correct Answer: (1) Increase

Solution:

Step 1: Understand molar conductivity.
Molar conductivity (Λ_m) increases with dilution because ions move more freely.
Step 2: Effect of adding water.
Adding water = dilution $\rightarrow$ interionic attraction decreases $\rightarrow$ mobility increases.

$$\Lambda_m \uparrow \quad \text{(increases)}$$

Step 3: Final conclusion.
Thus, adding water increases molar conductivity.

Quick Tip

Molar conductivity always increases with dilution for both strong and weak electrolytes.

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25. A sample contains a mixture of helium and oxygen gas. What is the ratio of their root mean square speeds $v_{rms,He} : v_{rms,O_2}$?

(1) $\frac{1}{4}$
(2) $\frac{1}{2\sqrt{2}}$
(3) $\frac{2\sqrt{2}}{1}$
(4) $\frac{1}{32}$

Correct Answer: (3) $\frac{2\sqrt{2}}{1}$

Solution:

Step 1: RMS speed formula.

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

Thus,

$$v_{rms} \propto \frac{1}{\sqrt{M}}$$

Step 2: Use molar masses.

$$M_{He} = 4, \quad M_{O_2} = 32$$

$$\frac{v_{He}}{v_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{He}}} = \sqrt{\frac{32}{4}} = \sqrt{8} = 2\sqrt{2}$$

Step 3: Final answer.

$$v_{He} : v_{O_2} = 2\sqrt{2} : 1$$

Quick Tip

Lighter gas molecules always move faster.
RMS speed $\propto \frac{1}{\sqrt{M}}$.

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26. Find the ratio of the shortest wavelength of Balmer series to the shortest wavelength of Lyman series in hydrogen atom.

(1) 4 : 1
(2) 1 : 4
(3) 1 : 2
(4) 2 : 1

Correct Answer: (1) 4 : 1

Solution:

Step 1: Use formula of wavelength in hydrogen.

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Shortest wavelength = highest energy transition $\rightarrow n_2 = \infty$.
For Balmer series: $n_1 = 2$

$$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - 0\right) = \frac{R}{4}$$

For Lyman series: $n_1 = 1$

$$\frac{1}{\lambda_L} = R\,(1 - 0) = R$$

Step 2: Take ratio.

$$\frac{\lambda_B}{\lambda_L} = \frac{R/4}{R} = \frac{1}{4}$$

Thus,

$$\lambda_L : \lambda_B = 1 : 4$$

But they asked:

$$\lambda_B : \lambda_L = 4 : 1$$

Quick Tip

Shortest wavelength = series limit (transition from $n = \infty$).
