MHT CET 2026 May 19 Shift 1

Question Paper with Solutions

Conducted by CET Cell, Maharashtra

General Instructions

(i) **Duration:** The total duration of the examination is 3 hours (180 minutes).

(ii) **Total Marks:** The complete paper carries a maximum of 200 marks.

(iii) **Structure:** The paper has 3 Sections:

- **Section A:** 50 Multiple Choice Questions (Physics).
- **Section B:** 50 Multiple Choice Questions (Chemistry).
- **Section B:** 100 Multiple Choice Questions (Biology).

(iv) **Compulsory Questions:** All 200 questions are compulsory.

(v) Each question has four options. Only **one** option is correct.

(vi) **Correct Answer:** +1 marks.

(vii) **Incorrect Answer:** (No Negative marking).

(viii) **Unanswered/Marked for Review:** 0 marks.

1. Which of the following compound is not in gaseous phase at 25°C?

(1) ClF

(2) BrF_3

(3) IF_3

(4) ClF_3

Correct Answer: (2) BrF_3

Solution:

Step 1: Understanding the Concept:

Interhalogen compounds are unique chemical species formed through the direct or indirect reaction between two different halogen elements. These compounds are binary in nature and generally follow the formula XY_n, where X represents the less electronegative (larger) halogen and Y represents the more electronegative (smaller) halogen. The physical state of these molecules at a specific temperature, such as 25°C (standard room temperature), is primarily dictated by the strength of their intermolecular forces. In non-polar or weakly polar covalent molecules like interhalogens, the dominant intermolecular forces are Van der Waals forces, specifically London dispersion forces and dipole-dipole interactions.

The strength of these forces is heavily dependent on the total number of electrons and the surface area of the molecule. Larger atoms with higher atomic numbers have more electrons and a more polarizable electron cloud, leading to stronger instantaneous dipoles. Consequently, as the molecular mass and size of the central halogen atom increase, the boiling point of the compound rises, causing a transition from the gaseous phase to the liquid or solid phase.

Step 2: Detailed Explanation:

To accurately identify the non-gaseous compound, we must evaluate the physical properties and molecular characteristics of each option provided:

(1) **ClF (Chlorine monofluoride):** This is the simplest type of interhalogen molecule. It is a diatomic molecule composed of one Chlorine and one Fluorine atom. Because both atoms are relatively small and located in the upper part of the periodic table, the total molecular weight is low (approximately 54.45 g/mol). The intermolecular forces are very weak, resulting in an extremely low boiling point of approximately -100.1°C. Since 25°C is significantly higher than its boiling point, ClF exists as a colorless gas.

(2) **BrF_3 (Bromine trifluoride):** This molecule consists of a central Bromine atom surrounded by three Fluorine atoms. Bromine belongs to the 4th period and is much larger and heavier than Chlorine. The molecule adopts a T-shaped geometry due to the presence of two lone pairs on the central Bromine atom. This asymmetry creates a significant permanent dipole moment. The combination of a higher molecular mass (136.9 g/mol) and strong dipole-dipole attractions raises its boiling point to 125.7°C. Since the boiling point is well above room

temperature, BrF_3 exists as a straw-colored, dense liquid.

(3) **IF_3 (Iodine trifluoride):** While Iodine is the heaviest of the common halogens, IF_3 is notorious for its instability. It is generally synthesized at very low temperatures and tends to decompose or disproportionate rapidly into IF and IF_5 at room temperature. In most standard academic classifications for stable interhalogens at STP, it is not listed as a primary liquid; rather, it is often discussed as a transient gaseous or solid species under specific controlled conditions.

(4) **ClF_3 (Chlorine trifluoride):** This is a highly reactive and volatile compound. Although it has a T-shaped geometry like BrF_3, the central atom is Chlorine, which is smaller. Its boiling point is approximately 11.7°C. At the specified temperature of 25°C, ClF_3 has already surpassed its boiling point and exists as a colorless gas.

Step 3: Final Answer:

By analyzing the boiling points and intermolecular attractions, it is clear that Bromine trifluoride (BrF_3) is the only stable compound among the choices that remains in the liquid state at 25°C. The others either exist as gases or are unstable.

Therefore, the compound not in the gaseous phase is BrF_3.

Hence, the correct answer is option (2).

Quick Tip: To solve phase-related questions for interhalogens, remember the general trend: physical state changes from Gas → Liquid → Solid as the size of the central atom X and the number of Y atoms increase. ClF is a gas, BrF_3 is a liquid, and ICl_3 is a solid.

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2. A solution is prepared by dissolving 2 gram of non-volatile solute in 500 mL solution at 27°C. The osmotic pressure of the solution is 0.82 atm. The molar mass of the solute is:

(1) 100 g mol^{-1}

(2) 120 g mol^{-1}

(3) 150 g mol^{-1}

(4) 180 g mol^{-1}

Correct Answer: (2) 120 g mol^{-1}

Solution:

Step 1: Understanding the Concept:

Osmotic pressure (π) is defined as one of the four colligative properties of a solution. Colligative properties are unique because they depend solely on the ratio of the number of solute particles to the number of solvent molecules in a solution, rather than the chemical identity of the solute. In dilute solutions, the behavior of the solute mimics that of an ideal gas. Jacobus Henricus van 't Hoff established a mathematical relationship known as the van 't Hoff equation, which relates osmotic pressure to the molarity of the solution and the absolute temperature.

This property is exceptionally useful in analytical chemistry and biochemistry for determining the molar mass of complex molecules, especially polymers and proteins, because even small amounts of solute can produce a measurable osmotic pressure, whereas changes in boiling or freezing points might be too small to detect accurately.

Step 2: Key Formula or Approach:

The van 't Hoff equation for a non-electrolyte, non-volatile solute is:

$$\pi = CRT$$

Where:

- π = Osmotic pressure (in atm)
- C = Molar concentration (moles per liter)
- R = Universal gas constant (0.0821 L·atm/mol·K)
- T = Absolute temperature (in Kelvin)

Since molarity $C = \frac{n}{V}$ and moles $n = \frac{w}{M}$, we can substitute these to find the molar mass M:

$$\pi = \frac{w}{M \cdot V} \cdot R \cdot T$$

Rearranging to solve for Molar Mass (M):

$$M = \frac{w \cdot R \cdot T}{\pi \cdot V}$$

Step 3: Detailed Explanation:

Let us extract and convert all given data into appropriate units for calculation:

- Mass of solute $(w) = 2$ g
- Volume of solution $(V) = 500$ mL $= 0.5$ L
- Temperature in Celsius $= 27^\circ$C
- Temperature in Kelvin $(T) = 27 + 273.15 \approx 300$ K
- Osmotic pressure $(\pi) = 0.82$ atm
- Gas constant $(R) = 0.0821$ L·atm/mol·K (For ease of calculation in exams, 0.082 is often used).

Now, substitute these values into the rearranged formula:

$$M = \frac{2 \times 0.082 \times 300}{0.82 \times 0.5}$$

Simplifying the numerator:

$$2 \times 0.082 = 0.164$$

$$0.164 \times 300 = 49.2$$

Simplifying the denominator:

$$0.82 \times 0.5 = 0.41$$

Performing the final division:

$$M = \frac{49.2}{0.41}$$

Multiply both top and bottom by 100 to remove decimals:

$$M = \frac{4920}{41}$$

By long division, $4920 \div 41 = 120$.
Thus, the calculated molar mass of the unknown solute is exactly 120 g/mol. This procedure demonstrates how physical measurements of pressure and volume can lead directly to the molecular identity of a substance.

Step 4: Final Answer:
The molar mass of the solute is 120 g mol^{-1}.
Therefore, the correct option is (2).

Quick Tip: In competitive chemistry exams, look for numerical "clues." Notice that the pressure 0.82 is ten times the gas constant 0.082. This is a common design in MHT CET to allow students to cancel terms quickly without a calculator. Always convert temperature to Kelvin immediately!

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3. What is the oxidation state of sulfur in Marshall's acid, $H_2S_2O_8$?

(1) +4
(2) +5
(3) +6
(4) +7

Correct Answer: (3) +6

Solution:

Step 1: Understanding the Concept:
The oxidation state (or oxidation number) represents the degree of oxidation of an atom in

a chemical compound. It is a formal charge assigned to an atom assuming that all bonds to different elements are 100% ionic. However, in complex oxyacids like Marshall's acid (peroxodisulfuric acid), relying solely on the formula $H_2S_2O_8$ and general rules (H=+1, O=-2) can lead to erroneous results. This is because standard rules fail to account for special bonding environments such as peroxide linkages ($-O-O-$). In a peroxide bond, the oxygen atoms are bonded to each other, and each oxygen is assigned an oxidation state of -1 instead of the usual -2. Sulfur, being a Group 16 element, has 6 valence electrons, meaning its maximum possible oxidation state is +6. Any calculation yielding a value higher than +6 indicates a structural anomaly like a peroxide bond.

Step 2: Key Formula or Approach:

The chemical structure of Marshall's acid is $HO-SO_2-O-O-SO_2-OH$.

From this structure, we can categorize the atoms:

- 2 Hydrogen atoms (each is +1).
- 2 Sulfur atoms (let their oxidation state be x).
- 6 "Normal" Oxygen atoms (bonded to S or H, each is -2).
- 2 "Peroxide" Oxygen atoms (forming the bridge between Sulfurs, each is -1).

The sum of all oxidation states in a neutral molecule is equal to zero.

Step 3: Detailed Explanation:

Let's set up the algebraic equation based on the structural breakdown:

$$2(\text{H}) + 2(\text{S}) + 6(\text{O}_{\text{oxide}}) + 2(\text{O}_{\text{peroxide}}) = 0$$

Substituting the known values into the equation:

$$2(+1) + 2(x) + 6(-2) + 2(-1) = 0$$

Simplifying the terms:

$$2 + 2x - 12 - 2 = 0$$

The +2 and -2 cancel out, leaving:

$$2x - 12 = 0$$

$$2x = 12$$

$$x = +6$$

If we had ignored the peroxide bridge and used the standard formula method:

$$2(+1) + 2(x) + 8(-2) = 0 \Rightarrow 2 + 2x - 16 = 0 \Rightarrow 2x = 14 \Rightarrow x = +7$$

Since Sulfur cannot have an oxidation state of +7 (as it only has 6 valence electrons to lose/share), the result of +7 is chemically impossible. This serves as a "red flag" that peroxide bonds exist in the molecule. Structure-based calculation correctly shows that each sulfur atom maintains its maximum stable oxidation state of +6 by sharing its valence electrons with the surrounding oxygens.

Step 4: Final Answer:

The oxidation state of sulfur in Marshall's acid ($H_2S_2O_8$) is +6.

Therefore, the correct answer is option (3).

Quick Tip: When calculating oxidation states for S, Cr, or P, if your answer exceeds the group number (+6 for S/Cr, +5 for P), it is almost certainly due to a peroxide linkage. In such cases, the answer is usually the group number itself. Common examples: H_2SO_5 (S=+6) and CrO_5 (Cr=+6).

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4. What is formed when an alkyl cyanide reacts with sodium in ether?

(1) Primary amine

(2) Secondary amine

(3) Alkene

(4) Alcohol

Correct Answer: (1) Primary amine

Solution:

Step 1: Understanding the Concept:

Alkyl cyanides (also known as nitriles) possess a functional group consisting of a carbon atom triple-bonded to a nitrogen atom ($-C \equiv N$). This group is highly unsaturated and susceptible to reduction. Reduction in organic chemistry involves the addition of hydrogen atoms across multiple bonds. When Sodium (Na) is used in a solvent like ether or ethanol, it acts as a chemical reducing agent. In this heterogeneous reaction, sodium atoms donate electrons to the nitrile group, while the solvent (usually an alcohol added to the ether or the ether system itself in specific setups) provides the protons needed to complete the reduction. This specific conversion of nitriles to amines using active metals is a fundamental transformation in nitrogen chemistry.

Step 2: Key Formula or Approach:

The reaction described is essentially the Mendius Reaction. The general chemical equation for the reduction of an alkyl cyanide is:

$$R-C \equiv N + 4[H] \xrightarrow{Na/\text{solvent}} R-CH_2-NH_2$$

The reduction is a multi-step process where:

1. The triple bond is converted to a double bond (imine stage).
2. The double bond is further reduced to a single bond (amine stage).

The result is a saturated carbon atom and a saturated nitrogen atom.

Step 3: Detailed Explanation:

Let us break down the mechanism and the nature of the product:

1. **Starting Material:** The reactant is $R-C\equiv N$. Here, the carbon of the nitrile group is bonded to one alkyl group (R) and triple-bonded to Nitrogen.
2. **Addition of Hydrogen:** During the reduction with Sodium, four hydrogen atoms are added to the functional group. Two hydrogen atoms are added to the carbon atom, turning it into a methylene group ($-CH_2-$). Two hydrogen atoms are added to the nitrogen atom, turning it into an amino group ($-NH_2$).
3. **Nature of the Product:** The resulting molecule has the formula $R-CH_2-NH_2$. In this structure, the Nitrogen atom is attached to only one alkyl-derivative carbon. By definition, an amine where the Nitrogen is bonded to only one carbon atom is a **primary amine**.
4. **Comparison with other options:**

- A **secondary amine** would require the Nitrogen to be bonded to two different carbon atoms, which cannot happen through simple reduction of a nitrile.
- **Alkenes** and **Alcohols** do not contain nitrogen, so they cannot be formed as the primary product from a nitrogen-containing nitrile.

This reaction is a classic method used in laboratories to "ascend" the amine series, as the product amine contains one more carbon than the starting alkyl halide used to make the cyanide.

Step 4: Final Answer:

The reduction of an alkyl cyanide with sodium in ether leads to the formation of a primary amine.

Hence, option (1) is the correct answer.

Quick Tip: Remember the "Nitrogen Rule" for reductions: Nitriles (RCN) $\rightarrow$ Primary Amines; Amides ($RCONH_2$) $\rightarrow$ Primary Amines; Nitro compounds (RNO_2) $\rightarrow$ Primary Amines. Most simple nitrogen functional groups reduce to primary amines unless substituted on the Nitrogen atom.

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5. Which of the following is not amphoteric in nature?

(1) NH_3

(2) HCl

(3) H_2O

(4) Cr_2O_3

Correct Answer: (2) HCl

Solution:

Step 1: Understanding the Concept:

The term "amphoteric" is derived from the Greek word *amphoteros*, meaning "both." In chemistry, an amphoteric substance is one that possesses the ability to react both as an acid and as a base. This behavior can be understood through different acid-base theories. According to the Brønsted-Lowry theory, an amphoteric (or amphiprotic) substance can both donate a proton (H^+) and accept a proton. In terms of Lewis theory, it can both accept and donate electron pairs. Additionally, certain metal oxides are called amphoteric because they react with both strong acids and strong bases to form salts and water. Identifying an amphoteric substance requires looking for features like exchangeable protons alongside lone pairs of electrons, or an intermediate metallic character.

Step 2: Detailed Explanation:

Let's evaluate the nature of each chemical species provided in the options:

(1) **NH_3 (Ammonia):** Ammonia is a well-known base because the lone pair on the nitrogen atom can accept a proton to form the ammonium ion (NH_4^+). However, under very specific conditions (such as reaction with a very strong base like metallic Sodium), Ammonia can act as an acid by losing a proton to form the amide ion (NH_2^-). Because it can technically function as both a proton donor and acceptor, it is classified as amphiprotic/amphoteric.

(2) **HCl (Hydrochloric acid):** HCl is one of the strongest mineral acids. In aqueous solution, it dissociates completely into H^+ and Cl^-. Because Chlorine is highly electronegative and the Cl^- ion is exceptionally stable, HCl has an overwhelming tendency to donate its proton. It has no realistic ability to accept an additional proton (H_2Cl^+ is not stable in standard conditions). Therefore, HCl behaves exclusively as an acid.

(3) **H_2O (Water):** Water is the textbook example of an amphoteric substance. It can act as a base by accepting a proton to form the hydronium ion (H_3O^+) or act as an acid by donating a proton to form the hydroxide ion (OH^-). This dual nature is the basis for the pH scale and the auto-ionization of water.

(4) **Cr_2O_3 (Chromium(III) oxide):** Transition metal oxides in intermediate oxidation states

often show amphoteric behavior. Cr_2O_3 is a green solid that does not dissolve in water but reacts with strong acids (like H_2SO_4) to form Chromium(III) salts and with strong bases (like $NaOH$) to form chromite complexes like $[Cr(OH)_6]^{3-}$.

Step 3: Comparison and Conclusion:
Among the four options, HCl stands out as a "unidirectional" chemical species. While the others can pivot their behavior depending on the reacting partner, HCl is a dedicated proton donor. It lacks the electronic or structural flexibility to act as a base.

Step 4: Final Answer:
Hydrochloric acid (HCl) is a strong acid and is not amphoteric.
Therefore, the correct answer is option (2).

Quick Tip: To quickly spot non-amphoteric substances, look for strong mineral acids (HCl, HNO_3, HI) or strong alkali bases (NaOH, KOH). These are "strictly" one-sided. Also, remember the "Z-pattern" for amphoteric oxides in the periodic table: Al, Zn, Sn, Pb, and Cr are the big five to remember.

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6. The rate of reaction A → P is 1.25×10^{-2} mol $dm^{-3}s^{-1}$ when [A] = 0.5 M. Calculate the rate constant if the reaction is second order in A.

(1) 0.05
(2) 0.04
(3) 0.03
(5) 0.01

Correct Answer: (1) 0.05

Solution:

Step 1: Understanding the Concept:
Chemical kinetics deals with the speed or rate at which a chemical reaction occurs. The

"Rate Law" is a mathematical expression that relates the rate of a reaction to the molar concentration of its reactants. For any reaction, the dependency on concentration is defined by the "order" of the reaction. In this problem, the reaction is explicitly stated to be "second order" with respect to reactant A. This means that if the concentration of A is doubled, the rate of the reaction will increase by a factor of four (2^2). The proportionality constant in this relationship is the rate constant (k), which is specific to a particular reaction at a given temperature. The units of the rate constant change depending on the overall order to ensure the rate always has units of $mol \cdot dm^{-3} \cdot s^{-1}$.

Step 2: Key Formula or Approach:

For a second-order reaction involving a single reactant A, the rate law is written as:

$$\text{Rate} = k[A]^2$$

Where:

- Rate = Velocity of the reaction (1.25×10^{-2} mol $dm^{-3}s^{-1}$)
- k = Rate constant (to be determined)
- $[A]$ = Concentration of reactant A (0.5 M or 0.5 mol dm^{-3})

To find the rate constant, we rearrange the formula:

$$k = \frac{\text{Rate}}{[A]^2}$$

Step 3: Detailed Explanation:

Let's plug in the numerical values provided in the question:

1. The given rate is 1.25×10^{-2}. This can also be written as 0.0125 for simpler decimal division if preferred.
2. The concentration $[A]$ is 0.5.
3. First, calculate the square of the concentration:

$$[A]^2 = (0.5)^2 = 0.5 \times 0.5 = 0.25$$

4. Now, substitute these into the rearranged rate constant equation:

$$k = \frac{1.25 \times 10^{-2}}{0.25}$$

5. To simplify the calculation, express both numbers in scientific notation or as fractions:

$$k = \frac{0.0125}{0.25}$$

If we divide 1.25 by 0.25, we get 5 (since $0.25 \times 4 = 1.00$ and one more 0.25 makes 1.25). Thus,

$$k = 5 \times 10^{-2}$$

6. Converting this back to a standard decimal:

$$k = 0.05$$

The units for this rate constant would be $M^{-1}s^{-1}$ or $dm^3 \cdot mol^{-1} \cdot s^{-1}$. The magnitude 0.05 corresponds to option (1). This value tells us how quickly the molecules of A are successfully colliding and reacting under the given conditions.

Step 4: Final Answer:
The calculated value for the rate constant k is 0.05.
Therefore, the correct option is (1).

Quick Tip: In kinetics problems, always check the units of the rate constant if they are provided, as they reveal the order of the reaction even if it isn't stated. For n^{th} order, the unit is $M^{1-n} \cdot s^{-1}$. For $n = 2$, it's $M^{-1}s^{-1}$. Here, knowing $(0.5)^2 = 1/4$ makes the math very easy: $1.25 \times 10^{-2} \times 4 = 5.0 \times 10^{-2}$.

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7. Identify the unit of rate constant for a first-order reaction.

(1) mol dm^{-3} s^{-1}

(2) s^{-1}

(3) mol^{-1} dm^3 s^{-1}

(4) mol dm^{-3}

Correct Answer: (2) s^{-1}

Solution:

Step 1: Understanding the Concept:

The rate constant (k) is a fundamental parameter in chemical kinetics that quantifies the speed of a reaction. Unlike the reaction rate itself, which always has units of change in concentration per unit time (e.g., $mol \cdot L^{-1} \cdot s^{-1}$), the dimensions of the rate constant are variable. The units of k must adjust so that the overall Rate Law equation remains dimensionally consistent. For a reaction of order n, the rate is proportional to the concentration raised to the power of n. Therefore, as the order changes, the units of the concentration term change, necessitating a corresponding change in the units of k to ensure the product always results in units of "Rate."

Step 2: Key Formula or Approach:

The general formula to determine the unit of the rate constant for any order n is:

$$\text{Unit of } k = (\text{Concentration})^{1-n} \cdot (\text{Time})^{-1}$$

Substituting the standard units for concentration ($mol \cdot dm^{-3}$) and time (s):

$$\text{Unit of } k = (mol \cdot dm^{-3})^{1-n} \cdot s^{-1}$$

Step 3: Detailed Explanation:

Let us apply this general formula to a first-order reaction ($n = 1$):

1. Plug $n = 1$ into the formula:

$$\text{Unit of } k = (mol \cdot dm^{-3})^{1-1} \cdot s^{-1}$$

2. Since any non-zero number raised to the power of zero is 1:

$$\text{Unit of } k = (mol \cdot dm^{-3})^0 \cdot s^{-1}$$

$$\text{Unit of } k = 1 \cdot s^{-1} = s^{-1}$$

3. This can be intuitively understood through the Rate Law for first order:

$$\text{Rate} = k[A]$$

Rearranging for k:

$$k = \frac{\text{Rate}}{[A]}$$

Substituting the units:

$$\text{Unit of } k = \frac{mol \cdot dm^{-3} \cdot s^{-1}}{mol \cdot dm^{-3}}$$

The concentration units in the numerator and denominator cancel out perfectly. This leaves only the reciprocal of time. This is a unique characteristic of first-order reactions; the rate constant is purely a frequency term (per second, per minute, etc.) and is independent of the initial concentration of the reactants. This property is why radioactive decay (which is always first-order) is characterized by a "half-life" that does not depend on the amount of material present.

Step 4: Final Answer:

The unit for the rate constant of a first-order reaction is s^{-1} (per second).

Therefore, option (2) is correct.

Quick Tip: Memorize the units for the first three orders:

Zero order: $mol \cdot L^{-1} \cdot s^{-1}$ (same as rate).

First order: s^{-1} (only time).

Second order: $L \cdot mol^{-1} \cdot s^{-1}$ (inverted concentration × time).

This is a very frequent question in MHT CET and JEE Main.

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8. The magnetic moment of Cr^{3+} ion is 3.87 BM. The number of unpaired electrons present is:

(1) 1

(2) 2

(3) 3

(4) 4

Correct Answer: (3) 3

Solution:

Step 1: Understanding the Concept:

The magnetic properties of transition metal complexes and ions are primarily due to the presence of unpaired electrons in their d-orbitals. Each electron has a magnetic dipole moment stemming from two sources: its orbital motion around the nucleus and its spin around its own axis. For many first-row transition metal ions, the "orbital contribution" is "quenched" (cancelled out) by the surrounding ligands or crystal field, meaning the magnetic moment can be accurately calculated using only the spin component. This is known as the "spin-only" magnetic moment. The magnitude of this moment is measured in units called Bohr Magnetons (BM). As the number of unpaired electrons increases, the total magnetic moment of the ion increases predictably.

Step 2: Key Formula or Approach:

The spin-only magnetic moment (μ) is given by the formula:

$$\mu = \sqrt{n(n+2)}$$

Where:

- μ = Magnetic moment in Bohr Magnetons (BM)
- n = Number of unpaired electrons

Step 3: Detailed Explanation:

We are given that the magnetic moment μ is 3.87 BM. We need to find the integer value of n.

Method 1: Mathematical Calculation

$$3.87 = \sqrt{n(n+2)}$$

Squaring both sides to remove the square root:

$$(3.87)^2 = n(n+2)$$

$$14.9769 = n^2 + 2n$$

Rearranging into a quadratic equation:

$$n^2 + 2n - 14.9769 = 0$$

Since n must be a whole number, we can look for integers where $n(n+2)$ is close to 15.

If $n = 3$, then $3(3+2) = 3 \times 5 = 15$.

The square root of 15 is approximately 3.872. This perfectly matches the given value.

Method 2: Electronic Configuration Check

Chromium (Cr) has an atomic number of 24. Its ground-state configuration is $[Ar]3d^5 4s^1$.

To form the Cr^{3+} ion, we must remove 3 electrons. Electrons are removed first from the $4s$ orbital and then from the $3d$ orbital:

- Remove 1 from $4s \rightarrow [Ar]3d^5$
- Remove 2 from $3d \rightarrow [Ar]3d^3$

In the $3d^3$ configuration, there are three electrons in the d subshell. According to Hund's

Rule of maximum multiplicity, these three electrons will occupy three separate d orbitals with parallel spins to minimize repulsion. Therefore, the number of unpaired electrons (n) is 3. Both the mathematical formula and the chemistry of the atom confirm that 3 unpaired electrons result in a magnetic moment of 3.87 BM.

Step 4: Final Answer:

The number of unpaired electrons present in the Cr^{3+} ion is 3.

Thus, option (3) is correct.

Quick Tip: There is a fantastic "First Digit" shortcut for magnetic moments. The value of μ always starts with the number of unpaired electrons.

If $\mu \approx 1.73$ BM, $n = 1$.

If $\mu \approx 2.83$ BM, $n = 2$.

If $\mu \approx 3.87$ BM, $n = 3$.

If $\mu \approx 4.90$ BM, $n = 4$.

Since the question says 3.87, you can immediately identify $n = 3$ without any calculation!

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9. Oil of wintergreen is chemically known as:

(1) Methyl acetate

(2) Methyl salicylate

(3) Ethyl salicylate

(4) Salicylic acid

Correct Answer: (2) Methyl salicylate

Solution:

Step 1: Understanding the Concept:

Many organic compounds have traditional "common names" derived from their natural origins long before formal IUPAC nomenclature was established. "Oil of wintergreen" is a naturally

occurring ester found in plants like wintergreen (*Gaultheria procumbens*) and sweet birch. It is famous for its minty, cooling fragrance and its medicinal properties. Esters are organic compounds produced by the reaction between an alcohol and a carboxylic acid (esterification). In the case of oil of wintergreen, the molecule is the product of the esterification of salicylic acid (a phenolic acid) with methanol (a simple alcohol). This compound is widely used in the pharmaceutical industry as a topical analgesic and in the food industry as a flavoring agent.

Step 2: Detailed Explanation:

Let's analyze the chemical identity of each option to find the correct match:

(1) **Methyl acetate:** This is an ester formed from Acetic acid (CH_3COOH) and Methanol (CH_3OH). It is a colorless liquid with a fruity, glue-like smell. It is used primarily as a solvent and is not related to wintergreen.

(2) **Methyl salicylate:** This is the ester formed from Salicylic acid (2-hydroxybenzoic acid) and Methanol. Its structure consists of a benzene ring with a hydroxyl group ($-OH$) and a methyl ester group ($-COOCH_3$) at the ortho position. This molecule is the primary constituent of natural oil of wintergreen. When applied to the skin, it causes a sensation of warmth and helps relieve muscle and joint pain (acting as a rubefacient).

(3) **Ethyl salicylate:** This is the ester of Salicylic acid and Ethanol (C_2H_5OH). While it has a similar structure, it has a slightly different odor and physical properties. It is not the compound referred to as "oil of wintergreen."

(4) **Salicylic acid:** This is the parent acid. It is a white crystalline solid that is precursor to many drugs, including Aspirin. However, as an acid, it does not have the "oily" physical state or the specific aromatic profile of the wintergreen ester.

Industrial Note: Methyl salicylate is synthesized industrially by heating salicylic acid with methanol in the presence of a strong acid catalyst like sulfuric acid. This is a classic Fischer-Speier esterification.

Step 3: Comparison:

The correspondence between the trivial name "Oil of Wintergreen" and the chemical name "Methyl salicylate" is a standard fact in organic chemistry curricula. It is often taught alongside other salicylic acid derivatives like Aspirin (Acetylsalicylic acid) and Salol (Phenyl salicylate).

Step 4: Final Answer:

The chemical name for Oil of wintergreen is methyl salicylate.

Therefore, option (2) is correct.

Quick Tip: To remember salicylate derivatives:

Salicylic acid + Methanol → Methyl Salicylate (Oil of Wintergreen).

Salicylic acid + Acetic Anhydride → Acetylsalicylic acid (Aspirin).

Salicylic acid + Phenol → Phenyl Salicylate (Salol - an intestinal antiseptic).

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10. Which of the following does not belong to Group 16 elements?

(1) Oxygen

(2) Sulfur

(3) Selenium

(4) Chlorine

Correct Answer: (4) Chlorine

Solution:

Step 1: Understanding the Concept:

The Modern Periodic Table organizes elements into vertical columns called "Groups" based on their valence shell electronic configurations. Elements in the same group exhibit similar chemical properties because they have the same number of electrons in their outermost shell. Group 16 is collectively known as the "Chalcogens" or the "Oxygen family." All elements in this group have six valence electrons, with the general electronic configuration ns^2np^4. This family includes both non-metals (Oxygen, Sulfur), metalloids (Selenium, Tellurium), and metals (Polonium). Identifying which element does not belong requires a basic knowledge of the periodic positions of common elements.

Step 2: Detailed Explanation:

Let's examine the members of the families involved in the options:

Members of Group 16 (Chalcogens):

1. **Oxygen (O):** Atomic number 8. Configuration: $[He]2s^2 2p^4$. It is the first member of Group 16.
2. **Sulfur (S):** Atomic number 16. Configuration: $[Ne]3s^2 3p^4$. It is the second member of Group 16.
3. **Selenium (Se):** Atomic number 34. Configuration: $[Ar]3d^{10} 4s^2 4p^4$. It is the third member of Group 16.
4. **Tellurium (Te):** Atomic number 52. Fourth member.
5. **Polonium (Po):** Atomic number 84. Fifth member.

Now let's look at the outlier:

Chlorine (Cl): Chlorine has an atomic number of 17. Its electronic configuration is $[Ne]3s^2 3p^5$. Since it has seven valence electrons (one more than sulfur), it belongs to Group 17. Group 17 elements are known as the "Halogens." This family includes Fluorine, Chlorine, Bromine, Iodine, and Astatine.

Step 3: Comparison and Conclusion:

Options (1), (2), and (3) - Oxygen, Sulfur, and Selenium - are all consecutive members of the same vertical column (Group 16). They all share the p^4 valence subshell configuration. Chlorine, however, is located one step to the right in the periodic table, placing it in the p^5 column. Therefore, it is chemically and structurally distinct from the Chalcogen family.

Step 4: Final Answer:

Chlorine does not belong to Group 16; it is a Group 17 element.

Hence, the correct answer is option (4).

Quick Tip: Memorize the p-block groups using simple mnemonics. For Group 16 (O, S, Se, Te, Po), a common one is "Old Style Se Te Po." For Group 17 (F, Cl, Br, I, At), use "First Class Biryani In Australia." This helps you place elements instantly during the exam.