

JEECUP Group A Chemistry Sample Paper-5

Duration: 45 Minutes

Maximum Marks: 100

Instructions

- This paper contains **25** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**. No marks will be deducted for incorrect answers. Unattempted questions carry **0** marks.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. According to Schrödinger's wave mechanical model, the total number of radial nodes and angular nodes characterizing a stable $4d$ electronic orbital subshell are respectively evaluated as:

- (A) 2 and 1
- (B) 1 and 2
- (C) 3 and 0
- (D) 2 and 2

Q2. The mathematical value of the spin-only magnetic moment (μ_s) belonging to a divalent transition metal cation M^{2+} ($Z = 26$) in an aqueous environment is found to be:

- (A) 3.87 BM
- (B) 4.90 BM
- (C) 5.92 BM
- (D) 2.84 BM

Q3. Based on molecular orbital theory (MOT), isolate the correct decreasing order of molecular stability among the following chemical species:

- (A) $O_2 > O_2^+ > O_2^- > O_2^{2-}$



- (B) $O_2^+ > O_2 > O_2^- > O_2^{2-}$
(C) $O_2^{2-} > O_2^- > O_2 > O_2^+$
(D) $O_2^+ > O_2^- > O_2 > O_2^{2-}$

Q4. If the de Broglie wavelength of an electron traveling in the n^{th} Bohr orbit of a hydrogen atom is equal to the orbit's radius, calculate the value of the principal quantum number n .

- (A) π
(B) 2π
(C) $\frac{1}{2\pi}$
(D) $\frac{2}{\pi}$

Q5. Identify the correct increasing order of electron gain enthalpy ($\Delta_{eg}H$, negative value magnitude) across the halogen family elements:

- (A) $I < Br < F < Cl$
(B) $I < Br < Cl < F$
(C) $F < Cl < Br < I$
(D) $Cl < F < Br < I$

Q6. The electronegativity values of elements down the boron family (Group 13) reflect an anomalous progression due to poor structural shielding. Choose the correct arrangement profile:

- (A) $B > Al > Ga > In > Tl$
(B) $B > Tl > In > Ga > Al$
(C) $Al < Ga < In < Tl < B$
(D) $B > Al < Ga < In < Tl$

Q7. Which of the following electronic configurations is linked to the element possessing the absolute highest first ionization energy (IE_1) among all p-block elements of the 3rd period?



- (A) $[\text{Ne}]3s^23p^2$
- (B) $[\text{Ne}]3s^23p^3$
- (C) $[\text{Ne}]3s^23p^4$
- (D) $[\text{Ne}]3s^23p^5$

Q8. Exactly 10 grams of a sample of calcium carbonate (CaCO_3) contains 20% inert matrix impurities. Calculate the total volume of dry carbon dioxide (CO_2) gas evolved at standard temperature and pressure (STP) conditions upon completing thermal decomposition.

- (A) 2.24 liters
- (B) 1.79 liters
- (C) 1.12 liters
- (D) 0.89 liters

Q9. If the density of an ideal molecular gas compound at 300 K and under a pressure of 2 atm is measured as 2.5 g/L, deduce the absolute molecular weight of this gas.

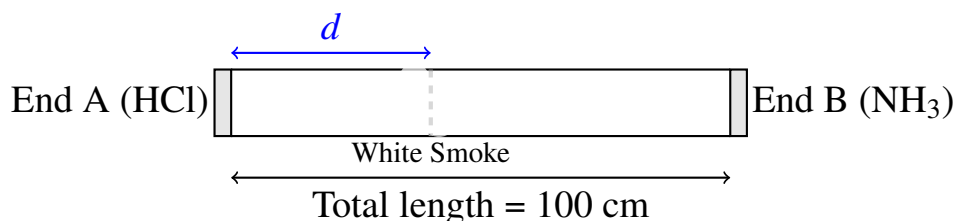
- (A) 30.8 g/mol
- (B) 44.6 g/mol
- (C) 61.5 g/mol
- (D) 52.3 g/mol

Q10. A fixed quantity of an ideal gas inside a non-expanding steel storage capsule registers a pressure value of 3 atm at 27°C . If the container is structurally rated to withstand a maximum internal threshold limit of 4.5 atm, find the temperature ceiling at which the unit bursts.

- (A) 40.5°C
- (B) 150°C
- (C) 177°C
- (D) 450°C



- Q11.** A chemistry instructor sets up an automated apparatus to study Graham's law of gas effusion. Two gaseous compounds are released simultaneously from opposite ends of a 100 cm glass diffusion column as shown below. If path end *A* introduces anhydrous Hydrogen Chloride gas (HCl , $M = 36.5$) and path end *B* introduces volatile Ammonia gas (NH_3 , $M = 17$), calculate the approximate travel distance d from end *A* where the white clouds of solid ammonium chloride (NH_4Cl) first precipitate:



- (A) 40.6 cm
(B) 59.4 cm
(C) 33.3 cm
(D) 50.0 cm
- Q12.** Evaluate the total mass of pure Sodium Hydroxide (NaOH , $M = 40$) crystals needed to synthesize exactly 250 mL of an aqueous primary standard volumetric test solution possessing a target concentration of 0.5 M.
- (A) 2.0 g
(B) 4.0 g
(C) 5.0 g
(D) 10.0 g
- Q13.** Calculate the exact pH value tracking an aqueous solution prepared by mixing equal volumes of a 0.2 M HNO_3 solution and a 0.1 M KOH solution at 25°C.
- (A) 1.00
(B) 1.30
(C) 2.00



(D) 7.00

Q14. According to the Lewis definitions of acid-base interactions, which of the following chemical species functions uniquely as a Lewis acid due to structural electron deficiency?

(A) NH_3

(B) H_2O

(C) BF_3

(D) F^-

Q15. Identify the exact number of water molecules bound as structural coordination elements within a single formula unit of traditional commercial plaster of Paris crystals:

(A) 2

(B) 1

(C) $\frac{1}{2}$

(D) $\frac{1}{4}$

Q16. A basic buffer solution module is formulated by mixing equimolar amounts of Ammonium Hydroxide (NH_4OH) and Ammonium Chloride (NH_4Cl). If the $\text{p}K_b$ parameter of NH_4OH is 4.75, calculate the operational pH value of this system.

(A) 4.75

(B) 9.25

(C) 7.00

(D) 8.35

Q17. The pyrometallurgical reduction strategy applied during the industrial extraction of iron within a blast furnace relies on which principal gaseous compound to reduce hematite ore (Fe_2O_3) in the lower temperature reduction zone?



- (A) CO_2
- (B) CO
- (C) H_2
- (D) CH_4

Q18. Which of the following pairs of metallic elements exhibits the property of dissolving smoothly in highly dilute (1%) cold nitric acid (HNO_3) to liberate flammable hydrogen gas (H_2)?

- (A) Cu and Ag
- (B) Fe and Zn
- (C) Mg and Mn
- (D) Al and Cr

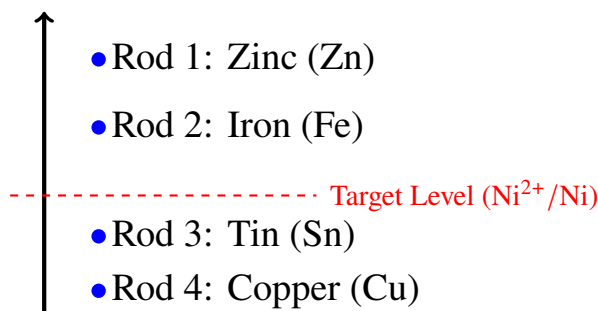
Q19. An industrial metallurgical engineer utilizes calamine ore as a primary raw material source matrix. Identify the correct chemical structure belonging to calamine:

- (A) ZnS
- (B) ZnCO_3
- (C) ZnO
- (D) $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$

Q20. An automated mechanical testing rig assesses the structural deformation profiles of four metallic test rods under high torsional stress. Based on the electromotive activity hierarchy schematic mapped below, determine which target metal rod will exhibit a spontaneous chemical displacement reaction when submerged in an aqueous container of Nickel Sulfate (NiSO_4):



Electrochemical Reactivity

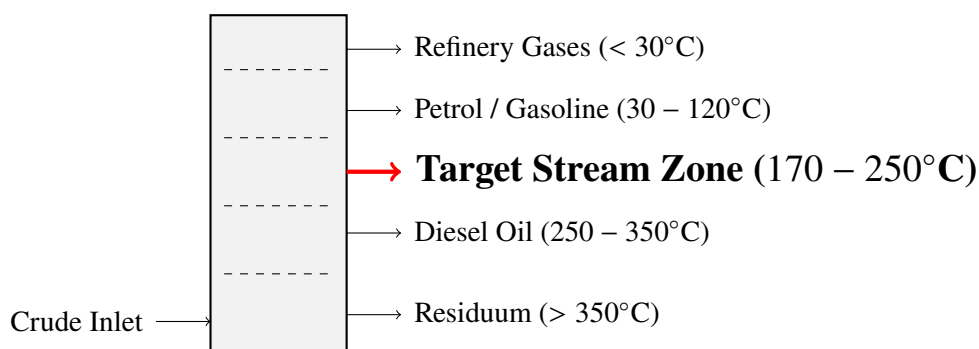


- (A) Rods 3 and 4 only
- (B) Rods 1 and 2 only
- (C) Rod 4 only
- (D) Rods 1, 2, 3 and 4

Q21. An organic chemist performs the complete combustion of one mole of a gaseous aliphatic hydrocarbon compound, yielding exactly 3 moles of carbon dioxide (CO_2) and 4 moles of water vapor (H_2O). Identify the IUPAC name of this hydrocarbon.

- (A) Propene
- (B) Propanone
- (C) Propane
- (D) Propyne

Q22. A fractional distillation column partitions crude petroleum into industrial feedstocks. Identify the specific destination path fraction range labeled in the engineering schematic below that isolates components optimized for use as high-performance aviation turbine fuels (kerosene fraction):



- (A) Petrol / Gasoline stream
- (B) Target Stream Zone
- (C) Diesel Oil stream
- (D) Residuum stream

Q23. Calculate the total count of catenated carbon atoms present within a single molecule of the stable ester compound formed by reacting Methanoic Acid with Isopropanol.

- (A) 3
- (B) 4
- (C) 5
- (D) 6

Q24. The conversion of industrial raw ethanol into ethanoic acid using an excess of acidified potassium dichromate ($K_2Cr_2O_7$) is classified under which type of primary organic reaction mechanism?

- (A) Dehydration reaction
- (B) Substitution reaction
- (C) Oxidation reaction
- (D) Addition reaction

Q25. An engine fuel blend exhibits exceptional anti-knocking properties and is assigned an octane rating score of exactly 90. This rating indicates that the fuel mimics the performance of a reference mixture containing:

- (A) 90% n-heptane and 10% isooctane
- (B) 90% isooctane and 10% n-heptane
- (C) 90% toluene and 10% benzene
- (D) 90% isohexane and 10% n-heptane



Detailed Solutions

Q1.

Solution

Concept:

According to Schrödinger's wave mechanical model, the spatial nodes of an electron orbital are divided into radial nodes (spherical nodes) and angular nodes (nodal planes/cones). The formulas to determine these values based on the principal quantum number n and the azimuthal quantum number l are:

$$\text{Angular Nodes} = l$$

$$\text{Radial Nodes} = n - l - 1$$

Solution:

For a stable $4d$ electronic orbital subshell, the associated quantum numbers are:

$$n = 4 \quad \text{and} \quad l = 2 \quad (\text{since } d \text{ subshell maps to } l = 2)$$

Substitute these numbers into the formulas to calculate the node values:

$$\text{Angular Nodes} = l = 2$$

$$\text{Radial Nodes} = 4 - 2 - 1 = 1$$

Therefore, the total numbers of radial and angular nodes are 1 and 2, respectively.

The configuration matches Option (B).

Final Answer: 1 and 2

Answer: (B)

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Q2.

Solution**Concept:**

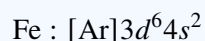
The spin-only magnetic moment (μ_s) of a transition metal ion depends exclusively on its total count of unpaired electrons (n) and is calculated using the formula:

$$\mu_s = \sqrt{n(n+2)} \text{ BM}$$

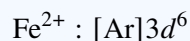
where BM represents Bohr Magnetons.

Solution:

The element with atomic number $Z = 26$ is Iron (Fe). Its neutral ground-state electronic configuration is:



When it loses two electrons to form the divalent transition metal cation Fe^{2+} , the electrons are stripped first from the outermost $4s$ subshell:



Applying Hund's rule to populate the five degenerate orbitals of the $3d$ subshell with 6 electrons ($\uparrow\downarrow\uparrow\uparrow\uparrow$), we find exactly $n = 4$ unpaired electrons. Substitute $n = 4$ into the magnetic moment formula:

$$\mu_s = \sqrt{4(4+2)} = \sqrt{24} \approx 4.90 \text{ BM}$$

The configuration matches Option (B).

Final Answer:

Answer: (B)

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Q3.

Solution**Concept:**

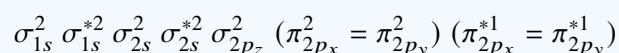
According to Molecular Orbital Theory (MOT), the chemical stability of a molecular species is directly proportional to its bond order (BO). The bond order is calculated using the formula:

$$BO = \frac{N_b - N_a}{2}$$

where N_b is the number of bonding electrons and N_a is the number of antibonding electrons. Higher bond orders equate to shorter bond lengths and greater thermodynamic stability.

Solution:

The molecular orbital configuration for an oxygen molecule (O_2 , 16 electrons) is:



Calculate the bond order for each species by varying the electron count in the antibonding molecular orbitals (π^*):

- O_2^+ (15 electrons): $BO = \frac{10-5}{2} = 2.5$
- O_2 (16 electrons): $BO = \frac{10-6}{2} = 2.0$
- O_2^- (17 electrons): $BO = \frac{10-7}{2} = 1.5$
- O_2^{2-} (18 electrons): $BO = \frac{10-8}{2} = 1.0$

Arranging these species in decreasing order of bond order (and stability) yields: $O_2^+ > O_2 > O_2^- > O_2^{2-}$.

The configuration matches Option (B).

Final Answer: $O_2^+ > O_2 > O_2^- > O_2^{2-}$

Answer: (B)

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Q4.

Solution**Concept:**

Bohr's orbit constraint rules stipulate that the circumference of an electron's circular orbit must match an integral multiple of its de Broglie wavelength (λ):

$$2\pi r_n = n\lambda$$

where r_n is the radius of the n^{th} orbit and n is the principal quantum number.

Solution:

The question states that the de Broglie wavelength is equal to the orbit's radius:

$$\lambda = r_n$$

Substitute this condition directly into the quantization equation:

$$2\pi r_n = n(r_n)$$

Dividing both sides by the radius r_n isolating the principal quantum number:

$$n = 2\pi$$

The configuration matches Option (B).

Final Answer:

Answer: (B)

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Q5.

Solution**Concept:**

Electron gain enthalpy ($\Delta_{eg}H$) is the enthalpy change accompanying the addition of an electron to a gaseous neutral atom. Generally, it becomes less negative down a group due to increasing atomic size. However, anomalies arise in the second period due to high inter-electronic repulsion in compact valence shells.

Solution:

In the halogen family, the expected trend is for the negative electron gain enthalpy to decrease down the group from Fluorine to Iodine ($F > Br > I$). However, Fluorine (F) has an exceptionally small atomic radius. When an electron enters its compact $2p$ subshell, it experiences significant electron-electron repulsion. Chlorine (Cl), having a larger $3p$ subshell, accommodates the incoming electron with less repulsion, releasing more energy. Consequently, Chlorine has the most negative electron gain enthalpy in the entire periodic table. The true strictly ascending order of magnitude is:

$$I < Br < F < Cl$$

The configuration matches Option (A).

Final Answer: $I < Br < F < Cl$

Answer: (A)

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Q6.

Solution**Concept:**

Electronegativity typically decreases continuously down a structural periodic group as atomic size expands. However, Group 13 (the boron family) displays an anomalous progression because the intervening d and f subshells provide poor electrostatic shielding, resulting in an unexpected contraction of atomic radii and a stronger nuclear pull on valence electrons.

Solution:

Let's analyze the electronegativity values down Group 13:

- Boron (B) is highly electronegative (2.0) due to its tiny size.
- Aluminum (Al) drops normally down to 1.5.
- Gallium (Ga) experiences poor shielding by $3d$ electrons, increasing its effective nuclear charge and raising its value slightly to 1.6.
- Indium (In) remains steady at 1.7.
- Thallium (Tl) contains a full shell of $4f$ electrons, which provide poor shielding, causing a relativistic contraction that spikes its value up to 1.8.

Arranging these elements in a strictly ascending order shows that Al is the lowest, while B remains the highest: $B > Al < Ga < In < Tl$ (or $Al < Ga < In < Tl < B$).

The configuration matches Option (D).

Final Answer: $B > Al < Ga < In < Tl$

Answer: (D)

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Q7.

Solution**Concept:**

First ionization energy (IE_1) generally increases across a period from left to right due to an increase in effective nuclear charge. However, elements with highly stable, completely filled or half-filled electronic configurations require significantly more energy to remove an electron, breaking the general trend.

Solution:

Let's look at the p-block elements of the 3rd period and their valence configurations:

- Silicon (Si): $[\text{Ne}]3s^23p^2$
- Phosphorus (P): $[\text{Ne}]3s^23p^3$ (Half-filled $3p$ subshell \rightarrow highly stable)
- Sulfur (S): $[\text{Ne}]3s^23p^4$
- Chlorine (Cl): $[\text{Ne}]3s^23p^5$

While ionization energy generally increases from Si to Cl, Phosphorus (P) has an anomalous spike. Its half-filled $3p^3$ configuration is exceptionally stable, meaning it requires more energy to disrupt than the $3p^4$ configuration of Sulfur (S). However, Chlorine (Cl), being further right, has a much higher nuclear charge that overcomes this effect, making its IE_1 higher than both P and S. Thus, among the given configurations, Chlorine ($[\text{Ne}]3s^23p^5$) has the highest absolute IE_1 .

The configuration matches Option (D).

Final Answer: $[\text{Ne}]3s^23p^5$

Answer: (D)

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Q8.

Solution**Concept:**

Stoichiometric mass-to-volume chemical calculations require analyzing the mass of the pure reacting component. Inert impurities do not participate in the reaction. The fundamental conversion ratio specifies that 1 mole of any ideal gas occupies exactly 22.4 liters at STP.

Solution:

Calculate the mass of pure calcium carbonate (CaCO_3 , Molar mass = 100 g/mol) in the sample:

$$\text{Purity} = 100\% - 20\% = 80\%$$

$$\text{Mass of pure CaCO}_3 = 10 \text{ g} \times 0.80 = 8 \text{ grams}$$

Convert this mass into moles:

$$\text{Moles of pure CaCO}_3 = \frac{8 \text{ g}}{100 \text{ g/mol}} = 0.08 \text{ moles}$$

The chemical equation for thermal decomposition is:



Since 1 mole of CaCO_3 generates 1 mole of CO_2 , 0.08 moles of reactant yields 0.08 moles of gas. Calculate the volume at STP:

$$\text{Volume} = 0.08 \text{ moles} \times 22.4 \text{ L/mole} = 1.792 \text{ liters}$$

The configuration matches Option (B).

Final Answer:

Answer:

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Q9.

Solution**Concept:**

The ideal gas law equation ($PV = nRT$) can be rewritten to express density ($d = \frac{m}{V}$) as a function of pressure (P), temperature (T), and molecular weight (M):

$$PV = \left(\frac{m}{M}\right)RT \implies P = \left(\frac{m}{V}\right)\frac{RT}{M} \implies P = \frac{dRT}{M}$$

Rearranging this to isolate the molecular weight M :

$$M = \frac{dRT}{P}$$

where $R = 0.0821 \text{ L} \cdot \text{atm}/(\text{mol} \cdot \text{K})$.

Solution:

Substitute the given values into the density equation:

$$d = 2.5 \text{ g/L}, \quad T = 300 \text{ K}, \quad P = 2 \text{ atm}$$

$$M = \frac{2.5 \times 0.0821 \times 300}{2}$$

$$M = \frac{61.575}{2} = 30.7875 \text{ g/mol}$$

The configuration matches Option (A).

Final Answer:

Answer: (A)

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Q10.

Solution**Concept:**

According to Gay-Lussac's Law of gas behavior, the absolute pressure (P) exerted by a fixed mass of an ideal gas inside a rigid, non-expanding container varies directly with its absolute thermodynamic temperature (T in Kelvin):

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \implies T_2 = T_1 \times \left(\frac{P_2}{P_1}\right)$$

Solution:

Convert the initial temperature from Celsius to Kelvin:

$$T_1 = 27^\circ\text{C} + 273 = 300 \text{ K}$$

Using $P_1 = 3 \text{ atm}$ and the maximum container pressure limit $P_2 = 4.5 \text{ atm}$, calculate the ceiling temperature T_2 :

$$T_2 = 300 \times \left(\frac{4.5}{3}\right) = 300 \times 1.5 = 450 \text{ K}$$

Convert the Kelvin temperature back to Celsius:

$$T_{\text{celsius}} = 450 - 273 = 177^\circ\text{C}$$

The configuration matches Option (C).

Final Answer:

Answer: (C)

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Q11.

Solution**Concept:**

According to Graham's Law of Effusion, the rate of effusion (r) of a gas is inversely proportional to the square root of its molar mass (M). Therefore, the relative distances traveled (x) by two gases simultaneously released in a tube of length L are related by:

$$\frac{x_A}{x_B} = \sqrt{\frac{M_B}{M_A}}$$

Solution:

Let d be the distance traveled by HCl from End A. The remaining distance traveled by NH_3 from End B is $(100 - d)$. Substitute the given molar masses ($M_{\text{HCl}} = 36.5$, $M_{\text{NH}_3} = 17$) into the formula:

$$\frac{d}{100 - d} = \sqrt{\frac{17}{36.5}} \approx \sqrt{0.4658} \approx 0.6825$$

Cross-multiply and solve for d :

$$d = 0.6825(100 - d) \implies d = 68.25 - 0.6825d$$

$$1.6825d = 68.25 \implies d = \frac{68.25}{1.6825} \approx 40.56 \text{ cm}$$

Thus, the white smoke first forms approximately 40.6 cm from end A.

The configuration matches Option (A).

Final Answer:

Answer: (A)

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Q12.

Solution**Concept:**

Molarity (M) measures the concentration of a solute in a solution, defined as the number of moles of solute per liter of solution. The formula linking mass (m), molar mass (M_w), volume (V in mL), and molarity is:

$$\text{Molarity} = \frac{m \times 1000}{M_w \times V \text{ (mL)}} \implies m = \frac{\text{Molarity} \times M_w \times V \text{ (mL)}}{1000}$$

Solution:

Substitute the target parameters into the rearranged mass equation:

$$\text{Target Molarity} = 0.5 \text{ M}, \quad M_w = 40 \text{ g/mol}, \quad V = 250 \text{ mL}$$

$$m = \frac{0.5 \times 40 \times 250}{1000}$$

$$m = \frac{5000}{1000} = 5.0 \text{ grams}$$

The configuration matches Option (C).

Final Answer:

Answer: (C)

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Q13.

Solution**Concept:**

When a strong acid (HNO_3) mixes with a strong base (KOH), a neutralization reaction occurs. The resulting pH depends on whether there is an excess of H^+ or OH^- ions after the reaction goes to completion.

Solution:

Let the volume of each solution be V L.

- Moles of H^+ from $\text{HNO}_3 = 0.2 \text{ M} \times V = 0.2V$ moles
- Moles of OH^- from $\text{KOH} = 0.1 \text{ M} \times V = 0.1V$ moles

The OH^- ions completely neutralize an equal number of H^+ ions, leaving an excess of H^+ :

$$\text{Excess moles of } \text{H}^+ = 0.2V - 0.1V = 0.1V \text{ moles}$$

The total final volume of the solution is $V + V = 2V$ L. Calculate the concentration of the remaining H^+ ions:

$$[\text{H}^+] = \frac{0.1V}{2V} = 0.05 \text{ M} = 5 \times 10^{-2} \text{ M}$$

Calculate the final pH value:

$$\text{pH} = -\log_{10}(5 \times 10^{-2}) = 2 - \log_{10}(5) \approx 2 - 0.699 = 1.301$$

The configuration matches Option (B).

Final Answer:

Answer: (B)

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Q14.

Solution**Concept:**

According to the Lewis definition of acid-base chemistry, a Lewis acid is an electron-pair acceptor, which is typically a cation or an electron-deficient molecule with an incomplete valence octet. A Lewis base is an electron-pair donor with available lone pairs.

Solution:

Let's evaluate the structural profiles of the given choices:

- NH_3 : The central Nitrogen atom has a lone pair available for donation (\rightarrow Lewis Base).
- H_2O : The central Oxygen atom contains two lone pairs available for donation (\rightarrow Lewis Base).
- F^- : A fluoride anion carries a full negative charge with extra electron pairs (\rightarrow Lewis Base).
- BF_3 : Boron trifluoride features a central Boron atom sharing 6 valence electrons, leaving it with an incomplete octet (electron-deficient). It acts as a classical Lewis acid by accepting an electron pair.

The configuration matches Option (C).

Final Answer: BF_3

Answer: (C)

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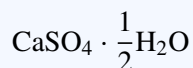
Q15.

Solution**Concept:**

Plaster of Paris is produced by the partial dehydration of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) when heated to 120°C .

Solution:

The chemical formula for traditional commercial plaster of Paris is written as Calcium Sulfate Hemihydrate:



This notation shows that exactly $\frac{1}{2}$ water molecule is bound as a structural coordination element per single formula unit of CaSO_4 (or two units share one water molecule: $2\text{CaSO}_4 \cdot \text{H}_2\text{O}$).

The configuration matches Option (C).

Final Answer: $\frac{1}{2}$

Answer: (C)

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Q16.

Solution**Concept:**

A basic buffer solution containing a weak base and its salt follows the Henderson-Hasselbalch equation to determine its pOH:

$$\text{pOH} = \text{p}K_b + \log_{10} \left(\frac{[\text{Salt}]}{[\text{Base}]} \right)$$

The final pH is then calculated using the relation: $\text{pH} = 14 - \text{pOH}$.

Solution:

The buffer is prepared using equimolar amounts of Ammonium Hydroxide and Ammonium Chloride, meaning:

$$[\text{Salt}] = [\text{Base}] \implies \frac{[\text{Salt}]}{[\text{Base}]} = 1$$

Substitute this ratio into the equation:

$$\text{pOH} = 4.75 + \log_{10}(1) = 4.75 + 0 = 4.75$$

Now, compute the operational pH:

$$\text{pH} = 14 - 4.75 = 9.25$$

The configuration matches Option (B).

Final Answer:

Answer: (B)

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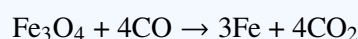
Q17.

Solution**Concept:**

In the pyrometallurgical reduction of iron within a blast furnace, carbon monoxide (CO) acts as the primary gaseous reducing agent. It is generated when upward-flowing carbon dioxide reacts with white-hot coke.

Solution:

In the upper, cooler reduction zone of the blast furnace (temperatures ranging from 500 – 800 K), hematite ore (Fe_2O_3) is reduced in stepwise stages by carbon monoxide (CO) gas:



The configuration matches Option (B).

Final Answer:

Answer: (B)

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Q18.

Solution**Concept:**

Nitric acid (HNO_3) is generally a powerful oxidizing agent that reduces to nitrogen oxides (NO_2 , NO , N_2O) rather than liberating hydrogen gas when reacting with metals. However, highly electropositive metals can reduce highly dilute (1%) cold nitric acid to evolve hydrogen gas.

Solution:

Only Magnesium (Mg) and Manganese (Mn) react with very dilute, cold nitric acid to reduce hydrogen ions and liberate flammable hydrogen gas (H_2), as the acid's oxidizing power is minimized at this concentration:



The configuration matches Option (C).

Final Answer:

Answer: (C)

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Q19.

Solution**Concept:**

Calamine is a widespread zinc mineral ore. Metallurgical engineers use it as a raw material to obtain zinc metal through calcination and carbon reduction.

Solution:

The mineral composition of calamine is **Zinc Carbonate**, which has the chemical formula:



Other options listed correspond to Zinc Blende (ZnS), Zincite (ZnO), and White Vitriol ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$).

The configuration matches Option (B).

Final Answer:

Answer: (B)

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Q20.

Solution**Concept:**

A spontaneous chemical displacement reaction occurs when a more reactive metal (positioned higher on the electrochemical activity series) replaces a less reactive metal ion from its aqueous salt solution.

Solution:

The task is to submerge metallic rods into an aqueous solution of Nickel Sulfate (NiSO_4). For a rod to cause a displacement reaction, its constituent metal must be more reactive than Nickel (Ni).

Looking at the activity chart provided:

- Zinc (Zn, Rod 1) and Iron (Fe, Rod 2) are located **above** the Nickel threshold line, meaning they are more reactive.
- Tin (Sn, Rod 3) and Copper (Cu, Rod 4) are located **below** the line, meaning they are less reactive.

Therefore, only Rod 1 (Zinc) and Rod 2 (Iron) will spontaneously displace Nickel ions from the solution.

The configuration matches Option (B).

Final Answer:

Answer: (B)

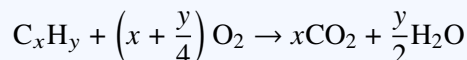
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Q21.

Solution**Concept:**

The general balanced equation for the complete combustion of any aliphatic hydrocarbon (C_xH_y) is:

**Solution:**

The problem states that burning 1 mole of the hydrocarbon yields exactly 3 moles of CO_2 and 4 moles of H_2O . Equating the coefficients:

$$x = 3 \quad (\text{Carbon atoms})$$

$$\frac{y}{2} = 4 \implies y = 8 \quad (\text{Hydrogen atoms})$$

This gives the molecular formula C_3H_8 . Since it follows the alkane general formula (C_nH_{2n+2}), its IUPAC name is Propane.

The configuration matches Option (C).

Final Answer:

Answer: (C)

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Q22.

Solution**Concept:**

Fractional distillation separates crude oil components based on differences in their boiling points. Higher-boiling fractions condense lower in the column, while lower-boiling fractions travel higher up before condensing.

Solution:

According to standard industrial chemical refining, aviation turbine fuels consist primarily of the kerosene fraction, which distills within a temperature range of approximately 170°C to 250°C .

The provided engineering schematic marks this specific zone as the "Target Stream Zone".

The configuration matches Option (B).

Final Answer:

Answer: (B)

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Q23.

Solution**Concept:**

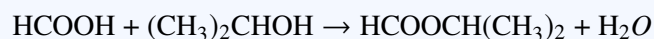
Esterification links a carboxylic acid with an alcohol to form an ester. The total count of carbon atoms in the resulting ester is the sum of the carbon atoms contributed by both the acid and the alcohol.

Solution:

Analyze the reactants:

- Methanoic Acid (Formic acid): Contains exactly 1 carbon atom (HCOOH).
- Isopropanol (Isopropyl alcohol): Contains exactly 3 carbon atoms (CH₃CH(OH)CH₃).

The condensation reaction yields the ester isopropyl methanoate:



Total carbon atoms = 1 (from methanoate) + 3 (from isopropyl) = 4.

The configuration matches Option (B).

Final Answer:

Answer: (B)

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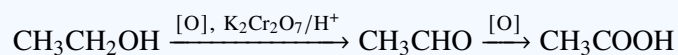
Q24.

Solution**Concept:**

Treating a primary alcohol with a strong oxidizing agent like acidified potassium dichromate (K₂Cr₂O₇) converts it first into an aldehyde, and then directly into a carboxylic acid.

Solution:

Converting industrial raw ethanol (CH₃CH₂OH) into ethanoic acid (CH₃COOH) involves increasing the oxygen content and decreasing the hydrogen content of the molecule. This process is classified as an **Oxidation reaction**:



The configuration matches Option (C).

Final Answer:

Answer: (C)

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Q25.

Solution**Concept:**

The octane rating of a fuel measures its ability to resist engine knocking. It is determined by comparing its performance to a reference mixture of highly knock-resistant isooctane (assigned a value of 100) and highly knock-prone n-heptane (assigned a value of 0).

Solution:

An octane rating score of exactly 90 means the fuel blend matches the performance of a reference mixture containing 90% isooctane and 10% n-heptane by volume.

The configuration matches Option (B).

Final Answer: 90% isooctane and 10% n-heptane

Answer: (B)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	B	4	B	5	A
6	D	7	D	8	B	9	A	10	C
11	A	12	C	13	B	14	C	15	C
16	B	17	B	18	C	19	B	20	B
21	C	22	B	23	B	24	C	25	B

