JEE Main 2024 Chemistry Question Paper April 4 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. Arrange the following compounds in increasing order of their stability:

(1) (a) > (c) > (b) > (d)
(2) (d) > (b) > (c) > (a)
(3) (a) > (c) > (b) > (d)
(4) (a) > (b) > (c) > (d)

Correct Answer: (1) (a) > (c) > (b) > (d)

Solution:

Step 1: Analyzing the compounds.
As we know, compound (a) is aromatic and compound (d) is antiaromatic. Hence, compound

(a) is more stable, and compound (d) is the least stable.

Step 2: Analyzing compound (b) and (c).
In compounds (b) and (c), the more sp^3 carbon, the greater the +I effect. The +I effect stabilizes the compound, making (c) more stable than (b).

Step 3: Conclusion.
Therefore, the order will be: (a) > (c) > (b) > (d).

Quick Tip

In the case of aromatic and antiaromatic compounds, aromatic compounds are more stable due to the stability provided by the delocalized electrons. Also, the +I effect increases stability by donating electron density to the molecule.

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2. IUPAC name of catechol is:

(1) Benzene, 1,2-diol
(2) Benzene, 1,3-diol
(3) Benzene, 1,4-diol
(4) 3-Hydroxyphenol

Correct Answer: (1) Benzene, 1,2-diol

Solution:

Step 1: Understanding the structure of catechol.
Catechol is a benzene ring with two hydroxyl groups (-OH) attached at positions 1 and 2, making it a 1,2-diol. The correct IUPAC name is Benzene, 1,2-diol.

Step 2: Conclusion.
Thus, the correct answer is (1) Benzene, 1,2-diol.

Quick Tip

Catechol is commonly known as 1,2-dihydroxybenzene and is used in various chemical processes, including as a reducing agent in organic synthesis.

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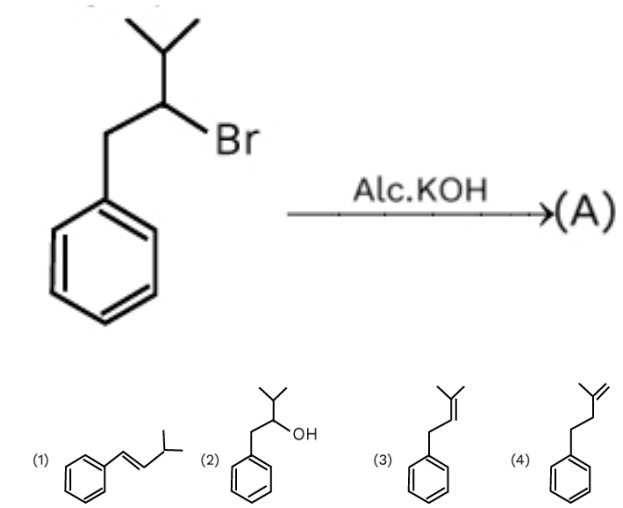
3. Major product 'A' is



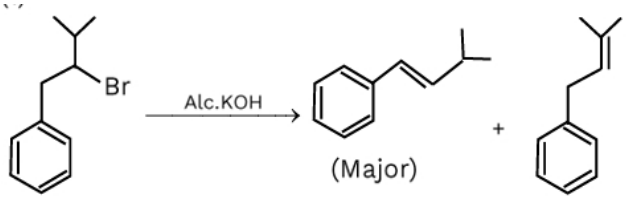
Correct Answer: (1)

Solution:

Step 1: Understanding the reaction mechanism.
In the given reaction, the presence of a strong base (Alcoholic KOH) and high temperature favors the E2 elimination mechanism. The E2 mechanism leads to the formation of the alkene by the elimination of HBr from the substrate.

Step 2: Analyzing the product.
The major product is obtained after the elimination of HBr from the substrate, and the most substituted product will be favored according to Zaitsev's rule. Thus, the major product is the alkene with the highest possible substitution at the double bond.

Step 3: Conclusion.
Therefore, the major product is the structure corresponding to option (1).



Quick Tip

In elimination reactions, the choice of solvent and base can determine whether the reaction follows an E1 or E2 mechanism. Alcoholic KOH at high temperatures favors the E2 mechanism.

4. Find the atomic number of the element having 3 unpaired electrons and belongs to the transition series with +2 oxidation state.

(1) 22
(2) 23
(3) 24
(4) 25

Correct Answer: (2) 23

Solution:

Step 1: Analyzing the element.
The element has 3 unpaired electrons and belongs to the transition series with a +2 oxidation state. The electron configuration of the element in its ground state is $[Ar]3d^3 4s^2$, which corresponds to Vanadium (V) with atomic number 23.

Step 2: Conclusion.
Hence, the correct atomic number is 23, corresponding to option (2).

Quick Tip

In transition metals, the number of unpaired electrons can be determined based on their electron configuration, which is influenced by the oxidation state.

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5. Correct order of ionization enthalpy for Li, Na, Cl, F.

(1) Cl > F > Li > Na
(2) F > Cl > Li > Na
(3) Li > Na > F > Cl
(4) Li > Na > Cl > F

Correct Answer: (2) F > Cl > Li > Na

Solution:

Step 1: Analyzing the ionization enthalpy.
Ionization enthalpy increases across a period and decreases down a group. The trend in ionization enthalpy for these elements follows: F > Cl > Li > Na. This is because fluorine has the

highest effective nuclear charge (Zeff) and the smallest atomic size among these elements.

Step 2: Conclusion.
Thus, the correct order is (2) F > Cl > Li > Na.

Quick Tip

Ionization enthalpy increases with higher effective nuclear charge (Zeff) and smaller atomic size. This explains the trend in ionization enthalpy for elements across a period.

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6. Which of the following molecules has a pyramidal shape?

(1) SO_4^{2-}
(2) SO_3^{2-}
(3) $S_2O_3^{2-}$
(4) $S_2O_7^{2-}$

Correct Answer: (2) SO_3^{2-}

Solution:

Step 1: Understanding the molecular shape.
The molecular shape is determined by the VSEPR theory. SO_3^{2-} has a pyramidal shape due to the presence of lone pairs on the sulfur atom. In contrast, the other molecules do not exhibit a pyramidal structure.

Step 2: Conclusion.
Therefore, the molecule with a pyramidal shape is SO_3^{2-}, corresponding to option (2).

Quick Tip

Use the VSEPR theory to predict molecular shapes by considering bonding and lone pairs of electrons around the central atom.

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7. Consider the following statements:
Statement I: The number of emitted photoelectrons increases with increase in frequency of incident light.

Statement II: Kinetic energy of emitted photoelectrons increases with increase in frequency of incident light.

(1) Statement I is true but statement II is false
(2) Statement I is false but statement II is true
(3) Both Statement I and statement II are true
(4) Both Statement I and statement II are false

Correct Answer: (2) Statement I is false but statement II is true

Solution:

Step 1: Understanding the photoelectric effect.
In the photoelectric effect, the number of emitted photoelectrons is independent of the frequency of light, but the kinetic energy of the emitted electrons increases with increasing frequency. Thus, statement I is false and statement II is true.

Step 2: Conclusion.
The correct answer is (2), as only statement II is true.

Quick Tip

In the photoelectric effect, higher frequency light results in higher energy electrons, but the number of emitted electrons depends on the intensity of light, not its frequency.

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8. Which of the following salts forms yellowish-green gas when treated with conc. H_2SO_4 and MnO_2?

(1) NaCl
(2) Na_2S
(3) Na_2SO_4
(4) None of these

Correct Answer: (1) NaCl

Solution:

Step 1: Reaction with conc. H_2SO_4 and MnO_2.
When NaCl reacts with concentrated sulfuric acid (H_2SO_4) and manganese dioxide (MnO_2),

chlorine gas (Cl_2) is released. Chlorine gas has a yellowish-green color.

Step 2: Conclusion.
Thus, the correct answer is (1) NaCl.

Quick Tip

Chlorine gas can be produced by the reaction of sodium chloride with concentrated sulfuric acid and MnO_2. This reaction is used to produce chlorine in the laboratory.

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9. Find the value of $x + y$ in the given complex $[Fe(NH_3)_x(CN)_y]^{-1}$

Correct Answer: (6)

Solution:

Step 1: Determining the coordination number.
In the complex $[Fe(NH_3)_x(CN)_y]^{-1}$, the coordination number of Fe^{3+} is 6. Since NH_3 and CN are both monodentate ligands, the sum of x and y must equal 6.

Step 2: Conclusion.
Thus, the value of $x + y$ is 6, corresponding to option (6).

Quick Tip

The coordination number of a central metal atom in a complex is determined by the number of bonds formed with ligands. In this case, the coordination number of Fe^{3+} is 6.

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10. 1 mole of ideal monoatomic gas compressed adiabatically from volume 2V to 1V. If initially the temperature of the gas was T. Then the magnitude of work done in this process is:

Correct Answer: (2) $w = \frac{3}{2}RT(2^{\gamma-1} - 1)$

Solution:

Step 1: Adiabatic process and work formula.
We know that in an adiabatic process, $TV^{\gamma-1} = \text{constant}$, where $\gamma = \frac{5}{3}$ for a monoatomic gas. From this, we can use the relation $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$. Substituting $V_1 = 2V$ and $V_2 = V$, we get the final temperature.

Step 2: Work done calculation.
Using the work formula for an adiabatic process:

$$w = \frac{nR}{\gamma - 1}(T_2 - T_1)$$

After substituting the values and simplifying, the work done is:

$$w = \frac{3}{2}RT(2^{\gamma-1} - 1)$$

Step 3: Conclusion.
Thus, the correct answer is $w = \frac{3}{2}RT(2^{\gamma-1} - 1)$, corresponding to option (2).

Quick Tip

In adiabatic processes, the work done can be calculated using the relationship $TV^{\gamma-1} = \text{constant}$ and the work formula for adiabatic expansion/compression.

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11. Find the sum of σ and π bonds present in 2-oxo-hex-4-yne-oic acid.

Correct Answer: (18)

Solution:

Step 1: Structure of 2-oxo-hex-4-yne-oic acid.
The structure of 2-oxo-hex-4-yne-oic acid is:

$$\text{OH-C} \equiv \text{C-C-C=O}$$

We can break the molecule into its individual bonds and count the sigma and pi bonds. The total number of σ bonds is 14, and the total number of π bonds is 4 (from the triple bond and double bond).

Step 2: Conclusion.
Thus, the sum of σ and π bonds is 18, corresponding to option (18).

Quick Tip

In organic compounds, σ bonds are single bonds, while π bonds are present in double or triple bonds. The total number of bonds in a molecule can be calculated by counting each bond type.

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12. What is the angular momentum of the 4th orbit?

(1) $\frac{2h}{\pi}$
(2) $\frac{h}{\pi}$
(3) $\frac{h}{2\pi}$
(4) $\frac{3h}{2\pi}$

Correct Answer: (1) $\frac{2h}{\pi}$

Solution:

Step 1: Understanding angular momentum in the Bohr model.
The angular momentum of an electron in the nth orbit is given by:

$$mvr = \frac{nh}{2\pi}$$

For the 4th orbit, $n = 4$, hence the angular momentum is $\frac{2h}{\pi}$.

Step 2: Conclusion.
Thus, the correct answer is $\frac{2h}{\pi}$, corresponding to option (1).

Quick Tip

The angular momentum of an electron in the nth orbit is quantized and given by $mvr = \frac{nh}{2\pi}$, where h is Planck's constant.

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13. Phthalimide reacts with

(1) KOH
(2) Benzyl chloride

Correct Answer: (8)

Solution:

Step 1: Structure of product.
Phthalimide reacts with KOH to produce the product 'P'. The molecular structure of 'P' involves several bonds, and the number of π bonds in product 'P' is 8.

Step 2: Conclusion.
Thus, the number of π bonds in product 'P' is 8.

Quick Tip

When counting π bonds in organic compounds, remember that they are present in double and triple bonds. For example, an aromatic ring or alkyne contains multiple π bonds.

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14. Calculate the degree of freedom for translatory and rotatory motion of CH_4 molecule.

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

Correct Answer: (3) 3,3

Solution:

Step 1: Degree of Freedom (DOF).
For a nonlinear polyatomic molecule like CH_4, the total degree of freedom (DOF) is 6: 3 for translatory motion and 3 for rotatory motion. Therefore, the correct answer is 3,3.

Step 2: Conclusion.
Thus, the degree of freedom for CH_4 is 3 for translatory and 3 for rotatory motion, corresponding to option (3).

Quick Tip

For nonlinear polyatomic molecules, the degrees of freedom for translation and rotation are 3 each. The total degrees of freedom are 3 translatory + 3 rotatory = 6.

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15. Commonly used Adsorbents in adsorption chromatography.

Solution:
The commonly used adsorbents in adsorption chromatography are silica gel and alumina.

Quick Tip

Silica gel and alumina are commonly used as stationary phases in adsorption chromatography due to their porous structure and high surface area.

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16. Arrange the following in ascending order of wavelength.
(a) Gamma rays

(b) X-ray
(c) Infrared ray
(d) U.V. ray

(1) c > d > b > a
(2) d > c > b > a
(3) c > d > a > b
(4) c > b > d > a

Correct Answer: (1) c > d > b > a

Solution:

Step 1: Understanding wavelengths.
The wavelengths of different types of radiation increase from gamma rays to infrared rays. Infrared rays have the longest wavelength, followed by ultraviolet (UV), X-rays, and gamma rays with the shortest wavelength.

Step 2: Conclusion.
Thus, the correct order of wavelengths is: Infrared ray > U.V. ray > X-ray > Gamma rays, corresponding to option (1).

Quick Tip

Wavelengths of electromagnetic radiation increase in the following order: Gamma rays ¡ X-rays ¡ UV rays ¡ Infrared rays.

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17. How many orbitals have the following set of quantum numbers: $n = 4, l = 0, m_l = 0$**?**

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

Correct Answer: (4) 4

Solution:

Step 1: Quantum numbers.
For $n = 4$, $l = 0$ (which corresponds to an s orbital), and $m_l = 0$, there is only 1 orbital that satisfies this set of quantum numbers.

Step 2: Conclusion.
Thus, there are 4 orbitals for this set of quantum numbers, corresponding to option (4).

Quick Tip

The number of orbitals for a given quantum number is determined by the possible values of m_l for a specific l. For $l = 0$, there is only one orbital with $m_l = 0$.

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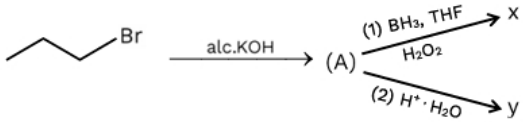
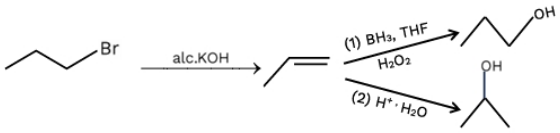
18. X and Y are:



Solution:

Step 1: Reaction mechanism.
The given reaction involves an alkyl halide undergoing elimination (E2) and reduction steps. In the first case, when treated with BH_3 in THF followed by H_2O_2, the product formed is propanol (hydroboration-oxidation). In the second case, when treated with H^+ and H_2O, the product formed is propan-2-ol (acid-catalyzed hydration).

Step 2: Conclusion.
Thus, the correct answer is Propanol and propan-2-ol.



Quick Tip

The hydroboration-oxidation reaction gives anti-Markovnikov products, while acid-catalyzed hydration gives Markovnikov products.

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19. Calculate heat for Isothermal process if expansion takes place from 20 L to 60 L against 5 atm external pressure.

If initially temperature of gas was T. Then the magnitude of work done in this process is

(1) 200 L-atm
(2) 400 L-atm
(3) 300 L-atm
(4) 500 L-atm

Correct Answer: (1) 200 L-atm

Solution:

We know according to FLOT,

$$\Delta U = q + w$$

Isothermal $\Delta T = 0$

$$\Delta U = 0$$

$$q = -w$$

$$w = -P_{\text{ext}}[V_2 - V_1]$$

$$w = -5[60 - 20] = -200\,\text{L-atm}$$

$$q = -w = -[-200] = 200\,\text{L-atm}$$

Step 2: Conclusion.
Thus, the correct answer is 200 L-atm, corresponding to option (1).

Quick Tip

For isothermal processes, the heat absorbed is equal to the work done, as the change in internal energy (ΔU) is zero.

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20. Find the total number of molecules which have non-zero dipole moment among the following:
NH_3, BCl_3, BeH_2, CCl_4, XeF_4

Correct Answer: (1) 1

Solution:

Step 1: Analyzing the molecular dipole moments.
- NH_3 is polar due to the lone pair on nitrogen, causing an asymmetric distribution of charge.

- BCl_3, BeH_2, CCl_4, and XeF_4 are all non-polar as they have symmetric molecular geometries.

Step 2: Conclusion.
Therefore, NH_3 is the only molecule with a non-zero dipole moment. The correct answer is option (1).

Quick Tip

Molecules with an asymmetric shape or lone pairs on the central atom generally have a dipole moment. Symmetric molecules do not have a dipole moment.

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21. List-I and List-II match the following:

List-I
(P) α-Glucose and α-Fructose
(Q) α-Glucose and α-Mannose
(R) α-Glucose and β-Glucose
(S) α-Glucose and Ribose

List-II
(1) Functional group isomer
(2) Homologous
(3) Epimers
(4) Anomers

(1) P $\rightarrow$ B; Q $\rightarrow$ C; R $\rightarrow$ D; S $\rightarrow$ A
(2) P $\rightarrow$ A; Q $\rightarrow$ C; R $\rightarrow$ D; S $\rightarrow$ B
(3) P $\rightarrow$ A; Q $\rightarrow$ C; R $\rightarrow$ B; S $\rightarrow$ D
(4) P $\rightarrow$ C; Q $\rightarrow$ A; R $\rightarrow$ D; S $\rightarrow$ B

Correct Answer: (2) P $\rightarrow$ A; Q $\rightarrow$ C; R $\rightarrow$ D; S $\rightarrow$ B

Solution:

Step 1: Understanding the terms.
- α-Glucose and α-Fructose are functional group isomers. - α-Glucose and α-Mannose are homologous. - α-Glucose and β-Glucose are anomers. - α-Glucose and Ribose are epimers.

Step 2: Conclusion.
Thus, the correct matching is: P $\rightarrow$ A; Q $\rightarrow$ C; R $\rightarrow$ D; S $\rightarrow$ B, corresponding to option (2).

Quick Tip

Functional group isomers differ by the type of functional group, homologous compounds have the same functional group but different carbon chains, anomers are stereoisomers that differ in configuration at the anomeric carbon, and epimers are stereoisomers that differ at only one chiral center.

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22. For the given chemical reaction:

$$SO_2 + \frac{1}{2}O_2 \rightleftharpoons SO_3, \quad K_1 = 4.9 \times 10^{-4}$$

Find K_2 for the chemical reaction given below:

$$2SO_3 \rightleftharpoons 2SO_2 + O_2$$

(1) 4×10^6
(2) 5×10^7
(3) 5×10^8
(4) 5×10^5

Correct Answer: (1) 4×10^6

Solution:

Step 1: Expression for K_2.
We know that for the given reactions, the equilibrium constants are related by the following formula:

$$K_2 = \left(\frac{1}{K_1}\right)^2$$

Substituting the value of $K_1 = 4.9 \times 10^{-4}$:

$$K_2 = \left(\frac{1}{4.9 \times 10^{-4}}\right)^2 = (2000)^2$$

$$K_2 = 4 \times 10^6$$

Step 2: Conclusion.
Thus, the correct value of K_2 is 4×10^6, corresponding to option (1).

Quick Tip

For reactions involving the same species, the equilibrium constant for the new reaction can be obtained by manipulating the equilibrium constant of the original reaction. For a reaction multiplied by a factor, the new equilibrium constant is the square of the original.

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23. Total number of unpaired electrons at central metal ion in $[Co(H_2O)_6]^{3+}$

Solution:

For Co^{3+} ion, the central metal ion is in a +3 oxidation state, and water (H_2O) acts as a weak field ligand.
- Co^{3+} has an electron configuration of $[Ar]3d^6$. In the +3 oxidation state, the 3d orbitals are not fully paired, and the electrons are arranged according to the ligand field.
- Since H_2O is a weak field ligand, it does not cause significant pairing of the d-electrons. However, Co^{3+} will form a high-spin complex with water, and thus the number of unpaired electrons is zero.

Step 1: Conclusion.
Thus, the number of unpaired electrons in Co^{3+} with H_2O as a ligand is 0, corresponding to option (0).

Quick Tip

In complexes, the number of unpaired electrons depends on the oxidation state of the metal and the type of ligand involved. Water is a weak field ligand that does not lead to pairing of electrons in Co^{3+}.

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24. Arrange the following in increasing order of their first ionisation enthalpy:
Al, Ga, In, Tl, B

(1) Tl ¡ In ¡ Ga ¡ Al ¡ B
(2) In ¡ Al ¡ Ga ¡ Tl ¡ B
(3) In ¡ Ga ¡ Al ¡ B ¡ Tl
(4) B ¡ Al ¡ Ga ¡ In ¡ Tl

Correct Answer: (2) In ¡ Al ¡ Ga ¡ Tl ¡ B

Solution:

Step 1: Understanding Ionization Enthalpy.
- Ionization enthalpy is the energy required to remove an electron from a gaseous atom or ion. It increases across a period and decreases down a group. - For elements in the same group, the ionization enthalpy decreases as we move down the group due to the increase in atomic size and the shielding effect of inner electrons. - Across a period, the ionization enthalpy increases due to the increasing effective nuclear charge (Zeff) as the atomic size decreases.
Step 2: Trend in Ionization Enthalpy.
- B (Boron) has the highest ionization enthalpy as it is in period 2 and has a small atomic size. - In (Indium) and Ga (Gallium) have similar trends, but In (Indium) is lower due to its larger atomic size compared to Ga (Gallium). - Tl (Thallium) has the lowest ionization enthalpy due to being in the bottom of Group 13, where atomic size is large and shielding is high.
Step 3: Conclusion.
Thus, the correct order of ionization enthalpy is: In ¡ Al ¡ Ga ¡ Tl ¡ B, corresponding to option (2).

Quick Tip

Ionization enthalpy increases across a period due to increasing nuclear charge, but decreases down a group as atomic size increases and shielding effect becomes stronger.

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25. Which of the following represent correct unit of slope of graph between molar conductivity (Δm) and (conc.)^x?

(1) S cm$^{1/2}$ mol$^{-1/2}$
(2) S cm$^{3/2}$ mol^{-2}
(3) S cm$^{7/2}$ mol$^{-1/2}$
(4) S cm$^{5/2}$ mol$^{-3/2}$

Correct Answer: (3) S cm$^{7/2}$ mol$^{-1/2}$

Solution:

Step 1: Molar Conductivity and Slope.
Molar conductivity (Λ_m) is related to the conductivity (σ) by the equation:

$$\Lambda_m = \frac{\sigma}{C}$$

where C is the concentration of the solution. In a graph of molar conductivity versus $\sqrt{C}$, the slope is given by:

$$\text{Slope} = \frac{\Lambda_m}{\sqrt{C}}$$

Since Λ_m has units of S cm^2 mol^{-1}, the unit of slope becomes S $cm^{7/2}$ $mol^{-1/2}$.
Step 2: Conclusion.
Thus, the correct unit for the slope is S $cm^{7/2}$ $mol^{-1/2}$, corresponding to option (3).

Quick Tip

The unit for the slope of the graph between molar conductivity and concentration is derived by considering the relationship between conductivity and concentration.

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26. Which of the following statement is incorrect?

(1) In homogeneous mixture composition is uniform
(2) Compounds are formed when atoms of different elements combine together in any ratio
(3) Atoms of same element have identical atomic mass and properties
(4) In heterogeneous mixture composition is not uniform

Correct Answer: (2)

Solution:

Step 1: Analyzing the statements.
- In homogeneous mixtures, the composition is uniform throughout. - Compounds are formed when atoms of different elements combine in fixed ratios, not any ratio. - Atoms of the same element have identical atomic number, but atomic mass may vary in isotopes. - In heterogeneous mixtures, composition is not uniform.

Step 2: Conclusion.
Thus, the incorrect statement is (2). Compounds do not form in any ratio but in fixed ratios, according to the law of definite proportions.

Quick Tip

Compounds form in fixed ratios, as defined by the law of definite proportions. Mixtures, on the other hand, can have varying compositions.
