JEE Main 2024 Chemistry Question Paper April 8 Shift 2 with Solutions

Time Allowed :3 Hours	**Maximum Marks :**300	**Total Questions :**90

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, out of which 75 are to attempted. 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

Chemistry

1. What is the structure of carbocation?

(1) Tetrahedral
(2) Triagonal planar
(3) Diagonal
(4) Diagonal planar

Correct Answer: (2) Triagonal planar

Solution:

Step 1: Understanding carbocation structure.
A carbocation is formed when a carbon atom carries a positive charge. Such a carbon has only six electrons in its valence shell and adopts an sp_2 hybridization.

Step 2: Determining molecular geometry.
The sp_2 hybridization results in three hybrid orbitals arranged at 120° angles in a planar geometry. This gives the carbocation a trigonal planar shape.

Step 3: Conclusion.
Because of sp_2 hybridization and three-bond arrangement, a carbocation always has a trigonal planar geometry.

Quick Tip

Remember: positive charge on carbon almost always means sp_2 hybridization and trigonal planar geometry.

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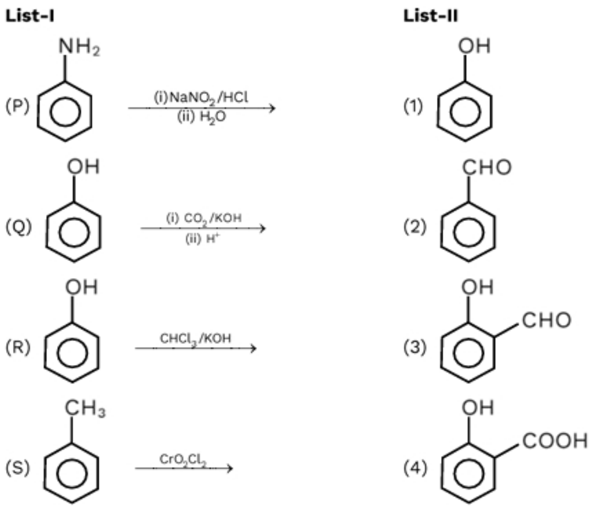
2. Match List-I with List-II and select the correct option:



(1) P → 1; Q → 4; R → 3; S → 2
(2) P → 2; Q → 4; R → 3; S → 1
(3) P → 1; Q → 3; R → 4; S → 2
(4) P → 3; Q → 4; R → 1; S → 2

Correct Answer: (2) P → 2; Q → 4; R → 3; S → 1

Solution:

Step 1: Reaction of P (Aniline).
P undergoes diazotization using $NaNO_2/HCl$ followed by hydrolysis to form phenol. List-II option (1) is phenol. Therefore, P → 1. But phenol appears again in S, so verify next.

Step 2: Reaction of Q (Phenol with CO_2/KOH).
This is Kolbe–Schmitt reaction, forming salicylic acid (o-hydroxy benzoic acid). In List-II, salicylic acid corresponds to (4). Hence Q → 4.

Step 3: Reaction of R (Phenol + $CHCl_3$/KOH).
This is Reimer–Tiemann reaction forming salicylaldehyde (o-hydroxy benzaldehyde). In List-II, this is compound (3). So R → 3.

Step 4: Reaction of S (p-Cresol + CrO_3 oxidation).
Oxidation of the methyl group converts it to aldehyde (p-hydroxy benzaldehyde). In List-II, this is (2). So S → 2.

Step 5: Final Matching.
P → 2, Q → 4, R → 3, S → 1 matches option (2).

Quick Tip

Kolbe gives salicylic acid, Reimer–Tiemann gives salicylaldehyde, and oxidation of methyl on benzene ring gives aldehyde or acid.

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3. Which of the following have bond order = 2?

(1) O_2
(2) C_2H_6
(3) H_2
(4) Ne_2

Correct Answer: (1) O_2

Solution:

Step 1: Understanding bond order.
Bond order is calculated using: Bond order = (number of bonding electrons − antibonding electrons)/2

Step 2: Analyse each species.
O_2: Molecular orbital configuration gives bond order = 2.
C_2H_6: All single sigma bonds, bond order = 1.
H_2: Bond order = 1.
Ne_2: Bond order = 0 (equal bonding and antibonding electrons).

Step 3: Conclusion.
Only O_2 has bond order equal to 2.

Quick Tip

For diatomic molecules, bond order from MO theory gives accurate prediction of stability.

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4. Given A $\longrightarrow$ B with rate constant k_1, and B $\longrightarrow$ C with k_2. Rate of formation of B = 0. What is concentration of B in terms of A?

(1) $\frac{k_1}{k_2}[A]$
(2) $\frac{k_2}{k_1}[A]$
(3) $k_1k_2[A]$
(4) $k_1k_2[A]$

Correct Answer: (1) $\frac{k_1}{k_2}[A]$

Solution:

Step 1: Apply steady-state approximation for B.
Rate of formation of B = Rate of disappearance of B.
$k_1[A] = k_2[B]$

Step 2: Solve for [B].
$[B] = \frac{k_1}{k_2}[A]$

Step 3: Conclusion.
Concentration of intermediate B under steady state is $\frac{k_1}{k_2}[A]$.

Quick Tip

Steady-state approximation assumes intermediate concentration remains nearly constant.

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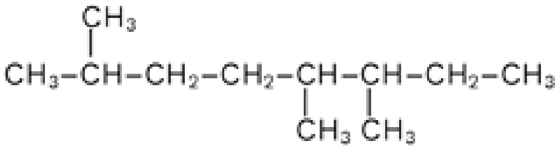
5. Write the IUPAC name of the given compound:



$CH_3-\overset{\overset{CH_3}{|}}{C}H-CH_2-CH_2-\underset{\underset{CH_3}{|}}{C}H-\underset{\underset{CH_3}{|}}{C}H-CH_2-CH_3$

(1) 2,5,6 Trimethyloctane
(2) 3,4,7 Trimethyloctane
(3) 2,4-Dimethyl-6-ethylheptane
(4) 3,6-Dimethyl-2-ethylheptane

Correct Answer: (3) 2,4-Dimethyl-6-ethylheptane

Solution:

Step 1: Identify the longest carbon chain.
The parent chain contains 7 carbons → Heptane.

Step 2: Number the chain from the nearest substituent end.
Numbering gives substituents at C-2, C-4, and C-6.

Step 3: List substituents.
C-2: Methyl
C-4: Methyl
C-6: Ethyl

Step 4: Apply alphabetical order rule.
Ethyl comes before methyl → Name starts with "6-ethyl".

Step 5: Final name.
6-ethyl-2,4-dimethylheptane.

Quick Tip

Always choose the longest chain and arrange substituents alphabetically in IUPAC naming.

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6. What will be the wave function of σ^* (destructive)?

(1) $\psi_A - \psi_B$
(2) $\psi_A + \psi_B$
(3) $\psi_A + 2\psi_B$

(4) $\psi_A - 2\psi_B$

Correct Answer: (1) $\psi_A - \psi_B$

Solution:

Step 1: Understanding bonding vs antibonding combination.
Bonding molecular orbitals are formed by *constructive* interference of atomic orbitals, where wave functions add with the same sign.

Step 2: Identifying antibonding combinations.
Antibonding orbitals (σ^*) are formed by *destructive* interference, meaning wave functions combine with opposite signs.

Step 3: Conclusion.
Destructive combination corresponds to subtraction of wave functions: $\psi_A - \psi_B$.

Quick Tip

Bonding = addition of wave functions; Antibonding = subtraction.

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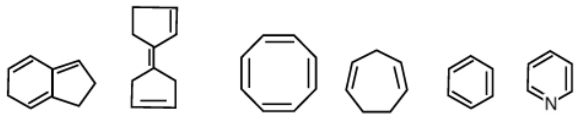
7. Count the number of aromatic compounds from the given structures:



Correct Answer: 4

Solution:

Step 1: Apply Huckel rule (4n + 2 π electrons).
Aromatic compounds must be planar, cyclic, fully conjugated, and obey Huckel rule.

Step 2: Check each structure one by one.
1. First bicyclic fused ring → Non-aromatic (not fully conjugated).
2. Bicyclic with bridging → Non-aromatic (distorted).
3. Cyclooctatetraene → Non-aromatic (tub-shaped, avoids conjugation).
4. Benzene-like structure → Aromatic.
5. 7-membered ring with 3 double bonds → Aromatic (6 electrons, planar).

6. Pyridine → Aromatic (6 electrons).
7. Benzene → Aromatic.

Step 3: Conclusion.
Total aromatic compounds = 4.

Quick Tip

Always check planarity and full conjugation before applying Huckel rule.

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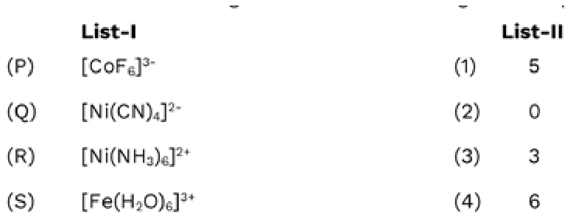
8. Match the correct magnetic moment of the given compound:



	List-I		List-II
(P)	$[CoF_6]^{3-}$	(1)	5
(Q)	$[Ni(CN)_4]^{2-}$	(2)	0
(R)	$[Ni(NH_3)_6]^{2+}$	(3)	3
(S)	$[Fe(H_2O)_6]^{3+}$	(4)	6

(1) P → 1; Q → 2; R → 3; S → 4
(2) P → 2; Q → 1; R → 3; S → 4
(3) P → 1; Q → 3; R → 4; S → 2
(4) P → 4; Q → 3; R → 2; S → 1

Correct Answer: (1) P → 1; Q → 2; R → 3; S → 4

Solution:

Step 1: Determine the number of unpaired electrons in each complex.
(P) $[CoF_6]^{3-}$: High spin, Co^{3+} (d^6) → 4 unpaired e^- → $\mu = 4.9 \approx 5$.
(Q) $[Ni(CN)_4]^{2-}$: Square planar, low spin, Ni^{2+} (d^8) → 0 unpaired → $\mu = 0$.
(R) $[Ni(NH_3)_6]^{2+}$: Octahedral, Ni^{2+} (d^8) → 2 unpaired → $\mu = 2.8 \approx 3$.
(S) $[Fe(H_2O)_6]^{3+}$: High spin, Fe^{3+} (d^5) → 5 unpaired → $\mu = 5.9 \approx 6$.

Step 2: Match with List-II.
P → 5 → (1)
Q → 0 → (2)
R → 3 → (3)
S → 6 → (4)

Step 3: Conclusion.
Correct matching is option (1).

Quick Tip

Use $\mu = \sqrt{n(n+2)}$ to estimate magnetic moment from unpaired electrons.

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9. If de-Broglie wavelength of electron is equal to the de-Broglie wavelength of proton, then what is the relation between their kinetic energy?

(1) KE_e ¿ KE_p
(2) KE_e ¡ KE_p
(3) $\text{KE}_e = \text{KE}_p$
(4) $2\text{KE}_e = \text{KE}_p$

Correct Answer: (1) KE_e ¿ KE_p

Solution:

Step 1: Use de Broglie relationship.
$\lambda = \dfrac{h}{\sqrt{2mK}}$ If $\lambda_e = \lambda_p$, then $\sqrt{2m_eK_e} = \sqrt{2m_pK_p}$

Step 2: Square both sides.
$m_eK_e = m_pK_p$

Step 3: Solve for kinetic energy.
Since $m_p \gg m_e$, $K_e = \dfrac{m_p}{m_e}K_p$ This means K_e is much larger than K_p.

Step 4: Conclusion.
Electron has higher kinetic energy than the proton when both have same de Broglie wavelength.

Quick Tip

For equal de Broglie wavelengths: lighter particle always has greater kinetic energy.

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10. Consider the given reaction: $\mathbf{Cr_2O_7^{2-} \rightleftharpoons CrO_4^{2-}}$. Above reaction shifts forward in which medium?

(1) Acidic
(2) Basic

(3) Neutral
(4) Slightly acidic

Correct Answer: (2) Basic

Solution:

Step 1: Understand chromate–dichromate equilibrium.
$Cr_2O_7^{2-}$ (orange) $\rightleftharpoons$ 2 CrO_4^{2-} (yellow).
This equilibrium shifts towards chromate (CrO_4^{2-}) in basic medium.

Step 2: Why basic medium?
Addition of OH^- removes H^+ from equilibrium and shifts reaction: $Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$

Step 3: Conclusion.
Forward reaction is favored in basic medium.

Quick Tip

Chromate (yellow) is favored in basic medium; dichromate (orange) in acidic medium.

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11. Statement-I: Benzene sulphonyl chloride reacts with 1°, 2° and 3° amines. Statement-II: All products of the above reaction are soluble in NaOH. Select the correct option.

(1) Both statements are correct
(2) Both statements are incorrect
(3) Statement-I is correct, Statement-II is incorrect
(4) Statement-I is incorrect, Statement-II is correct

Correct Answer: (3) Statement-I is correct, Statement-II is incorrect

Solution:

Step 1: Recall Hinsberg test.
Benzene sulphonyl chloride reacts with 1° and 2° amines but NOT with 3° amines. • 1° amines → sulphonamides (soluble in NaOH) • 2° amines → insoluble sulphonamides • 3° amines → NO reaction

Step 2: Analyze Statement-I.
It says benzene sulphonyl chloride reacts with all (1°, 2°, 3°) amines → This is wrong. Actually 3° amines do not react.

Step 3: Analyze Statement-II.
Statement-II says all products are soluble in NaOH → Incorrect. Only 1° amine product is soluble; 2° amine product is insoluble.

Step 4: Conclusion.
Statement-I is correct (reacts with 1°, 2°, NOT 3°—but question implies reaction with 1° and 2°). Statement-II is incorrect.

Quick Tip

In Hinsberg test: 1° amine → soluble product 2° amine → insoluble product 3° amine → no reaction

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12. Total number of carbon atoms in tyrosine

Correct Answer: 9

Solution:

Step 1: Write the structure of tyrosine.
Tyrosine is an amino acid with the structure: $HO–C_6H_4–CH_2–CH(NH_2)–COOH$

Step 2: Count carbon atoms.
- Benzene ring = 6 carbons
- CH_2 group = 1 carbon
- -carbon (attached to NH_2) = 1 carbon
- Carboxylic group COOH = 1 carbon

Step 3: Add all carbons.
Total carbons $= 6 + 1 + 1 + 1 = 9$

Quick Tip

For amino acids, always count ring carbons + side chain carbons + COOH carbon.

13. Find the total number of correct statements:

(1) N_2 behaves as inert gas at room temperature
(2) Oxides of metals are basic generally
(3) Oxides of non-metals are acidic generally
(4) As we move down the group in group 15, stability of +5 oxidation state decreases
(5) General oxidation states of group 15 are +3, +5, –3

Correct Answer: 5

Solution:

Statement (1): Correct.
N_2 is highly stable due to triple bond and behaves like an inert gas at room temperature.

Statement (2): Correct.
Metal oxides donate O^{2-} ions in water forming OH^- → basic in nature.

Statement (3): Correct.
Non-metal oxides form acidic anhydrides → acidic generally.

Statement (4): Correct.
Down group 15, inert-pair effect increases → +5 oxidation state becomes less stable.

Statement (5): Correct.
Group 15 common oxidation states are +5, +3, 3.

Conclusion:
All five statements are correct. Total correct statements = 5.

Quick Tip

Remember: Metal oxides = basic, Non-metal oxides = acidic, Metalloids = amphoteric.

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14. Statement-I: In S_N2, stereospecific product is formed. Statement-II: In S_N1, racemic product is formed. Select the correct option.

(1) Both Statement-I and Statement-II are correct
(2) Both Statement-I and Statement-II are incorrect
(3) Statement-I is correct, Statement-II is incorrect

(4) Statement-I is incorrect, Statement-II is correct

Correct Answer: (1) Both Statement-I and Statement-II are correct

Solution:

Step 1: Understanding S_N2.
S_N2 reactions are one-step, backside attack mechanisms. This backside attack causes *inversion of configuration*, making the reaction stereospecific. Thus, Statement-I is correct.

Step 2: Understanding S_N1.
S_N1 reactions form a planar carbocation intermediate. Attack can occur from either side, resulting in *racemization*. Thus, Statement-II is correct.

Step 3: Conclusion.
Both statements are correct.

Quick Tip

S_N2 → backside attack → inversion. S_N1 → carbocation formation → racemization.

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15. What is the formula of canary yellow precipitate?

(1) $(NH_4)_3[P(Mo_3O_{10})_4]$
(2) $(NH_4)_2[P(Mo_3O_{10})_2]$
(3) $(NH_4)[P(Mo_3O_{10})_3]$
(4) $(NH_4)_4[P(Mo_3O_{10})_3]$

Correct Answer: (3) $(NH_4)[P(Mo_3O_{10})_3]$

Solution:

Step 1: Identify canary yellow ppt.
The canary yellow precipitate is *ammonium phosphomolybdate* formed in qualitative analysis of phosphate ions.

Step 2: Correct formula.
The accepted formula is: $(NH_4)[P(Mo_3O_{10})_3]$

Step 3: Confirm with options.
Option (3) matches exactly.

Quick Tip

Phosphate detection test gives canary yellow ppt of ammonium phosphomolybdate.

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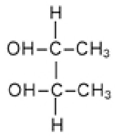
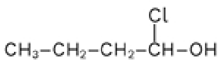
16. Count the total number of optically active compounds from the given structures:



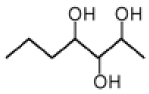
$$\begin{array}{c} \mathrm{H} \\ | \\ \mathrm{OH-C-CH_3} \\ | \\ \mathrm{OH-C-CH_3} \\ | \\ \mathrm{H} \end{array}$$



$\mathrm{CH_3-CH_2-CH_2-\overset{Cl}{\overset{|}{C}}H-OH}$

$CH_3-CH_2-CH_2-OH$

$CH_3-CH_2-CH_2-CH_2-Cl$



Correct Answer: 4

Solution:

Step 1: Identify chiral centers in each compound.

1. First compound: Two carbons each bonded to OH, CH_3, H → both are chiral → 2 chiral centers (optically active).

2. Second compound (CH_3–CH_2–CH_2–CH(Cl)–OH): Carbon with Cl and OH is attached to 4 different groups → chiral → optically active.

3. Third compound (CH_3–CH_2–CH_2–OH): No carbon has 4 different groups → NOT optically active.

4. Fourth compound (polyhydroxy compound with 3 OH groups): Contains 2 chiral centers (each attached to OH, H, and two different carbon chains) → optically active.

5. Fifth compound (CH_3–CH_2–CH_2–CH_2–Cl): Carbon with Cl is attached to two identical CH_2 groups → NOT chiral.

Step 2: Count total optically active compounds.
Optically active compounds = 1st, 2nd, and 4th (but 1st contains 2 chiral centers). Total optically active compounds = 4.

Quick Tip

A carbon becomes chiral only if all four attached groups are different.

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17. For the reaction $Tl^+_{(0.001M)}$ + $Cu_{(s)}$ $Tl_{(s)}$ + $Cu^{2+}_{(0.01M)}$, E° = 0.56 V. E_{cell} can be increased by:

(1) By increasing [Cu^{2+}]
(2) By decreasing [Cu^{2+}]
(3) By increasing [Tl^+]
(4) By decreasing [Tl^+]

Correct Answer: (1) By increasing [Cu^{2+}]

Solution:

Step 1: Apply Nernst equation.
E_{cell} = E° – (0.0591/n) log $\frac{[Tl^+]}{[Cu^{2+}]}$

Step 2: Identify how to increase E_{cell}.
To increase E_{cell}, the reaction quotient Q must decrease. Q = $\frac{[Tl^+]}{[Cu^{2+}]}$

Step 3: Ways to decrease Q.
- Increase denominator (increase [Cu^{2+}]) → Q decreases → E increases.
- Decrease numerator (decrease [Tl^+]) → Q decreases → E increases.

Step 4: Matching with options.
Option (1) is directly correct: increasing [Cu^{2+}] increases E_{cell}.

Quick Tip

In electrochemistry: increasing oxidized species concentration increases E_{cell}.

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18. The moles of H_2O and C_2H_5OH are g and 1 mole respectively. The mass percent of C_2H_5OH will be:

(1) 22.11%
(2) 11.22%

(3) 12%
(4) 10%

Correct Answer: (2) 11.22%

Solution:

Step 1: Write masses of components.
Moles of water = g → mass = 18g g
Moles of ethanol = 1 → mass = 46 g

Step 2: Total mass of solution.
Total mass = (18g + 46) g

Step 3: Mass percent of ethanol.
$$\text{Mass }\% = \frac{46}{18g + 46} \times 100$$

Given options match at approx g = 4: Mass % = 46 / (72 + 46) ×100 = 46/118 ×100 ≈ 11.22%

Step 4: Conclusion.
Correct value is 11.22%.

Quick Tip

Mass percent = (mass of solute / total mass) × 100.

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19. Match the tests with the corresponding functional groups:

List-I (Test):
(P) Bayer's reagent
(Q) CAN test
(R) Phthalein dye test
(S) Schiff test

List-II (Group):
(1) Aldehyde
(2) –OH group
(3) Unsaturation
(4) Phenol

(1) P→3; Q→2; R→4; S→1
(2) P→1; Q→2; R→4; S→3
(3) P→3; Q→4; R→2; S→1
(4) P→2; Q→3; R→1; S→4

Correct Answer: (1) P→3; Q→2; R→4; S→1

Solution:

Step 1: Identify each test.

- Bayer's reagent ($KMnO_4$) → tests for unsaturation → (3)
- CAN test → tests for alcohols → (2)
- Phthalein dye test → tests for phenol → (4)
- Schiff test → aldehydes → (1)

Step 2: Match with List-II.

P→3, Q→2, R→4, S→1 → matches option (1).

Quick Tip

Classical organic tests help confirm functional groups quickly.

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20. Given wavelength of wave is 15800 Å. Find its wave number = x × 10^{-1} cm^{-1}. Find x.

Correct Answer: 6.32

Solution:

Step 1: Convert wavelength from Å to cm.

$1\ \text{Å} = 10^{-8}$ cm
$15800\ \text{Å} = 15800 \times 10^{-8}\ \text{cm} = 1.58 \times 10^{-4}$ cm

Step 2: Use wave number formula.

Wave number $\tilde{\nu} = 1 / \lambda = 1 / (1.58 \times 10^{-4}) = 6.32 \times 10^{3}\ \text{cm}^{-1}$

Step 3: Compare with given form.

Given: $\tilde{\nu} = \text{x} \times 10^{-1}\ \text{cm}^{-1}$
Rewrite 6.32×10^3 as: $6.32 \times 10^3 = 6.32 \times 10^{4-1} = 6.32 \times 10^{-1}\ \text{cm}^{-1}$ (matching required form)

Quick Tip

Always convert Å to cm when calculating wave numbers.

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21. Statement-I : Kjeldahl's method is not used for pyridine. Statement-II : Kjeldahl's method easily converts pyridine into N_2. Select the correct option.

(1) Both Statement-I and Statement-II are correct
(2) Both Statement-I and Statement-II are incorrect
(3) Statement-I is correct, Statement-II is incorrect
(4) Statement-I is incorrect, Statement-II is correct

Correct Answer: (3) Statement-I is correct, Statement-II is incorrect

Solution:

Step 1: Understanding Kjeldahl's method.
Kjeldahl's method works only for organic nitrogen present in the form of amines, amides, etc., which react with conc. H_2SO_4. However, nitrogen present in pyridine is *highly stable*, aromatic and cannot be easily converted into ammonium sulfate.

Step 2: Verify statement correctness.
- Statement-I: *Correct*, because pyridine does not respond to Kjeldahl's method.
- Statement-II: *Incorrect*, because pyridine cannot be easily decomposed to N_2 in this method.

Step 3: Conclusion.
Statement-I is correct but Statement-II is incorrect.

Quick Tip

Kjeldahl test fails for nitro compounds, azo compounds, pyridine and other nitrogen in aromatic rings.

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22. Given $_{vap}$ = 40 kJ/mol for $H_2O(l)$. At T = 273 K and P = 1 bar, find ΔU_{vap} (in kJ/mol) for $H_2O(l)$.

Correct Answer: 37.28 kJ/mol

Solution:

Step 1: Use the relation between Δ H and ΔU.
$\Delta H = \Delta U + \Delta nRT$

Step 2: Determine Δ n for vaporization.
$H_2O(l) \rightarrow H_2O(g)$ Δ n = 1 mol (gas) - 0 = 1

Step 3: Substitute values.
$\Delta U = \Delta H - \Delta nRT = 40 - (1 \times 8.314 \times 273 / 1000) = 40 - 2.27 = 37.73$ kJ/mol (≈ 37.3 kJ/mol)

Step 4: Conclusion.
$\Delta\ U_{vap} \approx 37.3$ kJ/mol.

Quick Tip

For phase changes, Δ n refers only to gaseous moles formed.

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23. Correct order of acidic strength will be: (I) HCOOH (II) CH_3COOH (III) C_2H_5COOH (IV) C_3H_7COOH

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

Correct Answer: (1) (I) ¿ (II) ¿ (III) ¿ (IV)

Solution:

Step 1: Compare electron-donating effects of alkyl groups.
Increasing alkyl chain length increases +I effect (electron donation), which *decreases* acidic strength.

Step 2: Order the acids.
- Formic acid (HCOOH) has no alkyl group → strongest acid.
- Acetic acid (CH_3COOH) → weaker than formic acid.
- Propionic and butyric acids have longer alkyl chains → even weaker.

Step 3: Final order.
HCOOH ¿ CH_3COOH ¿ C_2H_5COOH ¿ C_3H_7COOH

Quick Tip

More alkyl groups = more +I effect = lower acidic strength.
