JEECUP Group A Chemistry Sample Paper – 3

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. Which of the following sets of quantum numbers represents the highest energy electron shell for a ground-state transition metal?

(A) $n = 3, l = 0, m_l = 0, m_s = +\frac{1}{2}$

(B) $n = 3, l = 2, m_l = -1, m_s = -\frac{1}{2}$

(C) $n = 4, l = 0, m_l = 0, m_s = +\frac{1}{2}$

(D) $n = 4, l = 1, m_l = 1, m_s = -\frac{1}{2}$

Q2. What is the fundamental chemical reason behind the temporary hardness of a fresh water sample?

(A) Dissolved calcium and magnesium sulfates

(B) Dissolved calcium and magnesium bicarbonates

(C) High concentration of sodium and potassium chlorides

(D) Traces of dissolved ferric oxides and silicates

Q3. Across the second period of the modern periodic table, which element exhibits an exceptional, abnormally high first ionization energy compared to its immediate neighbor on the right due to a stable, half-filled valence configuration?

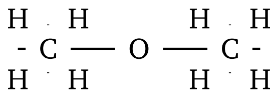
(A) Boron (B)

(B) Carbon (C)

(C) Nitrogen (N)

(D) Oxygen (O)

Q4. Which of the following isomeric forms represents the structure of an organic compound containing an ether functional group with the molecular formula C_2H_6O?



(A) Ethanol

(B) Dimethyl ether

(C) Methyl formate

(D) Acetaldehyde

Q5. An atom of an element Y has 3 valence electrons in its outermost M-shell. What is the atomic number and chemical group of this element?

(A) 13, Group 13

(B) 15, Group 15

(C) 11, Group 1

(D) 3, Group 3

Q6. During the metallurgical extraction of copper from copper pyrites ore ($CuFeS_2$), which substance is intentionally added as a flux in the blast furnace to remove iron oxide impurities as slag?

(A) Limestone ($CaCO_3$)

(B) Silica (SiO_2)

(C) Coke powder (C)

(D) Alumina (Al_2O_3)

Q7. When a mixture of iron powder and sulfur roll powder is heated intensely in a hard-glass test tube, a glowing dark solid is formed. What chemical change occurs, and what is its specific thermodynamic character?

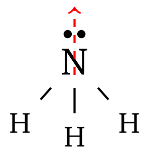
(A) Physical change, endothermic

(B) Chemical combination, endothermic

(C) Chemical combination, exothermic

(D) Thermal decomposition, exothermic

Q8. Which of the following molecules possesses a non-zero, permanent net dipole moment due to an asymmetric distribution of polar covalent bonds?



(A) CO_2

(B) BF_3

(C) NH_3

(D) CH_4

Q9. What is the main chemical component of Compressed Natural Gas (CNG), which typically accounts for more than 85% of its total volume?

(A) Methane

(B) Ethane

(C) Propane

(D) Isobutane

Q10. According to the Lewis acid-base concept, which of the following chemical species behaves explicitly as a Lewis base due to the presence of an unshared lone pair of electrons?

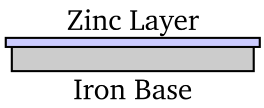
(A) BF_3

(B) $AlCl_3$

(C) H_2O

(D) H^+

Q11. Zinc metal sheets are widely used to coat structural iron profiles to prevent atmospheric rust formation. What is this industrial metallurgical process called?



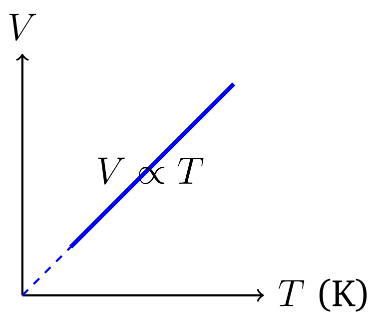
(A) Annealing

(B) Calcination

(C) Smelting

(D) Galvanization

Q12. According to Charles's Law, when the pressure of a fixed mass of an ideal gas is kept constant, what happens to its volume if its absolute temperature is reduced to exactly one-third of its initial value?



(A) The volume increases by three times

(B) The volume reduces to one-third of its initial value

(C) The volume remains completely unaffected

(D) The volume drops to one-ninth of its initial value

Q13. How many structural chain isomers can be cleanly drawn for the saturated open-chain alkane hydrocarbon named pentane (C_5H_{12})?

(A) 2

(B) 3

(C) 4

(D) 5

Q14. In the formation of an ammonium ion (NH_4^+) from an ammonia molecule (NH_3) and a hydrogen ion (H^+), what specific type of localized chemical bond is established between the nitrogen atom and the incoming proton?

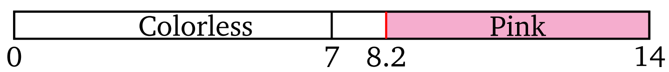
(A) Pure ionic bond

(B) Coordinate (dative) covalent bond

(C) Non-polar covalent bond

(D) Metallic hydrogen bridge

Q15. If a solution shows a strong pink color when a few drops of phenolphthalein indicator are added, what is the nature of the solution, and what is its estimated pH range?



(A) Highly acidic, pH < 3

(B) Completely neutral, pH $= 7$

(C) Weakly acidic, pH $= 5$

(D) Strongly basic, pH > 9

Q16. Solder is an alloy widely used in electrical engineering fields to join wires together. What are the primary metals mixed to form this low-melting-point material?

(A) Lead and Tin

(B) Zinc and Copper

(C) Iron and Nickel

(D) Aluminum and Magnesium

Q17. When crystalline Lead Nitrate is heated strongly in a dry test tube, it decomposes to emit a pungent, brown-colored gas along with a yellow residue. Identify the formula of this brown gas.

(A) O_2

(B) N_2

(C) NO_2

(D) N_2O

Q18. Which crystalline carbon allotrope is composed of large spherical, cage-like clusters containing exactly 60 carbon atoms organized into alternating hexagons and pentagons?

(A) Carbon nanotubes

(B) Buckminsterfullerene

(C) Amorphous lampblack

(D) Hexagonal graphite flakes

Q19. What is the correct IUPAC name of the branched unsaturated hydrocarbon represented by the formula $CH_3 - C(CH_3) = CH - CH_3$?

(A) 2-Methylbut-2-ene

(B) 3-Methylbut-2-ene

(C) Isobutene

(D) 2-Methylbut-3-ene

Q20. When a small strip of polished Magnesium ribbon is introduced into an aqueous solution of Zinc Sulfate ($ZnSO_4$), which of the following physical changes is observed?

(A) No reaction occurs because Zinc is more reactive than Magnesium

(B) Magnesium dissolves, and a dark grey layer of Zinc metal deposits on the strip

(C) The solution turns deep blue with the evolution of dense sulfur dioxide gas

(D) A bright yellow precipitate of magnesium sulfate settles down

Q21. Element Z belongs to Group 16 and Period 3 of the modern periodic table. What is the total number of valence electrons and the core valency of this element?

(A) 3 valence electrons, valency = 3

(B) 6 valence electrons, valency = 6

(C) 6 valence electrons, valency = 2

(D) 8 valence electrons, valency = 0

Q22. Which gas is evolved when a small piece of reactive Calcium metal is dropped into dilute Hydrochloric acid (HCl) inside a test tube?

(A) Chlorine gas (Cl_2)

(B) Hydrogen gas (H_2)

(C) Oxygen gas (O_2)

(D) Carbon dioxide (CO_2)

Q23. Which of the following industrial salts is chemically known as Sodium hydrogen carbonate ($NaHCO_3$), acting as a primary component in domestic baking formulations?

(A) Washing soda

(B) Baking soda

(C) Caustic soda

(D) Glauber's salt

Q24. When dry ice (solid carbon dioxide) is kept exposed to normal room conditions at 1 atm pressure, it gradually disappears without leaving behind any liquid puddle. What phase change transition does this represent?

(A) Evaporation

(B) Sublimation

(C) Liquefaction

(D) Condensation

Q25. At standard temperature and pressure (STP), what is the total volume occupied by a gaseous sample containing exactly 8.0 grams of clean Oxygen gas (O_2)? [Atomic mass of $O = 16$ u]

(A) 5.6 liters

(B) 11.2 liters

(C) 22.4 liters

(D) 44.8 liters

Detailed Solutions

Q1.

Solution

Concept: The energy of an electron in an atom is primarily determined by its principal quantum number (n) and azimuthal quantum number (l). According to the Bohr-Bury $(n + l)$ rule, subshells with a lower $(n + l)$ value possess lower energy. If two subshells share identical $(n + l)$ values, the subshell featuring the lower n value has lower energy.

Solution: Step 1: Understand the meaning of each quantum number given in the options. The principal quantum number n defines the main energy shell, while the azimuthal quantum number l determines the subshell ($l = 0$ for s, $l = 1$ for p, $l = 2$ for d, and $l = 3$ for f).

Step 2: Calculate the $(n + l)$ value for Option A $(n = 3, l = 0)$. This represents the $3s$ subshell. The value is:

$$3 + 0 = 3$$

Step 3: Calculate the $(n + l)$ value for Option B $(n = 3, l = 2)$. This represents the $3d$ subshell. The value is:

$$3 + 2 = 5$$

Step 4: Calculate the $(n + l)$ value for Option C $(n = 4, l = 0)$. This represents the $4s$ subshell. The value is:

$$4 + 0 = 4$$

Step 5: Calculate the $(n + l)$ value for Option D $(n = 4, l = 1)$. This represents the $4p$ subshell. The value is:

$$4 + 1 = 5$$

Step 6: Determine the highest energy subshell among the options. Both the $3d$ (Option B) and $4p$ (Option D) subshells have an $(n + l)$ value of 5. Applying the tie-breaking rule, the subshell with the larger n value ($4p$) possesses higher energy. Since ground-state transition metals fill up to the $4p$ shell only after completing the $3d$ subshell, the $4p$ subshell represents the highest energy level among those listed.

Final Answer: $\boxed{n = 4, l = 1, m_l = 1, m_s = -\frac{1}{2}}$

Answer: (D) Go Back to Question 1

Q2.

Solution

Concept: Hardness in water is caused by the presence of multivalent metallic cations, primarily calcium (Ca^{2+}) and magnesium (Mg^{2+}). Hardness is divided into temporary hardness and permanent hardness depending on the specific anions paired with these cations.

Solution: Step 1: Define temporary hardness. Temporary hardness, also known as carbonate hardness, is caused by the presence of dissolved hydrogen carbonate (bicarbonate) salts of calcium and magnesium.

Step 2: Identify the chemical formulas of these compounds. The substances responsible are calcium bicarbonate, $Ca(HCO_3)_2$, and magnesium bicarbonate, $Mg(HCO_3)_2$.

Step 3: Understand why it is called temporary. These salt minerals are thermally unstable. When water containing them is boiled, the soluble bicarbonates readily decompose into insoluble carbonates, releasing carbon dioxide gas:

$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 \downarrow + H_2O + CO_2 \uparrow$$

Step 4: Contrast with permanent hardness. Permanent hardness is caused by the sulfate and chloride salts of calcium and magnesium ($CaSO_4$, $MgSO_4$, $CaCl_2$, $MgCl_2$), which cannot be removed by simple boiling.

Step 5: Match with the correct option. The fundamental reason behind temporary hardness is the presence of dissolved calcium and magnesium bicarbonates.

Final Answer: Dissolved calcium and magnesium bicarbonates

Answer: (B) Go Back to Question 2

Q3.

Solution

Concept: First ionization energy generally increases when moving from left to right across a horizontal period because of the continuous increase in effective nuclear charge. However, exceptions occur due to the extra thermodynamic stability associated with completely filled or half-filled electronic configurations.

Solution: Step 1: Write down the ground-state electronic configurations of the adjacent elements in the second period: Carbon, Nitrogen, and Oxygen.

Step 2: Examine Carbon (C, $Z = 6$). Its valence configuration is $2s^2 2p^2$. It has two unpaired p-electrons.

Step 3: Examine Nitrogen (N, $Z = 7$). Its valence configuration is $2s^2 2p^3$. The three electrons in the $2p$ subshell reside in separate orbitals with parallel spins according to Hund's rule. This constitutes a symmetric, half-filled subshell configuration ($2p_x^1 2p_y^1 2p_z^1$), which possesses high exchange energy and structural stability.

Step 4: Examine Oxygen (O, $Z = 8$). Its valence configuration is $2s^2 2p^4$. One of its $2p$ orbitals contains paired electrons ($2p_x^2 2p_y^1 2p_z^1$), creating localized inter-electronic repulsion.

Step 5: Analyze the energy barrier. Removing an electron from Nitrogen requires overcoming its exceptionally stable half-filled $2p^3$ configuration. Conversely, removing an electron from Oxygen relieves the inter-electronic repulsion within the paired orbital, reverting it to a stable half-filled state. Therefore, Nitrogen exhibits a higher first ionization energy than Oxygen, breaking the general periodic trend.

Final Answer: Nitrogen (N)

Answer: (C) Go Back to Question 3

Q4.

Solution

Concept: Functional isomers are organic compounds that share an identical molecular formula but possess completely different functional groups, leading to distinct physical and chemical characteristics. The molecular formula $C_nH_{2n+2}O$ can represent either a monohydric alcohol or an open-chain aliphatic ether.

Solution: Step 1: Analyze the given molecular formula, C_2H_6O. This satisfies the general mathematical formula for saturated oxygenated hydrocarbons, $C_nH_{2n+2}O$, where $n = 2$.

Step 2: Explore the first structural possibility. Arranging the atoms as an alcohol gives a two-carbon chain containing a terminal hydroxyl group ($-OH$):

$$CH_3 - CH_2 - OH$$

This is ethanol, which belongs to the alcohol family.

Step 3: Explore the second structural possibility. Arranging the atoms as an ether features an oxygen atom linking two separate alkyl groups ($-O-$):

$$CH_3 - O - CH_3$$

This molecule is dimethyl ether.

Step 4: Identify the ether functional group. An ether contains an oxygen bridge bonded to two alkyl radicals. Dimethyl ether contains a central oxygen atom flanked by two methyl units.

Step 5: Conclude the correct isomeric form. Among the given options, dimethyl ether is the structure that satisfies the molecular formula C_2H_6O and contains an ether group.

Final Answer: Dimethyl ether

Answer: (B) Go Back to Question 4

Q5.

Solution

Concept: The placement of a main-group element in the periodic table is directly linked to its total number of occupied shells and the electron count within its outermost valence shell.

Solution: Step 1: Decipher the electron shell structure. The shells are designated as K ($n = 1$), L ($n = 2$), and M ($n = 3$). The question states that the element has its valence electrons in the M-shell. This means the inner K and L shells must be completely filled.

Step 2: Determine the core electron count. A filled K-shell holds 2 electrons, and a filled L-shell holds 8 electrons.

Step 3: Combine the inner shell electrons with the valence electrons. The element has 3 valence electrons in its outer M-shell. Summing these values gives the total number of electrons in a neutral atom of the element:

$$\text{Total Electrons} = 2(\text{in } K) + 8(\text{in } L) + 3(\text{in } M) = 13$$

Step 4: Identify the atomic number. For a neutral atom, the number of electrons equals the number of protons, which is the atomic number (Z). Therefore, $Z = 13$ (corresponding to Aluminum).

Step 5: Determine the group number using valence shell parameters. For elements whose valence electrons occupy a p-block shell ($n \geq 3$ valence electrons), the modern IUPAC group number is determined by adding 10 to the total number of valence electrons:

$$\text{Group Number} = 10 + 3 = 13$$

Thus, the element has an atomic number of 13 and belongs to Group 13.

Final Answer: 13, Group 13

Answer: (A) Go Back to Question 5

Q6.

Solution

Concept: During pyrometallurgical extraction, a chemical substance known as a flux is introduced into the smelting furnace to interact with high-melting, infusible impurities (gangue) present in the roasted ore, converting them into a low-melting fusible liquid compound called slag.

Solution: Step 1: Identify the nature of the raw ore and impurities. Copper pyrites ($CuFeS_2$) is the primary ore used to extract metallic copper. During the initial roasting stage, the iron content within the ore oxidizes to form iron(II) oxide (FeO).

Step 2: Determine the chemical character of the impurity. Iron(II) oxide (FeO) is a basic metal oxide that acts as the primary gangue material that must be removed during smelting.

Step 3: Choose the correct type of flux. To remove a basic impurity, an acidic flux must be added to the furnace to induce a neutralization reaction.

Step 4: Identify the acidic flux used. Silica (silicon dioxide, SiO_2) is an acidic oxide that is added to the blast furnace charge.

Step 5: Write the chemical equation for slag formation. The acidic silica flux reacts with the basic iron oxide gangue to produce a fusible liquid layer of ferrous silicate slag ($FeSiO_3$):

$$FeO(s) + SiO_2(s) \rightarrow FeSiO_3(l)$$

The liquid slag floats on top of the molten copper matte, allowing it to be easily separated.

Final Answer: Silica (SiO_2)

Answer: (B) Go Back to Question 6

Q7.

Solution

Concept: Chemical reactions are classified into distinct categories based on how the starting materials interact. A combination reaction occurs when two or more simple elements or compounds unite to form a single new product compound, accompanied by a net energy change.

Solution: Step 1: Identify the starting materials. The reactants are elemental iron powder (Fe) and elemental sulfur powder (S).

Step 2: Evaluate the nature of their initial physical mixture. At room temperature, mixing iron fillings and sulfur powder forms a heterogeneous physical mixture from which the iron can be separated using a magnet.

Step 3: Analyze the effect of heating. When this mixture is heated strongly inside a test tube, a vigorous chemical reaction is initiated. The two elements combine chemically to form iron(II) sulfide (FeS), a dark solid compound:

$$Fe(s) + S(s) \xrightarrow{\Delta} FeS(s)$$

Step 4: Determine the thermodynamic character. Once the reaction begins, it releases a significant amount of heat energy, causing the solid mass to glow brightly even after the external heating source is removed. This release of heat energy into the surroundings classifies the reaction as highly exothermic.

Step 5: Synthesize both classifications. The process is a chemical combination reaction that exhibits an exothermic thermodynamic profile.

Final Answer: Chemical combination, exothermic

Answer: (C) Go Back to Question 7

Q8.

Solution

Concept: The net dipole moment (μ) of a polyatomic molecule depends on both the individual polarities of its covalent bonds and its overall spatial geometry. If a molecule has a highly symmetrical shape, the individual bond dipole vectors cancel each other out completely, resulting in a net dipole moment of zero.

Solution: Step 1: Analyze Carbon Dioxide (CO_2). It has a linear geometry ($O = C = O$). The two polar $C = O$ bond dipoles point in exactly opposite directions (180° apart), canceling each other out to give $\mu = 0$.

Step 2: Analyze Boron Trifluoride (BF_3). It features a symmetric trigonal planar geometry with a central boron atom. The three polar $B - F$ bond dipoles are oriented at 120° relative to one another. Their vector sum is zero, resulting in $\mu = 0$.

Step 3: Analyze Methane (CH_4). It has a perfectly symmetrical tetrahedral geometry. The four $C - H$ bond dipoles cancel each other out completely, resulting in $\mu = 0$.

Step 4: Analyze Ammonia (NH_3). The central nitrogen atom is sp^3 hybridized and possesses a trigonal pyramidal geometry due to the presence of three bonding pairs and one lone pair of electrons.

Step 5: Sum the dipole vectors for Ammonia. The individual polar $N - H$ bonds point upward toward the highly electronegative nitrogen atom. The dipole moment vector of the lone pair also points upward along the principal axis. Because the vectors reinforce one another instead of canceling out, ammonia possesses a permanent, non-zero net dipole moment ($\mu = 1.47$ D).

Final Answer: $\boxed{NH_3}$

Answer: (C) Go Back to Question 8

Q9.

Solution

Concept: Natural gas is a fossil fuel mixture consisting primarily of gaseous hydrocarbons. When compressed to high pressures, it forms Compressed Natural Gas (CNG), which is used as an eco-friendly fuel alternative to gasoline and diesel.

Solution: Step 1: Review the chemical composition of CNG. CNG is composed of low-molecular-weight alkanes, along with minor percentages of nitrogen, carbon dioxide, and water vapor.

Step 2: Quantify the main alkane component. The lightest alkane, Methane (CH_4), is the dominant component of natural gas, typically making up between 80% and 95% of its total volumetric composition depending on its source.

Step 3: Identify the secondary components. Other heavier hydrocarbons, such as Ethane (C_2H_6), Propane (C_3H_8), and Butane (C_4H_{10}), are present only in small, residual fractions.

Step 4: Understand its environmental benefit. Because of its high methane content, the combustion of CNG produces fewer tailpipe emissions of carbon monoxide, nitrogen oxides, and particulate matter compared to long-chain petroleum products.

Step 5: Conclude the primary component. Methane is the main chemical component that accounts for more than 85% of the total volume of CNG.

Final Answer: Methane

Answer: (A) Go Back to Question 9

Q10.

Solution

Concept: According to the Lewis definition of electronic acid-base interactions, a Lewis acid is a chemical species capable of accepting an electron pair into its vacant shell, whereas a Lewis base is a chemical species that contains at least one unshared lone pair of electrons available for donation.

Solution: Step 1: Analyze Boron Trifluoride (BF_3). The central boron atom forms three covalent bonds, leaving it with only 6 valence electrons. Because it has an incomplete octet and an empty p-orbital, it acts as a Lewis acid.

Step 2: Analyze Aluminum Chloride ($AlCl_3$). Like boron, the central aluminum atom is electron-deficient with only 6 valence electrons, making it a strong Lewis acid.

Step 3: Analyze the Hydrogen ion (H^+). A proton has no electrons and a vacant $1s$ orbital, making it an electron-pair acceptor (Lewis acid).

Step 4: Analyze the Water molecule (H_2O). The central oxygen atom undergoes sp^3 hybridization and is bonded to two hydrogen atoms. This leaves two unshared lone pairs of electrons in its valence shell:

$$\text{Valence configuration of } O \text{ in } H_2O = 2 \text{ bonding pairs} + 2 \text{ lone pairs}$$

Step 5: Conclude based on the Lewis criteria. Because the oxygen atom in water possesses these accessible non-bonding electron pairs, it can readily donate one to an electron-deficient species (such as a proton to form H_3O^+). This allows water to function as a Lewis base.

Final Answer: $\boxed{H_2O}$

Answer: (C) Go Back to Question 10

Q11.

Solution

Concept: Corrosion mitigation involves applying a barrier layer to shield vulnerable transition metals from moisture and atmospheric oxygen. Galvanization is a specific anti-corrosion technique that uses a sacrificial metal layer to protect structural iron steel surfaces.

Solution: Step 1: Examine the chemical vulnerability of iron. When iron is exposed to moisture and oxygen, it undergoes slow oxidation to form hydrated iron(III) oxide ($Fe_2O_3 \cdot xH_2O$), commonly known as rust. This structural degradation weakens the metal over time.

Step 2: Evaluate the protective mechanism of Zinc. Zinc is positioned higher than iron in the electrochemical reactivity series, making it more electropositive and more easily oxidized than iron.

Step 3: Define the industrial process of Galvanization. Galvanization involves coating clean iron sheets or profiles with a thin layer of molten zinc metal.

Step 4: Understand sacrificial protection. The zinc coating acts as a physical barrier against atmospheric moisture. Additionally, if the zinc surface becomes scratched, it undergoes preferential oxidation instead of the underlying iron, providing sacrificial cathodic protection.

Step 5: Identify the correct term. This metallurgical process of coating iron profiles with a protective layer of zinc is called galvanization.

Final Answer: Galvanization

Answer: (D) Go Back to Question 11

Q12.

Solution

Concept: Charles's Law states that for a fixed mass of an ideal gas maintained at a constant pressure, the volume occupied by the gas is directly proportional to its absolute temperature measured on the Kelvin scale.

Solution: Step 1: Write down the mathematical statement of Charles's Law under constant pressure conditions ($P = \text{constant}$):

$$V \propto T \implies \frac{V}{T} = k$$

where V represents the gas volume, T represents the absolute temperature in Kelvin, and k is a constant.

Step 2: Express the law for two distinct thermal states of a gas system:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Step 3: Identify the boundary parameters specified in the problem. The initial volume is V_1 at temperature T_1. The absolute temperature is reduced to one-third of its initial value, which means:

$$T_2 = \frac{1}{3} \cdot T_1$$

Step 4: Rearrange the comparative equation to solve for the final volume (V_2):

$$V_2 = V_1 \cdot \left(\frac{T_2}{T_1}\right)$$

Step 5: Substitute the expression for T_2 into the equation:

$$V_2 = V_1 \cdot \left(\frac{\frac{1}{3} \cdot T_1}{T_1}\right) = \frac{1}{3} \cdot V_1$$

Therefore, reducing the absolute temperature to one-third causes the volume of the gas to decrease to exactly one-third of its initial value.

Final Answer: The volume reduces to one-third of its initial value

Answer: (B) Go Back to Question 12

Q13.

Solution

Concept: Structural isomers are molecules that share an identical molecular formula but differ in the connectivity and arrangement of their constituent atoms. For saturated open-chain alkanes, chain isomerism involves reorganizing the carbon skeleton into straight or branched structures.

Solution: Step 1: Identify the molecular formula of pentane, which is C_5H_{12}. This is a saturated alkane with five carbon atoms.

Step 2: Sketch the first structural arrangement. Connect all five carbon atoms in a single, continuous unbranched chain. This straight-chain isomer is known as n-pentane:

$$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$$

Step 3: Sketch the second structural arrangement. Shorten the main carbon chain to four atoms and attach the remaining carbon atom as a methyl branch at the second position. This branched isomer is known as isopentane (or 2-methylbutane):

$$CH_3 - CH(CH_3) - CH_2 - CH_3$$

Step 4: Sketch the third structural arrangement. Shorten the main carbon chain to three atoms and attach two methyl branches to the central carbon atom. This highly branched isomer is known as neopentane (or 2,2-dimethylpropane):

$$C(CH_3)_4$$

Step 5: Verify if any other distinct arrangements are possible. Attempting to place a branch at other positions results in structures that are identical to those already drawn when numbered using IUPAC rules. Thus, pentane has exactly 3 structural chain isomers.

Final Answer: 3

Answer: (B) Go Back to Question 13

Q14.

Solution

Concept: A coordinate covalent bond (also known as a dative bond) is a specific type of covalent linkage where the shared pair of electrons is contributed entirely by only one of the participating atoms.

Solution: Step 1: Analyze the electronic structure of the ammonia (NH_3) reactant molecule. The central nitrogen atom has five valence electrons. It uses three of these electrons to form three single covalent bonds with three hydrogen atoms, leaving one unshared lone pair of electrons in its valence shell.

Step 2: Analyze the electronic state of the incoming hydrogen ion (H^+). A proton is a hydrogen atom that has lost its valence electron, leaving it with an empty $1s$ orbital and a positive charge.

Step 3: Examine the interaction during bond formation. The electron-deficient proton approaches the electron-rich ammonia molecule. The nitrogen atom donates its entire lone pair of electrons to fill the vacant $1s$ orbital of the proton.

Step 4: Describe the resulting bond. This mutual sharing of an electron pair provided solely by the nitrogen atom establishes a coordinate covalent bond, which is typically represented by an arrow pointing from the donor atom to the acceptor atom ($N \rightarrow H$):

$$H_3N : + H^+ \rightarrow [H_3N \rightarrow H]^+$$

Step 5: Identify the correct option. The chemical bond formed between the nitrogen atom and the proton is a coordinate (dative) covalent bond.

Final Answer: Coordinate (dative) covalent bond

Answer: (B) Go Back to Question 14

Q15.

Solution

Concept: Chemical indicators are weak organic acids or bases that change color at specific ion concentrations due to structural rearrangements that alter their light absorption profile. Phenolphthalein is a widely used pH indicator in acid-base titrations.

Solution: Step 1: Understand the operational color response of phenolphthalein. In strongly acidic or completely neutral aqueous solutions, phenolphthalein exists in its protonated form, which is entirely colorless.

Step 2: Note the indicator's transition range. Phenolphthalein begins to change color around pH 8.2. As the hydroxide ion concentration increases, the indicator undergoes deprotonation into its conjugate base form.

Step 3: Associate the color change with alkalinity. In basic (alkaline) environments, the deprotonated form of phenolphthalein gives the solution a distinct pink to deep magenta color.

Step 4: Correlate the color with the pH scale. A strong pink color indicates that the solution is basic, corresponding to a pH value well above the neutral point of 7.0.

Step 5: Evaluate the given options. A solution that turns phenolphthalein pink must be strongly basic, falling within a pH range greater than 9 (pH > 9).

Final Answer: Strongly basic, pH > 9

Answer: (D) Go Back to Question 15

Q16.

Solution

Concept: Alloys are homogeneous solid mixtures containing two or more elements that are engineered to optimize physical properties such as melting point, tensile strength, and corrosion resistance for specific industrial applications.

Solution: Step 1: Identify the function of solder. Solder is an alloy used in electronics to join metallic components together. It must possess a low melting point so that it can be easily melted by a soldering iron without damaging delicate electronic circuits.

Step 2: Examine the composition of common soft solder. Traditional soft solder is made by combining two main post-transition metals: Lead (Pb) and Tin (Sn).

Step 3: Analyze the metallurgical properties of this mixture. Pure lead melts at $327°$C and pure tin melts at $232°$C. When combined, the mixture forms a eutectic or near-eutectic alloy that melts at a significantly lower temperature (typically around $183°$C for a $60/40$ tin-lead blend).

Step 4: Differentiate from other common alloys. Brass and bronze are copper-based alloys. Alnico and steel are iron-based alloys.

Step 5: Conclude the primary components. Based on metallurgical definitions, the primary metallic constituents of standard solder are Lead and Tin.

Final Answer: Lead and Tin

Answer: (A) Go Back to Question 16

Q17.

Solution

Concept: Thermal decomposition involves breaking down a single chemical compound into two or more simpler substances by applying heat energy. This process often involves the breakdown of complex polyatomic oxoanion frameworks.

Solution: Step 1: Write down the chemical formula for lead nitrate, which is $Pb(NO_3)_2$. This is a white, crystalline inorganic salt.

Step 2: Analyze the reaction that occurs upon heating. Heating dry lead nitrate crystals inside a test tube induces a thermal decomposition reaction.

Step 3: Formulate the balanced chemical equation for this decomposition:

$$2Pb(NO_3)_2(s) \xrightarrow{\Delta} 2PbO(s) + 4NO_2(g) \uparrow + O_2(g) \uparrow$$

Step 4: Match the products with the physical observations described in the question. The reaction produces solid lead(II) oxide (PbO), which forms a residue that appears yellow when cold. It also releases colorless oxygen gas (O_2) and a pungent, suffocating brown gas.

Step 5: Identify the brown gas. The characteristic reddish-brown color and pungent odor are due to nitrogen dioxide gas (NO_2). Therefore, the brown gas released during the thermal decomposition of lead nitrate is NO_2.

Final Answer: $\boxed{NO_2}$

Answer: (C) Go Back to Question 17

Q18.

Solution

Concept: Allotropy is the property that allows certain chemical elements to exist in two or more distinct physical forms in the same state, arising from differences in how the atoms are bonded and arranged. Carbon forms several distinct allotropes, including diamond, graphite, and fullerenes.

Solution: Step 1: Review the molecular structure of fullerenes. Fullerenes are a class of carbon allotropes characterized by hollow spherical, ellipsoid, or tubular molecular geometries composed entirely of carbon atoms.

Step 2: Examine Buckminsterfullerene. The most prominent and symmetrical member of this family is the C_{60} molecule, discovered by Kroto, Curl, and Smalley.

Step 3: Analyze the cage geometry of C_{60}. A C_{60} cluster contains exactly 60 carbon atoms arranged in a spherical cage structure that resembles a standard soccer ball. This geometry consists of 20 hexagonal rings and 12 pentagonal rings.

Step 4: Understand the atomic hybridization. Each carbon atom in Buckminsterfullerene undergoes sp^2 hybridization, forming covalent bonds with three adjacent carbon atoms while leaving a delocalized electron cloud that contributes to its electronic properties.

Step 5: Match with the choices. The carbon allotrope composed of large spherical, cage-like clusters of 60 carbon atoms is Buckminsterfullerene.

Final Answer: Buckminsterfullerene

Answer: (B) Go Back to Question 18

Q19.

Solution

Concept: The definitive nomenclature of organic molecules follows formal IUPAC rules. For branched unsaturated hydrocarbons, this involves identifying the longest continuous carbon chain containing the multiple bond, numbering it to give the double bond the lowest possible position, and listing substituents alphabetically with their locants.

Solution: Step 1: Write out the structural formula of the compound:

$$CH_3 - C(CH_3) = CH - CH_3$$

Step 2: Identify the principal functional feature. The molecule contains a carbon-carbon double bond ($C = C$), classifying it as an alkene.

Step 3: Find the longest continuous carbon chain that encompasses both carbon atoms of the double bond. A horizontal count reveals a straight chain containing exactly four carbon atoms. The root word for a four-carbon chain is "but".

Step 4: Number the main chain to give the double bond the lowest possible position. Numbering from right-to-left puts the double bond at position 2 (C_2). Numbering from left-to-right also puts the double bond at position 2 (C_2). To break this tie, choose the direction that gives the substituent the lower number. Numbering from left-to-right places the methyl branch at position 2, which is lower than position 3. Thus, the correct numbering sequence is from left to right.

Step 5: Combine the root chain name, double bond position, and substituent locants into a single IUPAC name. This structure features a methyl branch at position 2 of a but-2-ene chain, giving the name: 2-Methylbut-2-ene.

Final Answer: 2-Methylbut-2-ene

Answer: (A) **Go Back to Question 19**

Q20.

Solution

Concept: A single displacement reaction occurs when a more chemically reactive metal displaces a less reactive metal from its aqueous salt solution. This reaction is driven by the greater tendency of the more active metal to undergo oxidation.

Solution: Step 1: Consult the electrochemical reactivity series to compare the relative activities of Magnesium (Mg) and Zinc (Zn). Magnesium is positioned higher in the series than zinc, indicating that magnesium is more reactive and acts as a stronger reducing agent.

Step 2: Predict the chemical outcome. Because Magnesium is more reactive than Zinc, it will readily displace zinc ions from an aqueous solution of zinc sulfate ($ZnSO_4$).

Step 3: Write down the balanced chemical equation for this single displacement process:

$$Mg(s) + ZnSO_4(aq) \rightarrow MgSO_4(aq) + Zn(s)$$

Step 4: Translate the chemical equation into physical observations. As the reaction proceeds, elemental magnesium dissolves into the solution as colorless magnesium sulfate ($MgSO_4$) ions. Simultaneously, the displaced zinc ions (Zn^{2+}) gain electrons and precipitate out as a dark grey layer of metallic zinc on the surface of the magnesium strip.

Step 5: Match the predicted observations with the options. The correct option states that the magnesium dissolves while a dark grey layer of zinc metal deposits on the strip.

Final Answer: Magnesium dissolves, and a dark grey layer of Zinc metal deposits on the strip

Answer: (B) Go Back to Question 20

Q21.

Solution

Concept: The valence configuration of an element can be deduced directly from its group and period numbers in the modern periodic table. The period number corresponds to the total number of occupied electron shells, while the group number indicates the number of valence electrons for main-group elements.

Solution: Step 1: Analyze the period assignment. Element Z is located in Period 3, meaning it has three occupied electron shells (K, L, and M).

Step 2: Analyze the group assignment. Element Z belongs to Group 16 (the chalcogen family, which includes Oxygen and Sulfur). For p-block elements in Groups 13–18, the number of valence electrons is equal to the group number minus 10:

$$\text{Valence Electrons} = 16 - 10 = 6$$

Thus, a neutral atom of element Z has 6 valence electrons in its outer shell.

Step 3: Determine the element's identity. Summing the electrons in the filled inner shells ($K = 2$, $L = 8$) and the valence shell ($M = 6$) gives a total of 16 electrons. This corresponds to an atomic number of 16, identifying element Z as Sulfur (S).

Step 4: Calculate the core chemical valency. Valency represents the combining capacity of an atom, which depends on the number of electrons it needs to gain, lose, or share to attain a stable noble gas octet. For an element with 6 valence electrons, it is energetically easiest to gain or share 2 electrons to complete its octet:

$$\text{Valency} = 8 - 6 = 2$$

Therefore, element Z has 6 valence electrons and a core valency of 2.

Final Answer: $\boxed{\text{6 valence electrons, valency = 2}}$

Answer: (C) Go Back to Question 21

Q22.

Solution

Concept: Active metals positioned above hydrogen in the electrochemical reactivity series react with dilute mineral acids to produce a soluble metal salt and displace hydrogen gas.

Solution: Step 1: Identify the chemical nature of the reactants. The metal is Calcium (Ca), an alkaline earth metal from Group 2, and the acid is dilute Hydrochloric acid (HCl).

Step 2: Check the position of Calcium in the reactivity series. Calcium is highly electropositive and sits well above hydrogen in the reactivity series, meaning it can readily displace hydrogen from acidic solutions.

Step 3: Formulate the balanced chemical equation for the reaction:

$$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g) \uparrow$$

Step 4: Describe the physical observations. When calcium is added to the acid, a vigorous reaction occurs accompanied by effervescence as bubbles of a colorless, odorless gas are evolved. This gas is elemental hydrogen (H_2).

Step 5: Verify the identity of the gas. Evolved hydrogen gas can be identified in the laboratory because it ignites with a characteristic "pop" sound when exposed to a burning splint. Thus, the gas evolved is hydrogen.

Final Answer: Hydrogen gas (H_2)

Answer: (B) Go Back to Question 22

Q23.

Solution

Concept: Many industrial chemical salts are known by common or domestic names that reflect their traditional applications in cooking, cleaning, or manufacturing.

Solution: Step 1: Analyze the provided chemical formula, $NaHCO_3$. This compound is composed of sodium cations (Na^+) and bicarbonate (hydrogen carbonate) anions (HCO_3^-). Its systematic chemical name is Sodium hydrogen carbonate.

Step 2: Evaluate the common names listed in the choices. Washing soda is sodium carbonate decahydrate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$). Caustic soda is sodium hydroxide ($NaOH$). Glauber's salt is sodium sulfate decahydrate ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$).

Step 3: Examine the properties of Baking Soda. Baking soda is the common household name for pure sodium hydrogen carbonate ($NaHCO_3$).

Step 4: Understand its role in baking. When heated or mixed with an acidic ingredient (such as cream of tartar) during baking, baking soda decomposes to release carbon dioxide gas:

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2 \uparrow$$

The trapped bubbles of carbon dioxide gas expand within the dough, causing bread and cakes to rise and achieve a light, porous texture.

Final Answer: Baking soda

Answer: (B) Go Back to Question 23

Q24.

Solution

Concept: Phase transitions describe physical changes in the state of matter that occur when a substance absorbs or releases thermal energy under specific ambient pressure conditions.

Solution: Step 1: Identify the nature of the substance. "Dry ice" is the common name for solid carbon dioxide (Solid CO_2).

Step 2: Analyze its physical behavior under standard conditions. At standard atmospheric pressure (1 atm), carbon dioxide does not have a stable liquid phase. Its triple point occurs at a pressure of 5.11 atm.

Step 3: Describe the transition that occurs upon warming. When solid dry ice is exposed to room temperature and standard atmospheric pressure, it absorbs ambient heat energy. Instead of melting into a liquid, it transitions directly from the solid phase into a gas.

Step 4: Apply the correct term for this phase change. The direct physical transition of a substance from a solid to a gas, bypassing the intermediate liquid state, is defined as sublimation.

Step 5: Match with the options. Because dry ice turns directly into gaseous carbon dioxide without leaving a liquid residue, this process is an example of sublimation.

Final Answer: Sublimation

Answer: (B) Go Back to Question 24

Q25.

Solution

Concept: According to Avogadro's Law and the molar volume concept, one mole of any ideal gas occupies a fixed volume of exactly 22.4 liters when maintained at standard temperature and pressure (STP, defined as $0°$C and 1 atm).

Solution: Step 1: Determine the molecular formula and molar mass of oxygen gas. Oxygen gas exists as a diatomic molecule, O_2. Using the given atomic mass of oxygen ($O = 16$ u), calculate its molar mass:

$$\text{Molar Mass of } O_2 = 16 \times 2 = 32 \text{ g/mol}$$

Step 2: Calculate the number of moles (n) contained in the given sample mass (8.0 grams):

$$n = \frac{\text{Given Mass}}{\text{Molar Mass}} = \frac{8.0 \text{ g}}{32 \text{ g/mol}} = 0.25 \text{ moles}$$

Step 3: Relate the mole count to gas volume at STP. Use the molar volume constant (22.4 L/mol) to calculate the total volume occupied by the gas:

$$\text{Volume} = \text{Number of Moles} \times \text{Molar Volume at STP}$$

Step 4: Substitute the values into the equation:

$$\text{Volume} = 0.25 \text{ moles} \times 22.4 \text{ liters/mole} = 5.6 \text{ liters}$$

Thus, an 8.0 gram sample of oxygen gas occupies a volume of 5.6 liters at STP.

Final Answer: 5.6 liters

Answer: (A) **Go Back to Question 25**

Answer Key

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