JEECUP Group A Chemistry Sample Paper – 1

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 elements has the highest fundamental electropositive character?

(A) Lithium

(B) Sodium

(C) Potassium

(D) Caesium

Q2. What is the nature of the aqueous solution of copper sulfate ($CuSO_4$)?

(A) Strongly alkaline

(B) Weakly acidic

(C) Neutral

(D) Amphoteric

Q3. In the modern periodic table, moving from left to right across a period generally causes the atomic radius to decrease. What is the primary reason for this behavior?

(A) Increase in the number of principal energy levels

(B) Increase in the effective nuclear charge pulling the electron cloud closer

(C) Stronger repulsive forces between inner core electrons

(D) Decrease in the total mass number of the elements

Q4. Which of the following organic compounds will rapidly decolorize bromine water under standard laboratory conditions?

(A) Propane

(B) Ethane

(C) Ethene

(D) Cyclohexane

Q5. An atom has the electronic configuration $2, 8, 7$. To which group and period of the modern periodic table does this element belong?

(A) Group 15, Period 3

(B) Group 17, Period 3

(C) Group 7, Period 2

(D) Group 17, Period 2

Q6. Which method is most structurally suitable for extracting highly reactive metals like Sodium and Magnesium from their ores?

(A) Reduction of their oxides using carbon or carbon monoxide

(B) Heating their sulfide ores strongly in the presence of excess air

(C) Electrolysis of their molten chloride salts

(D) Displacement from their aqueous salt solutions using iron scraps

Q7. When hydrogen sulfide gas (H_2S) is passed through an acidified solution of copper sulfate ($CuSO_4$), a black precipitate is formed. This reaction is a classic example of:

(A) Combination reaction

(B) Decomposition reaction

(C) Displacement reaction

(D) Double displacement reaction

Q8. What type of chemical bond is primarily formed when an element with low ionization energy reacts with an element possessing highly negative electron gain enthalpy?

(A) Covalent bond

(B) Coordinate bond

(C) Ionic bond

(D) Metallic bond

Q9. Which of the following gaseous fuels has the highest calorific value per unit mass?

(A) Biogas

(B) Hydrogen gas

(C) Liquid Petroleum Gas (LPG)

(D) Compressed Natural Gas (CNG)

Q10. What is the conjugate base of the bisulfate ion (HSO_4^-)?

(A) H_2SO_4

(B) SO_4^{2-}

(C) SO_3^{2-}

(D) OH^-

Q11. Pure iron is highly malleable and soft when hot, making it difficult to use directly for structural purposes. Which element is primarily added in a small percentage ($0.05\% - 1.5\%$) to make it hard and strong?

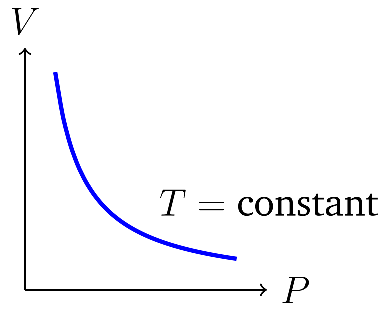
(A) Zinc

(B) Sulfur

(C) Carbon

(D) Aluminum

Q12. According to Boyle's Law, when the temperature of a fixed mass of an ideal gas is kept constant, what happens to the volume if the pressure is doubled?



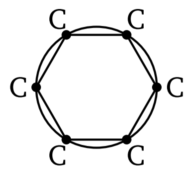
(A) It becomes four times the original volume

(B) It remains completely unchanged

(C) It reduces to exactly half of the original volume

(D) It reduces to one-fourth of the original volume

Q13. The self-linking property of carbon atoms through covalent bonds to form long chains, branched networks, or rings is known as:



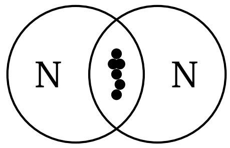
(A) Isomerism

(B) Catenation

(C) Homology

(D) Allotropy

Q14. What is the total number of shared pairs of electrons present in a single molecule of nitrogen gas (N_2)?



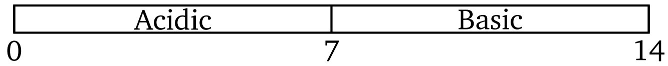
(A) 1

(B) 2

(C) 3

(D) 4

Q15. An aqueous solution turns red litmus paper blue. The pH value of this solution is most likely to be:



(A) 2

(B) 5

(C) 7

(D) 9

Q16. Brass is a widely used industrial alloy. What are its principal metallic components?

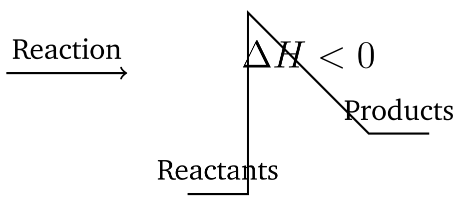
(A) Copper and Tin

(B) Copper and Zinc

(C) Lead and Tin

(D) Aluminum and Magnesium

Q17. During the process of respiration in living cells, glucose combines with oxygen to produce carbon dioxide, water, and energy. This reaction is classified as an:



(A) Endothermic reaction

(B) Exothermic reaction

(C) Isothermal decomposition

(D) Photochemical reduction

Q18. Which structural property explains why graphite can conduct electricity while diamond acts as an electrical insulator?

(A) Graphite has a rigid three-dimensional tetrahedral network

(B) Every carbon atom in graphite uses all four valence electrons in σ-bonding

(C) Graphite contains delocalized π-electrons free to move within its hexagonal layers

(D) Diamond contains large interstitial spaces that trap charge carriers

Q19. Which functional group is explicitly present in the organic molecule CH_3CH_2CHO?

(A) Alcohol

(B) Ketone

(C) Carboxylic acid

(D) Aldehyde

Q20. When iron filings are added to a blue-colored solution of copper sulfate, the solution slowly turns light green. What type of chemical phenomenon does this represent?

(A) Combination

(B) Single displacement

(C) Neutralization

(D) Thermal decomposition

Q21. An element X forms a chloride with the chemical formula XCl_2, which is a solid with a relatively high melting point. Element X is most likely to be placed in the same group of the periodic table as:

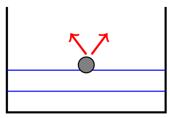
(A) Sodium (Na)

(B) Magnesium (Mg)

(C) Aluminum (Al)

(D) Silicon (Si)

Q22. What happens when a small piece of sodium metal is dropped into clean water?



$Na + H_2O$

(A) It sinks silently and dissolves to form a clear solution without generating gas

(B) It reacts violently, floats, melts into a silvery ball, catches fire, and evolves hydrogen gas

(C) It forms a heavy green precipitate of sodium oxide along the bottom of the container

(D) It absorbs all the heat energy from water, causing the liquid to instantly freeze

Q23. Which of the following compounds is the principal chemical constituent of bleaching powder?

(A) $CaCO_3$

(B) $CaOCl_2$

(C) $Ca(OH)_2$

(D) $CaCl_2$

Q24. In a sample of matter, when a substance changes directly from its solid phase to its gaseous phase without passing through the intermediate liquid state, the process is called:

(A) Vaporization

(B) Condensation

(C) Sublimation

(D) Fusion

Q25. Equal masses of oxygen (O_2) and methane (CH_4) gases are mixed thoroughly in an empty vessel at a constant temperature. What is the fraction of the total pressure exerted by the oxygen gas? [Atomic masses: $O = 16$, $C = 12$, $H = 1$]

(A) $1/2$

(B) $1/3$

(C) $2/3$

(D) $1/4$

Detailed Solutions

Q1.

Solution

Concept: Electropositivity refers to the tendency of an element to lose its valence electrons and form a positively charged cation. This characteristic depends directly on the atomic radius and the effective nuclear charge holding the outermost valence shell.

Solution: Step 1: Identify the position of the given elements in the periodic table. All the options listed (Lithium, Sodium, Potassium, and Caesium) belong to Group 1, which represents the alkali metals.

Step 2: Analyze the group trend for electropositive character. As we move down a group from top to bottom, a new principal energy level is added to each successive element. This significantly increases the atomic size.

Step 3: Evaluate the shielding effect and nuclear attraction. The inner core electron shells shield the outermost valence electron from the attractive pull of the nucleus. Because of the larger atomic radius and higher shielding down the group, the effective nuclear force acting on the outermost electron drops.

Step 4: Compare the ionization energies. Due to the weakened nuclear attraction, the energy required to remove the outermost electron (ionization energy) decreases drastically from Lithium to Caesium.

Step 5: Conclude the highest fundamental electropositive character. Since Caesium has the lowest ionization energy among the options, it loses its valence electron most easily, making it the most fundamental electropositive element.

Final Answer: Caesium

Answer: (D) Go Back to Question 1

Q2.

Solution

Concept: The nature of an aqueous salt solution is determined by salt hydrolysis, where the component ions of the salt interact dynamically with water molecules to disturb the fundamental balance of hydrogen and hydroxyl ions.

Solution: Step 1: Break down the salt into its parent components. Copper sulfate ($CuSO_4$) is derived from the chemical neutralization reaction between a weak base, Copper(II) hydroxide ($Cu(OH)_2$), and a strong acid, Sulfuric acid (H_2SO_4).

Step 2: Dissociate the salt in an aqueous medium. When dissolved in water, copper sulfate completely dissolves into copper cations and sulfate anions:

$$CuSO_4 \rightarrow Cu^{2+} + SO_4^{2-}$$

Step 3: Analyze ionic hydrolysis. The sulfate anion (SO_4^{2-}), being the conjugate partner of a strong acid, does not undergo hydrolysis. However, the copper cation (Cu^{2+}) undergoes cationic hydrolysis by interacting with water molecules:

$$Cu^{2+} + 2H_2O \rightleftharpoons Cu(OH)_2 + 2H^+$$

Step 4: Determine the relative concentrations of ions. The hydrolysis reaction releases excess hydrogen ions (H^+) into the solution while binding hydroxyl groups into weak copper hydroxide molecules.

Step 5: Deduce the final nature of the solution. Because the concentration of H^+ ions exceeds that of OH^- ions, the solution becomes acidic. Since copper hydroxide is moderately weak, the solution behaves as weakly acidic.

Final Answer: Weakly acidic

Answer: (B) Go Back to Question 2

Q3.

Solution

Concept: The periodic variation of atomic size across a horizontal period is governed by the delicate balance between the addition of protons to the nucleus and the spatial distribution of incoming valence electrons.

Solution: Step 1: Observe the structural additions across a period. When moving from left to right within the same period, electrons are successively added to the exact same principal valence energy shell.

Step 2: Observe the nuclear changes. For every electron added to the valence shell, a proton is concurrently added to the central atomic nucleus, steadily increasing the atomic number and raw nuclear charge.

Step 3: Evaluate the internal shielding efficiency. Electrons residing in the same valence shell offer very poor screening or shielding against each other from the core nuclear pull.

Step 4: Calculate the net effective nuclear charge (σ_{eff}). Because the raw nuclear charge increases while inner shielding remains nearly constant, the effective nuclear charge pulling on the valence electrons increases continuously across the period.

Step 5: Determine the effect on the electron cloud. The elevated effective nuclear charge exerts a powerful electrostatic contraction on the outer electron shell, drawing it closer to the nucleus and resulting in a decreased atomic radius.

Final Answer: Increase in the effective nuclear charge pulling the electron cloud closer

Answer: (B) Go Back to Question 3

Q4.

Solution

Concept: The rapid decolorization of bromine water acts as a standard analytical test for unsaturation, relying on the high reactivity of carbon-carbon multiple bonds toward electrophilic addition reactions.

Solution: Step 1: Categorize the chemical structures of the given options. Propane (C_3H_8) and ethane (C_2H_6) are saturated open-chain alkanes. Cyclohexane (C_6H_{12}) is a saturated cyclic alkane. Ethene (C_2H_4) is an unsaturated alkene containing a double bond.

Step 2: Examine the reactivity of saturated hydrocarbons. Alkanes contain only stable carbon-carbon single (σ) bonds. They do not react with bromine water under standard laboratory conditions without ultraviolet light.

Step 3: Examine the reactivity of unsaturated hydrocarbons. Alkenes contain a highly accessible, electron-rich carbon-carbon π bond. This structural double bond is susceptible to electrophilic attack by halogen molecules.

Step 4: Trace the electrophilic addition mechanism. When ethene is exposed to reddish-brown bromine water, the bromine molecule adds across the double bond to form a colorless vicinal dihalide product:

$$CH_2 = CH_2 + Br_2 \rightarrow CH_2Br - CH_2Br$$

Step 5: Conclude the observational outcome. The consumption of molecular bromine changes the solution from reddish-brown to completely clear and colorless. Therefore, ethene decolorizes bromine water rapidly.

Final Answer: Ethene

Answer: (C) Go Back to Question 4

Q5.

Solution

Concept: The positioning of any element in the modern periodic table can be extracted directly from its ground-state electronic configuration by analyzing its principal quantum shell and valence electron count.

Solution: Step 1: Analyze the given electron configuration $(2, 8, 7)$. Count the total number of occupied electron shells. The electrons are distributed across three distinct shells: $K = 2$, $L = 8$, and $M = 7$.

Step 2: Determine the period number. The maximum principal quantum number or the total number of occupied energy levels corresponds exactly to the period. Since there are 3 occupied shells, the element belongs to Period 3.

Step 3: Count the number of valence electrons. The outermost shell (M shell) contains exactly 7 electrons.

Step 4: Determine the group number using standard IUPAC rules. For elements belonging to the p-block (possessing 3 or more valence electrons), the group number is calculated by adding 10 to the total number of valence electrons:

$$\text{Group Number} = 10 + 7 = 17$$

Step 5: Combine both parameters. The element with electronic configuration $2, 8, 7$ (which is Chlorine, Cl) is situated precisely in Group 17, Period 3.

Final Answer: Group 17, Period 3

Answer: (B) Go Back to Question 5

Q6.

Solution

Concept: The metallurgical extraction scheme of a metal is dictated by its chemical reactivity and position in the electrochemical series. Highly active metals hold oxygen and chlorine atoms with tremendous chemical affinity.

Solution: Step 1: Check the positions of Sodium (Na) and Magnesium (Mg) in the reactivity series. Both elements are located near the very top of the series, classifying them as highly reactive metals.

Step 2: Evaluate chemical reduction using carbon. Because of their immense electropositive nature, highly active metals have a greater chemical affinity for oxygen than carbon does. Hence, conventional reduction using carbon or carbon monoxide fails.

Step 3: Evaluate reduction of aqueous solutions. Attempting to reduce or displace these highly active metals from their aqueous solutions fails because the freed metal reacts immediately with water to form hydroxides and hydrogen gas.

Step 4: Identify the optimal extraction methodology. To overcome the high chemical stability of their compounds, a high-energy method is required. Electrolytic reduction supplies electrons directly to break the stable ionic lattice.

Step 5: Specify the industrial parameters. The electrolysis must be conducted using their molten or fused chloride salts to avoid interference from water, yielding pure metal at the cathode.

Final Answer: Electrolysis of their molten chloride salts

Answer: (C) Go Back to Question 6

Q7.

Solution

Concept: Chemical reactions are classified into distinct structural types depending on how atoms, ions, or molecular fragments rearrange themselves to generate new chemical species.

Solution: Step 1: Formulate the explicit chemical equation described in the question. The reactants are hydrogen sulfide gas (H_2S) and copper sulfate ($CuSO_4$):

$$CuSO_4 + H_2S \rightarrow CuS \downarrow + H_2SO_4$$

Step 2: Observe the chemical status of the reactants. Both copper sulfate and hydrogen sulfide are ionic or highly polar compound species in an aqueous medium.

Step 3: Track the movement of individual ionic components during the reaction. The copper cation (Cu^{2+}) pairs with the sulfide anion (S^{2-}) to establish a solid black precipitate of copper sulfide (CuS).

Step 4: Track the remaining chemical components. Simultaneously, the hydrogen cations (H^+) pair with the sulfate anions (SO_4^{2-}) to form sulfuric acid (H_2SO_4) in solution.

Step 5: Identify the reaction category. This reaction features a mutual exchange of ions between two distinct compounding agents. By definition, a chemical reaction involving a mutual swap of ionic partners is classified as a double displacement reaction.

Final Answer: Double displacement reaction

Answer: (D) Go Back to Question 7

Q8.

Solution

Concept: Chemical bonding styles are defined by how reacting atomic structures optimize their outer electron configurations based on their respective ionization potentials and electron affinities.

Solution: Step 1: Define the energetic property of the first element. An element with a low ionization energy requires minimal energy to lose its outermost valence electron, readily forming a stable, positively charged cation. This behavior is characteristic of reactive metals.

Step 2: Define the energetic property of the second element. An element with a highly negative electron gain enthalpy releases a significant amount of energy when absorbing an extra electron into its valence shell, readily forming a stable anion. This behavior is typical of active non-metals.

Step 3: Analyze the electron transfer mechanism. When these two distinct classes of elements interact, a complete transfer of valence electrons occurs from the electropositive metallic atom to the highly electronegative non-metallic atom.

Step 4: Identify the resulting forces. This complete electron migration creates distinct oppositely charged ions (M^+ and X^-), which are bound together by powerful, non-directional electrostatic forces of attraction.

Step 5: Classify the chemical bond. A chemical bond constructed via the complete transfer of electrons and sustained by strong electrostatic forces is termed an ionic or electrovalent bond.

Final Answer: Ionic bond

Answer: (C) Go Back to Question 8

Q9.

Solution

Concept: The calorific value of a combustible fuel represents the net amount of heat energy released during the complete combustion of a unit mass of that fuel under standard parameters.

Solution: Step 1: Define the chemical composition and typical calorific ranges of the listed gaseous fuels. Biogas consists mostly of methane and carbon dioxide, possessing a modest calorific value of around $35 - 40$ MJ/kg.

Step 2: Assess Compressed Natural Gas (CNG) and Liquid Petroleum Gas (LPG). CNG consists mainly of methane, yielding a calorific value of about 50 MJ/kg. LPG consists of propane and butane, exhibiting an excellent calorific yield of around 55 MJ/kg.

Step 3: Evaluate the chemical combustion parameters of Hydrogen gas (H_2). Hydrogen possesses a lightweight molecular mass and undergoes highly efficient clean oxidation with oxygen:

$$2H_2 + O_2 \rightarrow 2H_2O + \text{Energy}$$

Step 4: Check the specific energy density of Hydrogen. On combustion, pure hydrogen gas yields a calorific value of approximately 150 MJ/kg.

Step 5: Compare all values. The calorific value of hydrogen (150 MJ/kg) is roughly three times higher than that of commercial hydrocarbon alternatives like LPG and CNG, making it the highest per unit mass.

Final Answer: Hydrogen gas

Answer: (B) Go Back to Question 9

Q10.

Solution

Concept: According to the Brønsted-Lowry acid-base theory, a conjugate base is the chemical species left behind after an acid donates a single proton (H^+) to a receiving base.

Solution: Step 1: Write down the formula of the starting species. The given ion is the bisulfate or hydrogen sulfate ion, denoted as HSO_4^-.

Step 2: Recognize the chemical amphiprotic capability of HSO_4^-. This polyatomic ion can act either as an acid by donating its proton or as a base by accepting another proton.

Step 3: Apply the condition to find the conjugate base. To identify the conjugate base of any species, the starting substance must act explicitly as a Brønsted-Lowry proton donor.

Step 4: Formulate the proton donation step. Remove exactly one hydrogen ion (H^+) from the molecular structure of the bisulfate ion:

$$HSO_4^- \rightarrow H^+ + SO_4^{2-}$$

Step 5: Track the modification of net electrical charge. Removing a positive charge ($+1$) from a species that already has a -1 charge leaves behind a net charge of -2. This results in the formation of the sulfate ion (SO_4^{2-}).

Final Answer: $\boxed{SO_4^{2-}}$

Answer: (B) **Go Back to Question 10**

Q11.

Solution

Concept: The mechanical strength and crystalline lattice arrangement of pure metals can be altered by introducing precise amounts of small non-metallic or metallic atoms to form interstitial alloys.

Solution: Step 1: Examine the structural nature of pure iron. In pure iron, the constituent metallic atoms are arranged in a regular, uniform layer-by-layer lattice configuration. When hot, these layers slide past one another easily, making the metal soft and malleable.

Step 2: Analyze the role of alloying agents. To make pure iron structurally viable for construction or tool fabrication, its physical properties must be modified by adding small amounts of a non-metal.

Step 3: Evaluate Carbon as an interstitial addition. Carbon atoms have a small atomic radius. When added in precise, controlled fractions (0.05% to 1.5%), they fit into the small interstitial gaps between the larger iron atoms.

Step 4: Understand the mechanical locking mechanism. The presence of these carbon atoms distorts the regular arrangement of the iron lattice, preventing the metallic layers from sliding smoothly over one another.

Step 5: Identify the final material. This interstitial carbon-iron blend produces carbon steel, which is significantly harder, tougher, and stronger than pure iron.

Final Answer: Carbon

Answer: (C) Go Back to Question 11

Q12.

Solution

Concept: Boyle's Law states that for a fixed mass of an ideal gas maintained at a constant temperature, the volume occupied by the gas is inversely proportional to its pressure.

Solution: Step 1: State the mathematical expression of Boyle's Law. Under constant temperature parameters (T = constant):

$$V \propto \frac{1}{P} \implies P \cdot V = k$$

where P represents the gas pressure, V represents the gas volume, and k represents a constant.

Step 2: Set up the initial and final states of the gas system:

$$P_1 \cdot V_1 = P_2 \cdot V_2$$

Step 3: Incorporate the structural boundary conditions stated in the question. The initial pressure is P_1, and the initial volume is V_1. The pressure is doubled, which means:

$$P_2 = 2 \cdot P_1$$

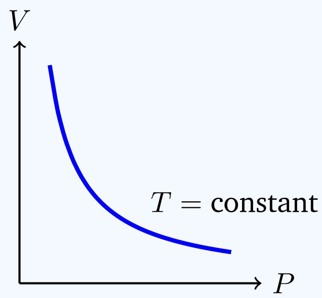
Step 4: Substitute these values back into the comparative equation to solve for the final volume (V_2):

$$P_1 \cdot V_1 = (2 \cdot P_1) \cdot V_2$$

Step 5: Cancel out the pressure term P_1 from both sides of the equation:

$$V_1 = 2 \cdot V_2 \implies V_2 = \frac{V_1}{2}$$

Thus, doubling the pressure forces the final volume to reduce to exactly half of its initial value.



Final Answer: It reduces to exactly half of the original volume

Answer: (C) Go Back to Question 12

Q13.

Solution

Concept: The structural diversity of organic molecules stems from the ability of certain elements to form stable, continuous covalent link networks among their own atoms.

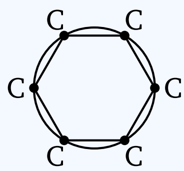
Solution: Step 1: Define the unique bonding capabilities of carbon. Carbon possesses an atomic number of 6, leading to a valence shell containing 4 electrons $(2, 4)$. To achieve stability, it readily shares these 4 electrons to form strong covalent bonds.

Step 2: Examine the carbon-carbon single bond strength. Due to its exceptionally small atomic radius, the shared electron pair between two carbon atoms is held tightly by their respective nuclei, making the carbon-carbon bond incredibly stable.

Step 3: Define Catenation. This high bond energy allows carbon atoms to link together in long, continuous straight chains, branched structures, or closed ring networks. This property is known as catenation.

Step 4: Differentiate from other terms. Isomerism describes compounds sharing identical formulas but varying in structural arrangement. Allotropy refers to the existence of an element in multiple distinct physical states.

Step 5: Conclude the definitive term. The unique self-linking structural property that allows carbon to form vast chains and rings is called catenation.



Final Answer: Catenation

Answer: (B) Go Back to Question 13

Q14.

Solution

Concept: Covalent molecular structures achieve structural stability by sharing valence electrons to satisfy the octet rule, establishing single, double, or triple covalent bonds.

Solution: Step 1: Determine the valence status of Nitrogen. Nitrogen has an atomic number of 7, giving it an electronic configuration of $2, 5$. It contains 5 electrons in its outermost valence shell.

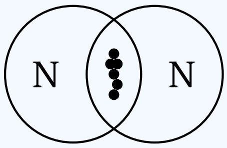
Step 2: Determine the electronic requirement for stability. To satisfy the octet rule and achieve a stable noble gas configuration (like Neon), each nitrogen atom requires 3 additional electrons.

Step 3: Analyze the electron sharing mechanism in N_2. Since both interacting nitrogen atoms require 3 electrons, they contribute 3 valence electrons each to be shared mutually between them.

Step 4: Count the shared electron pairs. The mutual sharing of 3 electrons from each atom results in a total of 6 shared electrons localized between the two nitrogen nuclei:

$$\text{Shared Pairs} = \frac{6 \text{ electrons}}{2 \text{ electrons per pair}} = 3 \text{ pairs}$$

Step 5: Conclude the bond order. These 3 shared pairs form a strong covalent triple bond ($N \equiv N$). Therefore, the total number of shared electron pairs is 3.



Final Answer: 3

Answer: (C) Go Back to Question 14

Q15.

Solution

Concept: The pH scale provides a logarithmic measurement of the hydronium ion concentration in a solution, indicating its relative acidity, neutrality, or alkalinity.

Solution: Step 1: Analyze the experimental behavior with litmus indicators. The question states that the given aqueous solution turns red litmus paper blue.

Step 2: Match the litmus indicator response with chemical character. It is a standard chemical rule that acidic solutions turn blue litmus red, whereas basic (alkaline) solutions turn red litmus blue. This indicates that the solution is basic.

Step 3: Relate chemical alkalinity to the pH scale. The standard pH scale ranges from 0 to 14 at room temperature ($25°C$):

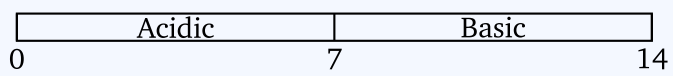
$$\text{pH} < 7 \implies \text{Acidic solution}$$

$$\text{pH} = 7 \implies \text{Neutral solution}$$

$$\text{pH} > 7 \implies \text{Basic/Alkaline solution}$$

Step 4: Filter the given choices based on pH ranges. Option A ($\text{pH} = 2$) and Option B ($\text{pH} = 5$) represent acidic solutions. Option C ($\text{pH} = 7$) represents a completely neutral solution.

Step 5: Choose the correct basic pH value. Option D ($\text{pH} = 9$) is the only value greater than 7, making it the only possible choice for an alkaline solution that turns red litmus blue.



Final Answer: 9

Answer: (D) Go Back to Question 15

Q16.

Solution

Concept: Alloys are homogeneous solid mixtures composed of two or more metals, or a metal and a non-metal, designed to enhance mechanical, thermal, or anti-corrosive properties compared to their pure constituent elements.

Solution: Step 1: Identify the nature of Brass. Brass is a widely used industrial alloy known for its structural strength, workability, and corrosion resistance.

Step 2: Differentiate Brass from Bronze. A common point of confusion is distinguishing between brass and bronze. Bronze is primarily an alloy of Copper (Cu) and Tin (Sn).

Step 3: Analyze the chemical composition of Brass. Brass is constructed by combining Copper (Cu) as the base host metal with Zinc (Zn) as the primary alloying addition.

Step 4: Examine typical industrial ratios. Standard commercial brass contains roughly $60\% - 70\%$ copper and $30\% - 40\%$ zinc, though the proportions can be adjusted to vary its mechanical hardness and acoustic properties.

Step 5: Select the correct combination. Based on metallurgical definitions, the principal metallic components of brass are Copper and Zinc.

Final Answer: Copper and Zinc

Answer: (B) Go Back to Question 16

Q17.

Solution

Concept: Chemical reactions are classified thermodynamically as either endothermic or exothermic based on whether they absorb heat energy from their surroundings or release energy into them.

Solution: Step 1: Formulate the balanced chemical equation for cellular respiration. During respiration, glucose is oxidized by metabolic pathways within cells:

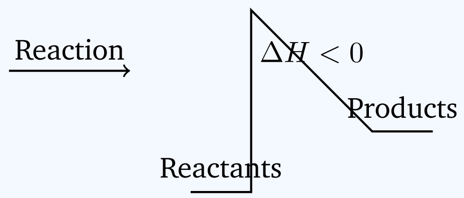
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy (ATP + Heat)}$$

Step 2: Analyze the energetic balance of the reaction. In this process, the energy required to break the structural bonds of the reactants (glucose and oxygen) is significantly lower than the chemical energy released during the formation of the stronger bonds in the products (carbon dioxide and water).

Step 3: Note the observational criteria. The primary biological purpose of respiration is to generate chemical energy in the form of ATP to power living organisms, with a portion of the energy released as metabolic body heat.

Step 4: Relate the energy release to thermodynamic definitions. Since the net reaction results in a surplus release of energy to the system's surroundings, the change in enthalpy (ΔH) is negative.

Step 5: Choose the correct classification. A chemical process that proceeds with a net release of energy is defined as an exothermic reaction.



Final Answer: Exothermic reaction

Answer: (B) Go Back to Question 17

Q18.

Solution

Concept: The physical properties of allotropes of carbon, such as electrical conductivity and mechanical hardness, depend directly on their atomic hybridization and crystalline arrangements.

Solution: Step 1: Analyze the structural geometry of diamond. In diamond, every single carbon atom undergoes sp^3 hybridization, forming four localized covalent σ bonds with four neighboring carbon atoms arranged in a rigid, three-dimensional tetrahedral lattice. All valence electrons are tightly bound, leaving no free charge carriers.

Step 2: Analyze the structural geometry of graphite. In graphite, each carbon atom undergoes sp^2 hybridization, bonding covalently with only three neighboring carbon atoms within a two-dimensional hexagonal planar layer.

Step 3: Account for the remaining valence electron in graphite. Since carbon has 4 valence electrons and uses only 3 for σ-bonding, each carbon atom retains one unhybridized p-orbital containing a single valence electron.

Step 4: Describe electron delocalization in graphite. These unhybridized p-orbitals overlap laterally across the entire layer, creating a vast cloud of delocalized π-electrons. These electrons are highly mobile when an electrical potential is applied.

Step 5: Correlate the structure with electrical properties. The presence of mobile, delocalized π-electrons parallel to its hexagonal layers allows graphite to conduct electricity effectively, whereas diamond lacks free electrons and acts as an insulator.

Final Answer: Graphite contains delocalized π-electrons free to move within its hexagonal layers

Answer: (C) Go Back to Question 18

Q19.

Solution

Concept: Functional groups are specific structural arrangements of atoms within organic molecules that dictate the chemical reactivity and IUPAC classification of those compounds.

Solution: Step 1: Analyze the condensed molecular formula provided in the question: CH_3CH_2CHO. This represents a three-carbon open-chain organic molecule known as propanal.

Step 2: Expand the structural connectivity of the terminal group. The suffix shorthand notation $-CHO$ features a carbon atom double-bonded to an oxygen atom and single-bonded to a hydrogen atom:

$$-C(=O)H$$

Step 3: Evaluate the nature of the carbonyl group. A carbonyl unit ($C = O$) located at the very end of a carbon chain, bound directly to at least one hydrogen atom, is the defining feature of the aldehyde family.

Step 4: Distinguish from other oxygen-containing functional groups. Alcohols contain a hydroxyl group ($-OH$). Ketones contain an internal carbonyl group ($C = O$) bound to two carbon atoms. Carboxylic acids contain a carboxyl group ($-COOH$).

Step 5: Match the structural formula to the correct group. The structural group $-CHO$ present in CH_3CH_2CHO explicitly classifies the compound as an aldehyde.

Final Answer: Aldehyde

Answer: (D) Go Back to Question 19

Q20.

Solution

Concept: A single displacement reaction occurs when a more chemically reactive element displaces a less reactive element from its compound solution, driven by differences in standard reduction potentials.

Solution: Step 1: Write down the chemical formulas for the reactants. The reaction involves solid iron filings (Fe) and an aqueous solution of copper sulfate ($CuSO_4$).

Step 2: Consult the electrochemical reactivity series. In the reactivity series of metals, iron (Fe) is positioned higher than copper (Cu), meaning iron is more electropositive and acts as a stronger reducing agent.

Step 3: Trace the chemical reaction. When iron is added to the solution, it loses electrons to form iron(II) ions (Fe^{2+}), which enter the solution. Concurrently, copper ions (Cu^{2+}) accept these electrons to precipitate out as metallic copper:

$$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$$

Step 4: Account for the color changes. The initial blue color of the solution is due to hydrated copper ions ($[Cu(H_2O)_6]^{2+}$). As iron displaces the copper, the concentration of copper ions drops, and green iron(II) sulfate ($FeSO_4$) forms in solution.

Step 5: Classify the reaction type. Because a single element (iron) replaces another element (copper) within a compound, this phenomenon is classified as a single displacement reaction.

Final Answer: Single displacement

Answer: (B) Go Back to Question 20

Q21.

Solution

Concept: Elements belonging to the same vertical group of the modern periodic table share identical valence electron counts and exhibit similar valencies, chemical formulas, and bonding characteristics.

Solution: Step 1: Analyze the chemical formula of the given metal chloride, XCl_2. Chlorine is a highly electronegative halogen that systematically exhibits a valency of -1 when forming binary metal chlorides (Cl^-).

Step 2: Determine the valency or oxidation state of element X. Since two chloride ions are required to balance a single atom of X to form a neutral compound, the net oxidation state or valency of element X must be $+2$.

Step 3: Relate valency to periodic table groups. Elements that form stable cations with a $+2$ charge possess exactly 2 valence electrons in their outermost shell, which is characteristic of Group 2 (alkaline earth metals).

Step 4: Check the given choices. Sodium (Na) belongs to Group 1 (valency $+1$). Aluminum (Al) belongs to Group 13 (valency $+3$). Silicon (Si) belongs to Group 14 (valency $+4$). Magnesium (Mg) belongs to Group 2 (valency $+2$).

Step 5: Conclude the group assignment. Since Magnesium has a valency of $+2$ and forms a high-melting solid chloride ($MgCl_2$), element X belongs to the same group as Magnesium.

Final Answer: Magnesium (Mg)

Answer: (B) Go Back to Question 21

Q22.

Solution

Concept: The chemical interaction between alkali metals and water is an exothermic process determined by the low ionization energy of the metal and its rapid reaction with water molecules.

Solution: Step 1: Examine the physical density and properties of Sodium (Na). Sodium is a soft alkali metal with a density lower than that of water (0.97 g/cm^3), allowing it to float on the water's surface.

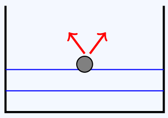
Step 2: Formulate the chemical reaction equation. Sodium reacts with water to form soluble sodium hydroxide and hydrogen gas:

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g) \uparrow$$

Step 3: Analyze the thermodynamics of the reaction. This reaction is highly exothermic. The heat released quickly melts the sodium into a highly mobile, silvery sphere that skitters across the surface of the water.

Step 4: Account for the ignition behavior. The heat generated is often sufficient to ignite the evolved hydrogen gas, causing the sodium piece to burn with a characteristic golden-yellow flame.

Step 5: Match the observed phenomena with the options. The metal reacts violently, floats, melts into a silvery ball, catches fire, and evolves hydrogen gas.



$Na + H_2O$

Final Answer: It reacts violently, floats, melts into a silvery ball, catches fire, and evolves hydrogen gas

Answer: (B) Go Back to Question 22

Q23.

Solution

Concept: Commercial inorganic chemicals are typically multi-component compounds whose common name reflects their practical industrial function, such as bleaching or disinfection.

Solution: Step 1: Identify the chemical nature of bleaching powder. Bleaching powder is produced industrially by passing chlorine gas over dry slaked lime ($Ca(OH)_2$).

Step 2: Review the chemical manufacture reaction:

$$Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$$

Step 3: Determine the chemical formula of the product. The primary active component generated in this reaction is Calcium oxychloride, written as $CaOCl_2$.

Step 4: Analyze alternative formulas. $CaCO_3$ is Calcium carbonate (limestone). $Ca(OH)_2$ is Calcium hydroxide (slaked lime). $CaCl_2$ is Calcium chloride, a simple salt.

Step 5: Select the formula for bleaching powder. Based on chemical production standards, the principal chemical constituent of bleaching powder is $CaOCl_2$.

Final Answer: $\boxed{CaOCl_2}$

Answer: (B) Go Back to Question 23

Q24.

Solution

Concept: Phase changes are physical transitions between different states of matter governed by ambient temperature, pressure, and intermolecular forces.

Solution: Step 1: Define standard phase transitions. Typically, heating a solid increases its thermal energy, causing it to melt into a liquid (fusion). Further heating converts the liquid into a gas (vaporization).

Step 2: Examine the direct phase transition bypassing the liquid state. Certain substances possess intermolecular forces and vapor pressures that cause them to transition directly from a solid to a gas upon heating, without melting into a liquid.

Step 3: Define Sublimation. This specific direct transition from the solid phase directly to the gaseous phase is known as sublimation. Common examples include dry ice, iodine, and naphthalene.

Step 4: Define alternative terms. Vaporization is the transition from liquid to gas. Condensation is the transition from gas to liquid. Fusion is the transition from solid to liquid.

Step 5: Conclude the definitive term. The process described in the question, where a substance transitions directly from solid to gas, is sublimation.

Final Answer: Sublimation

Answer: (C) Go Back to Question 24

Q25.

Solution

Concept: According to Dalton's Law of Partial Pressures, the partial pressure exerted by an individual gas in a non-reacting mixture is directly proportional to its mole fraction in that mixture.

Solution: Step 1: Establish the mass conditions. Let the mass of both oxygen gas (O_2) and methane gas (CH_4) in the vessel be w grams.

Step 2: Calculate the molar masses of both gases using the provided atomic masses:

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

$$\text{Molar mass of } CH_4 = 12 + (1 \times 4) = 16 \text{ g/mol}$$

Step 3: Determine the number of moles (n) of each gas:

$$n_{O_2} = \frac{w}{32}$$

$$n_{CH_4} = \frac{w}{16} = \frac{2w}{32}$$

Step 4: Calculate the total number of moles in the gas mixture:

$$n_{\text{total}} = n_{O_2} + n_{CH_4} = \frac{w}{32} + \frac{2w}{32} = \frac{3w}{32}$$

Step 5: Calculate the mole fraction (X) of oxygen gas:

$$X_{O_2} = \frac{n_{O_2}}{n_{\text{total}}} = \frac{\frac{w}{32}}{\frac{3w}{32}} = \frac{1}{3}$$

By Dalton's law, the partial pressure fraction equals the mole fraction. Therefore, the fraction of the total pressure exerted by oxygen is $1/3$.

Final Answer: $1/3$

Answer: (B) Go Back to Question 25

Answer Key

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