

NCERT Class 9: Atomic Foundations of Matter - Ultimate Question Bank

This document contains a comprehensive question bank structured specifically for NCERT Class 9 (Science/Chemistry) covering the foundational macroscopic and particulate laws of chemistry: the Law of Conservation of Mass, the Law of Definite Proportions (Constant Proportions), Dalton's Atomic Theory, the concept of atoms and molecules, atomic mass unit (u), molecular mass, formula unit mass, ions (cations and anions), polyatomic ions, and writing chemical formulas using the criss-cross valency method. All questions strictly follow the Class 9 framework while challenging students to think deeply and logically.

1. Easy Level Segment

Multiple Choice Questions (20 Items)

1. The Law of Conservation of Mass was strictly formulated by: (a) John Dalton, (b) Antoine Lavoisier, (c) Joseph Proust, (d) J.J. Thomson
2. "In a chemical substance, the elements are always present in definite proportions by mass." This law was given by: (a) Lavoisier, (b) Proust, (c) Dalton, (d) Avogadro
3. The smallest particle of an element that can take part in a chemical reaction is called a/an: (a) Molecule, (b) Atom, (c) Ion, (d) Compound
4. Which of the following contains a polyatomic ion? (a) NaCl, (b) MgO, (c) CaCO₃, (d) CaCl₂
5. The atomic mass unit (u) is defined as exactly: (a) The mass of a Hydrogen atom, (b) 1/12th the mass of a Carbon-12 atom, (c) The mass of an Oxygen atom, (d) 1/16th the mass of a Carbon-12 atom
6. What is the atomicity of a phosphorus molecule? (a) Monoatomic, (b) Diatomic, (c) Triatomic, (d) Tetraatomic
7. The chemical formula of Magnesium Chloride is: (a) MgCl, (b) Mg₂Cl, (c) MgCl₂, (d) Mg₂Cl₂
8. A charged particle formed by the gain or loss of electrons is called a/an: (a) Atom, (b) Molecule, (c) Ion, (d) Element
9. The molecular mass of water (H₂O) is (Given H = 1 u, O = 16 u): (a) 17 u, (b) 18 u, (c) 16 u, (d) 2 u
10. The valency of Carbon in Carbon Dioxide (CO₂) is: (a) 2, (b) 4, (c) 1, (d) 3
11. Which of the following is a diatomic molecule? (a) Helium, (b) Oxygen, (c) Water, (d) Ozone
12. Formula unit mass is used instead of molecular mass for substances containing: (a) Non-metals only, (b) Gases, (c) Ions/Metals combined with non-metals, (d) Organic molecules
13. The cluster of atoms that behaves as a single charged unit is called a: (a) Monoatomic ion, (b) Polyatomic ion, (c) Diatomic molecule, (d) Covalent compound
14. The symbol for the element Sodium is derived from its Latin name Natrium. It is written as: (a) So, (b) Sd, (c) Na, (d) Nu
15. The atomicity of Ozone (O₃) is: (a) 1, (b) 2, (c) 3, (d) 4

16. A cation is formed when an atom: (a) Gains protons, (b) Loses electrons, (c) Gains electrons, (d) Loses neutrons
17. The formula unit mass of Calcium Oxide (CaO) is (Given Ca = 40 u, O = 16 u): (a) 56 u, (b) 40 u, (c) 16 u, (d) 32 u
18. According to Dalton's Atomic Theory, atoms: (a) Can be broken down into subatomic particles during extreme reactions, (b) Are indivisible and indestructible particles, (c) Of different elements can have identical masses, (d) Change their identities in reactions
19. The chemical formula for Ammonium Carbonate is: (a) NH_4CO_3 , (b) $(\text{NH}_4)_2\text{CO}_3$, (c) $\text{NH}_4(\text{CO}_3)_2$, (d) $(\text{NH}_3)_2\text{CO}_3$
20. Anion carries a: (a) Positive charge, (b) Negative charge, (c) Neutral state, (d) Variable fluctuating charge

Answer Key (Easy MCQs): 1-(b), 2-(b), 3-(b), 4-(c), 5-(b), 6-(d), 7-(c), 8-(c), 9-(b), 10-(b), 11-(b), 12-(c), 13-(b), 14-(c), 15-(c), 16-(b), 17-(a), 18-(b), 19-(b), 20-(b)

Subjective Questions (20 Items)

1. State the Law of Conservation of Mass with a suitable conceptual example.
2. Explain the Law of Constant Proportions using water as an illustrative example.
3. Write down two major limitations or drawbacks of Dalton's Atomic Theory based on modern knowledge.
4. Define the term 'Atomicity' and classify the following: He, H_2 , P_4 , S_8 .
5. What is a polyatomic ion? Give the formulas and charges of two distinct polyatomic anions.
6. Write the chemical formulas for: (i) Aluminum Sulfate, (ii) Calcium Hydroxide.
7. Distinguish clearly between the terms 'Molecular Mass' and 'Formula Unit Mass'.
8. Calculate the molecular mass of Nitric Acid (HNO_3). (Given: H = 1 u, N = 14 u, O = 16 u).
9. Why is it not possible to see an atom with our naked eyes? Explain in terms of scale.
10. An atom of an element X shows a valency of 3, and an atom of Y shows a valency of 2. Write the formula of the compound formed between X and Y.
11. Define an atomic mass unit (u). Why was Carbon-12 chosen as the universal standard?
12. What is the difference between a cation and an anion? Give one example of each with symbols.
13. Write the names of the elements present in the following chemical compounds: (i) Quicklime, (ii) Baking soda.
14. Explain why the formula of Sodium Chloride is written as NaCl and not Na_2Cl or NaCl_2 based on valencies.
15. A 5.3 g sample of Sodium Carbonate reacted with 6.0 g of Ethanoic Acid. The products were 2.2 g of Carbon Dioxide, 0.9 g of water, and 8.2 g of Sodium Ethanoate. Show that these observations are in agreement with the law of conservation of mass.
16. Define 'Valency'. How does it help in predicting the formula of a compound?
17. What is meant by saying that the atomicity of noble gases is one?
18. Calculate the formula unit mass of Carbonate ion containing compounds like Zinc Carbonate (ZnCO_3). (Given: Zn = 65 u, C = 12 u, O = 16 u).
19. State the postulates of Dalton's atomic theory regarding the nature of atoms combining to form compounds.
20. Give the symbols and charges of the following radicals: (i) Ammonium, (ii) Nitrate, (iii) Phosphate.

2. Moderate Level Segment

Multiple Choice Questions (20 Items)

1. In a compound containing Hydrogen and Oxygen, the mass ratio is always 1:8. If a reaction vessel contains 3 g of Hydrogen gas, what is the maximum mass of Oxygen gas that can completely react with it? (a) 8 g, (b) 24 g, (c) 16 g, (d) 32 g
2. An element X forms an oxide with the formula X_2O_3 . The valency of X is: (a) 2, (b) 3, (c) 1, (d) 6
3. The mass ratio of Calcium to Oxygen in Calcium Oxide is 5:2. If 20 g of Calcium is burned completely in air, the mass of Calcium Oxide formed is: (a) 28 g, (b) 8 g, (c) 40 g, (d) 50 g
4. Which of the following contains the maximum number of atoms? (a) 18 u of H_2O , (b) 18 u of O_2 , (c) 18 u of CO_2 , (d) 18 u of He
5. The formula of a metal ion is M^{2+} and its phosphate formula will be: (a) MPO_4 , (b) $M_3(PO_4)_2$, (c) $M_2(PO_4)_3$, (d) M_3PO_4
6. The ratio by mass of Carbon and Oxygen in Carbon Monoxide is: (a) 3:4, (b) 3:8, (c) 1:2, (d) 12:16
7. A compound contains elements A and B. A has a valency of 4 and B has a valency of 2. The simplified empirical formula of the compound is: (a) A_2B_4 , (b) AB_2 , (c) A_2B , (d) AB
8. The total number of atoms present in one formula unit of Copper Sulfate Pentahydrate ($CuSO_4 \cdot 5H_2O$) is: (a) 6, (b) 9, (c) 21, (d) 15
9. Which of the following statements matches Dalton's theory with the Law of Definite Proportions? (a) Atoms are indivisible, (b) Atoms of different elements have different masses, (c) The relative number and kinds of atoms are constant in a given compound, (d) Atoms are neither created nor destroyed
10. The formula unit mass of Sodium Carbonate (Na_2CO_3) is (Given Na = 23 u, C = 12 u, O = 16 u): (a) 106 u, (b) 83 u, (c) 53 u, (d) 116 u
11. An element Z forms a nitride with the formula Z_3N_2 . The formula of its sulfate will be: (a) ZSO_4 , (b) $Z_2(SO_4)_3$, (c) $Z_3(SO_4)_2$, (d) $Z(SO_4)_2$
12. The atomicity of a molecule of Ethanoic Acid (CH_3COOH) is: (a) 4, (b) 8, (c) 6, (d) 7
13. A sample of pure ammonia gas (NH_3) prepared by three different chemical routes always contains Nitrogen and Hydrogen in a mass ratio of 14:3. This proves the validity of: (a) Law of Conservation of Mass, (b) Law of Definite Proportions, (c) Law of Multiple Proportions, (d) Dalton's atomic postulate
14. The total number of individual ions in one formula unit of Aluminum Nitrate is: (a) 2, (b) 3, (c) 4, (d) 13
15. If the atomic mass of Carbon was redefined to be 100 u instead of 12 u, the absolute mass of one atom of carbon would: (a) Increase, (b) Decrease, (c) Remain unchanged, (d) Become relative
16. The valency of iron in Fe_2O_3 and FeO are respectively: (a) 2 and 3, (b) 3 and 2, (c) 2 and 1, (d) 3 and 4
17. Which of the following ions is divalent and polyatomic? (a) Sulfate, (b) Ammonium, (c) Chloride, (d) Phosphate
18. The molecular mass of Ethanol (C_2H_5OH) is: (a) 46 u, (b) 30 u, (c) 44 u, (d) 52 u
19. An element M forms a chloride MCl_3 . The formula of its carbonate is: (a) MCO_3 , (b) $M_2(CO_3)_3$, (c) $M_3(CO_3)_2$, (d) $M(CO_3)_3$
20. The mass percentage of Oxygen in a molecule of Hydrogen Peroxide (H_2O_2) is approximately: (a) 50%, (b) 94.1%, (c) 88.9%, (d) 6.2%

Answer Key (Moderate MCQs): 1-(b), 2-(b), 3-(a), 4-(d), 5-(b), 6-(a), 7-(b), 8-(c), 9-(c), 10-(a), 11-(a), 12-(b), 13-(b), 14-(c), 15-(c), 16-(b), 17-(a), 18-(a), 19-(b), 20-(b)

Subjective Questions (20 Items)

1. A compound XH_3 contains 82.35% of X by mass. If the remaining mass belongs to Hydrogen, calculate the mass of X that combines with 1 g of Hydrogen.
2. Explain why Dalton's hypothesis that "atoms are indivisible" had to be modified following later scientific breakthroughs.
3. A sample of Calcium Carbonate contains 40% Calcium, 12% Carbon, and 48% Oxygen by mass. If we decompose a 50 g sample of pure Calcium Carbonate, what masses of Calcium, Carbon, and Oxygen will be accounted for?
4. Write down the chemical formulas of the following compounds by showing the criss-cross system of valencies explicitly: (i) Aluminum Oxide, (ii) Ferric Sulfate.
5. Deduce the atomicity and calculate the molecular mass of Chloroform (CHCl_3). (Given C = 12 u, H = 1 u, Cl = 35.5 u).
6. An element A has a variable valency of 2 and 4. Write down the formulas of the two distinct oxides it can form and name them.
7. Explain why the mass of a molecule of Carbon Dioxide is always 44 u when using the atomic mass unit scale.
8. Give the chemical formulas for the following combinations: (i) Potassium and Dichromate, (ii) Ammonium and Phosphate.
9. Verify the Law of Conservation of Mass for the thermal decomposition of 10 g of Calcium Carbonate, which yields 5.6 g of Calcium Oxide and 4.4 g of Carbon Dioxide.
10. Why do we write the formula of copper(II) chloride as CuCl_2 but copper(I) chloride as CuCl ? Explain in terms of stable valency states.
11. Verify the mass ratio of elements in Magnesium Nitride (Mg_3N_2). (Given Mg = 24 u, N = 14 u).
12. An element Y forms a compound $\text{Y}(\text{NO}_3)_3$. What will be the chemical formula of its oxide, chloride, and phosphate?
13. Explain the term 'Formula Unit' and why it is specifically applied to ionic crystals like Sodium Nitrate instead of individual molecules.
14. Calculate the total number of constituent atoms present in 34 u of Ammonia (NH_3) molecules.
15. Explain how Dalton's atomic theory accounts for the observation that when elements react to form compounds, they do so in simple whole-number ratios of their atoms.
16. Write the formulas for: (i) Sodium Sulfite, (ii) Sodium Sulfide, (iii) Sodium Sulfate. Pay careful attention to the suffixes.
17. Determine the ratio by mass of the combining elements in Carbon Disulfide (CS_2). (Given C = 12 u, S = 32 u).
18. A metal M forms an oxide MO . Identify the valency of the metal and write the formula of its bicarbonate.
19. Explain why hydrogen gas exists as H_2 molecules while Helium exists as independent He atoms in nature.
20. Calculate the molecular mass of Sucrose ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) using standard masses: C = 12 u, H = 1 u, O = 16 u.

3. Difficult Level Segment

Multiple Choice Questions (20 Items)

1. Two elements P and Q combine to form two different compounds. In the first compound, 0.3 g of P combines with 0.4 g of Q. In the second compound, 1.2 g of P combines with 3.2 g of Q. The ratio of masses of Q that combine with a fixed mass of P across these

- compounds demonstrates the existence of multiple combinations, but for the first compound, the mass percentage of P is: (a) 42.8%, (b) 57.1%, (c) 75%, (d) 25%
- An element M forms an acetate with the formula $(\text{CH}_3\text{COO})_3\text{M}$. The formula of its pyrophosphate (where pyrophosphate ion is $\text{P}_2\text{O}_7^{4-}$) will be: (a) $\text{M}_4(\text{P}_2\text{O}_7)_3$, (b) $\text{M}(\text{P}_2\text{O}_7)$, (c) $\text{M}_2(\text{P}_2\text{O}_7)_3$, (d) $\text{M}_3(\text{P}_2\text{O}_7)_4$
 - A mixture of 10 g of Hydrogen gas and 64 g of Oxygen gas is ignited in a steel bomb. The amount of unreacted water-forming reactant left behind is: (a) 2 g of Hydrogen, (b) 8 g of Hydrogen, (c) 2 g of Oxygen, (d) 4 g of Hydrogen
 - An element X has an atomic mass of 24 u. It combines with an element Y (atomic mass = 16 u) to form a compound containing 60% of X by mass. The empirical formula of this compound is: (a) XY, (b) X_2O_3 , (c) XY_2 , (d) X_3Y_2
 - A sample of a compound contains 2.4 g of Carbon, 0.4 g of Hydrogen, and 3.2 g of Oxygen. The simplest whole-number ratio of atoms of C, H, and O in this compound is: (a) 1:2:1, (b) 2:4:1, (c) 1:1:1, (d) 1:4:2
 - The formula unit mass of a hydrated metal salt $\text{MSO}_4 \cdot x\text{H}_2\text{O}$ is 246 u. If the atomic mass of M is 24 u, the value of x must be (Given S = 32 u, O = 16 u, H = 1 u): (a) 5, (b) 6, (c) 7, (d) 2
 - Two elements X (valency = 3) and Y (valency = 2) react. If 0.1 formula units of the compound X_2Y_3 are produced, the total number of atomic valency bonds satisfied across the reaction components matches a specific structure. The formula of the compound containing X and a polyatomic silicate radical (SiO_3^{2-}) is: (a) $\text{X}(\text{SiO}_3)_3$, (b) $\text{X}_2(\text{SiO}_3)_3$, (c) $\text{X}_3(\text{SiO}_3)_2$, (d) XSiO_3
 - A certain gas molecule has an atomicity of 4 and its molecular mass is 124 u. The atomic mass of the constituent element is: (a) 31 u, (b) 62 u, (c) 16 u, (d) 14 u
 - An element A forms an oxide AO_2 . Another element B forms a chloride BCl_3 . The formula of the compound formed between A and B, assuming A exhibits its maximum group valency from the oxide, is: (a) BA_2 , (b) B_4A_3 , (c) B_2A_3 , (d) BA
 - The mass percentage of water of crystallization in Green Vitriol ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) is approximately (Given Fe = 56, S = 32, O = 16, H = 1): (a) 45.3%, (b) 54.7%, (c) 10%, (d) 25.5%
 - According to the laws of chemical combination, when 100 g of mercuric oxide is heated, it breaks down into 92.6 g of mercury and 7.4 g of oxygen. If we take 50 g of mercuric oxide, the mass of oxygen produced will be: (a) 7.4 g, (b) 3.7 g, (c) 14.8 g, (d) 5.0 g
 - An ionic compound is made of a metal M and a non-metal N. M forms a stable cation M^{3+} and N forms an anion N^{2-} . The total number of nucleons in a formula unit depends on their individual isotopes, but the formula of the compound is: (a) MN, (b) M_2N_3 , (c) M_3N_2 , (d) M_2N
 - The ratio of the masses of nitrogen and hydrogen in a molecule of ammonium ion (NH_4^+) is: (a) 14:3, (b) 14:4, (c) 7:2, (d) 14:1
 - A sample of calcium chloride (CaCl_2) contains 3.6×10^{24} calcium ions. The number of chloride ions present in the same sample is: (a) 3.6×10^{24} , (b) 7.2×10^{24} , (c) 1.8×10^{24} , (d) 1.2×10^{24}
 - An element X forms a compound with formula $\text{X}(\text{HPO}_4)_2$. The valency of X in this compound is: (a) 2, (b) 4, (c) 1, (d) 3
 - The molecular mass of a compound A_2B_3 is 150 u. If the atomic mass of B is 32 u, the atomic mass of A is: (a) 27 u, (b) 54 u, (c) 56 u, (d) 23 u
 - Which of the following contains the same number of atoms as 12 u of Carbon-12? (a) 1 u of Hydrogen, (b) 4 u of Helium, (c) 16 u of Oxygen, (d) All of the above relative weights contain an equal count of their respective atoms
 - A compound of formula $\text{M}(\text{NO}_3)_2$ contains 14.2% nitrogen by mass. The atomic mass of the metal M is closest to (Given N = 14 u, O = 16 u): (a) 24 u, (b) 40 u, (c) 65 u, (d) 56 u

19. The atomicities of Nitrogen, Fluorine, Sulfur, and Argon are respectively: (a) 2, 2, 8, 1, (b) 2, 1, 4, 1, (c) 1, 2, 8, 2, (d) 2, 2, 4, 2
20. The formula unit mass of Alum $[K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O]$ is: (a) 948 u, (b) 474 u, (c) 258 u, (d) 1050 u

Answer Key (Difficult MCQs): 1-(a), 2-(a), 3-(b), 4-(a), 5-(a), 6-(c), 7-(b), 8-(a), 9-(b), 10-(a), 11-(b), 12-(b), 13-(c), 14-(b), 15-(b), 16-(a), 17-(d), 18-(b), 19-(a), 20-(a)

Subjective Questions (20 Items)

1. An element X forms a compound X_2O_5 . If the mass percentage of Oxygen in the compound is 56.34%, calculate the accurate atomic mass of element X.
2. When 4.2 g of Sodium Bicarbonate is added to a solution of Hydrochloric acid weighing 10.0 g, it is observed that 2.2 g of Carbon Dioxide gas escapes into the atmosphere. The mass of the residue left behind in the flask is measured to be 12.0 g. Show that these experimental steps rigorously validate the Law of Conservation of Mass.
3. A monovalent metal M reacts with a polyatomic acid radical to form a compound $M_2C_2O_4$. Identify the valency and charge of the radical C_2O_4 and write down the formula of its compound with Aluminum.
4. Explain why Dalton's theory could not explain the laws of gaseous volumes (Gay-Lussac's law) while staying strictly within the paradigm of indivisible solid atoms.
5. A crystalline substance loses 45.5% of its mass upon heating due to the complete loss of its water of crystallization. If the anhydrous residue is Sodium Carbonate (Na_2CO_3), determine the number of water molecules (x) present in the original hydrated formula $Na_2CO_3 \cdot xH_2O$.
6. An element Z forms a chloride ZCl_4 . The mass ratio of Z to Cl in the compound is 1:3.88. Find the atomic mass of Z and identify the element.
7. Calculate the total mass of individual atoms present in 5 formula units of Ammonium Ferric Sulfate $[NH_4Fe(SO_4)_2 \cdot 6H_2O]$.
8. Design a logical argument to prove why the formula unit mass of a compound like Potassium Nitrate (KNO_3) must be a constant value regardless of the source or method of preparation of the sample.
9. An element A forms a stable ion A^{3+} and an element B forms an ion B^{2-} . Deduce the chemical formula of the compound. If the atomic mass of A is 27 u and B is 16 u, find the formula unit mass.
10. Explain how the modern definition of atomic mass using Carbon-12 relates to the physical balance weighing system, showing why it represents a relative mass scale rather than absolute values.
11. A compound consists of 43.4% Sodium, 11.3% Carbon, and 45.3% Oxygen by mass. Find its empirical formula.
12. A metal M forms an oxide with the formula M_2O_3 . If the metal M contains 14 neutrons in its nucleus and its atomic mass is 27 u, find the number of protons and electrons in the neutral atom and write its chloride formula.
13. Explain the precise difference between $2H$, H_2 , and H^+ in chemical notation terms.
14. Calculate the percentage by mass of Nitrogen in Urea $[CO(NH_2)_2]$. (Given C = 12 u, O = 16 u, N = 14 u, H = 1 u).
15. A compound of sulfur and oxygen contains 50% sulfur by mass. Find the atomicity ratio of sulfur to oxygen in one molecule of this gas and write its formula.
16. A certain polyatomic ion is represented as XO_4^{3-} . If the valency of element X in this ion is 5, show how the net charge of -3 arises mathematically based on common oxygen charges.
17. Calculate the formula unit mass of anhydrous Copper Sulfate ($CuSO_4$) and compare it

- with the mass of its pentahydrate form. (Given Cu = 63.5 u, S = 32 u, O = 16 u, H = 1 u).
18. A metal carbonate MCO_3 yields 56% metal oxide MO and 44% carbon dioxide by mass upon heating. If the mass of carbon dioxide released from a sample is 4.4 g, what was the initial mass of the metal carbonate?
 19. Explain why polyatomic ions like Nitrate (NO_3^-) and Hydroxide (OH^-) remain tightly bound as a single unit during simple displacement chemical reactions.
 20. An element forms an oxide XO_3 . If it forms a compound with Calcium, what will be the formula of the calcium salt of the corresponding anion formed by X? Explain using valency balances.

4. Olympiad Level Segment

Multiple Choice Questions (20 Items)

1. An element X forms a compound with hydrogen having the formula XH_3 . It forms another compound with oxygen. If the mass ratio of X to O in the oxide compound is 7:20, and the valency of X in the oxide is 5, the true atomic mass of X is: (a) 14 u, (b) 31 u, (c) 15 u, (d) 52 u
2. A mixture containing only Calcium Carbonate (CaCO_3) and Magnesium Carbonate (MgCO_3) is heated until all carbon dioxide is driven off. The mass of the residual oxide mixture is exactly half the mass of the initial carbonate mixture. The mass percentage of CaCO_3 in the original mixture is closest to (Given Ca=40, Mg=24, C=12, O=16): (a) 28.4%, (b) 71.6%, (c) 50.0%, (d) 36.2%
3. An element A has a relative atomic mass of 27 u. It forms a complex coordination-like double salt with Potassium and Sulfate radicals, containing water of crystallization. If the mass percentage of water in the compound is 45.56%, the formula matches a standard alum. The total number of atoms in one formula unit of this double salt $[\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}]$ is: (a) 48, (b) 52, (c) 40, (d) 36
4. A container holds a gaseous mixture of two diatomic gases A_2 and B_2 . The mass ratio of A_2 to B_2 in the container is 1:2. If the atomic mass of A is 4 times that of B, the ratio of the number of atoms of A to the number of atoms of B in the container is: (a) 1:8, (b) 1:4, (c) 1:2, (d) 2:1
5. A pure sample of an iron oxide compound contains 69.9% iron and 30.1% oxygen by mass. The simplest particulate formula matching this law of constant proportions is: (a) FeO , (b) Fe_2O_3 , (c) Fe_3O_4 , (d) FeO_2
6. A polyatomic anion is represented as $[\text{M}(\text{CN})_6]^{3-}$. The valency/charge state of the transition metal M in this radical, assuming each cyanide group (CN) carries a charge of -1, is: (a) +2, (b) +3, (c) +4, (d) +6
7. The Law of Definite Proportions breaks down or shows apparent deviations for compounds that: (a) Contain heavy radioactive elements, (b) Are prepared under high pressure, (c) Contain elements that exist as different isotopes with significantly different natural abundance ratios across locations, (d) Are gaseous at room temperature
8. An organic liquid compound contains Carbon, Hydrogen, and Oxygen. Combustion analysis of a sample shows that the ratio of the mass of Carbon to the mass of Hydrogen is 6:1, and the ratio of the mass of Carbon to the mass of Oxygen is 3:4. The empirical molecular formula of the compound is: (a) CH_2O , (b) $\text{C}_2\text{H}_4\text{O}$, (c) CHO_2 , (d) $\text{C}_2\text{H}_4\text{O}_2$
9. A metal M forms a compound with the formula M_2O_7 . The stable chloride of this metal where it exhibits a valency equal to half its valency in the oxide (rounded down to a whole number) will be: (a) MCl_3 , (b) MCl_4 , (c) MCl_2 , (d) MCl

10. The formula unit mass of a compound with formula $A_x B_y$ is 110 u. If the atomic masses of A and B are 14 u and 16 u respectively, the values of x and y are: (a) $x=2, y=3$, (b) $x=1, y=6$, (c) $x=3, y=4$, (d) $x=2, y=5$
 11. A sample of water contains 11.11% Hydrogen and 88.89% Oxygen by mass. Another sample of water obtained from an underground glacier contains 20.00% Deuterium (heavy isotope of hydrogen, ^2H) and 80.00% Oxygen by mass. The apparent shift in mass ratios across these two pure water samples is an explicit manifestation of: (a) Breakdown of the law of conservation of mass, (b) Isotopic variation influencing the macroscopic mass ratios within the framework of constant proportions, (c) Experimental error, (d) Formation of a new element
 12. An element X forms a volatile chloride XCl_3 with a molecular mass of 137.5 u. The valency of X is 3. The formula of its stable orthophosphate salt is: (a) XPO_4 , (b) $\text{X}_3(\text{PO}_4)_2$, (c) $\text{X}(\text{PO}_4)_3$, (d) $\text{X}_2(\text{PO}_4)_3$
 13. A crystalline salt of formula $\text{Na}_2\text{SO}_4 \cdot x\text{H}_2\text{O}$ contains 55.9% water of crystallization by mass. The value of x is: (a) 5, (b) 7, (c) 10, (d) 12
 14. A compound contains 3 atoms of element A for every 2 atoms of element B. The mass percentage of A in the compound is 60%. The ratio of the atomic mass of A to the atomic mass of B is: (a) 4:9, (b) 9:4, (c) 2:3, (d) 3:2
 15. An element M forms an entry in a chemistry table. The formula of its thiosulfate is $\text{M}_2\text{S}_2\text{O}_3$. The formula of its nitride will be: (a) MN , (b) M_3N , (c) M_3N_2 , (d) MN_3
 16. The total number of valence electrons present in one single formula unit of Sodium Azide (NaN_3) is: (a) 15, (b) 16, (c) 24, (d) 8
 17. A block of pure copper contains two isotopes, ^{63}Cu and ^{65}Cu . The average atomic mass of the copper block is 63.5 u. The mass ratio of ^{63}Cu to ^{65}Cu in the block is: (a) 3:1, (b) 1:3, (c) 75:25, (d) 3:1 by atom count, but by mass it is 189:65
 18. An element forms an oxide in which the mass percentage of the element is 50%. The valency of the element in this oxide is 4. The atomic mass of the element is: (a) 32 u, (b) 16 u, (c) 64 u, (d) 12 u
 19. A certain non-metallic compound has the formula $\text{N}_x \text{O}_y$. The mass ratio of Nitrogen to Oxygen is 7:16. The value of x and y must satisfy the ratio: (a) 1:2, (b) 2:1, (c) 2:3, (d) 1:1
 20. The formula unit mass of a coordination-like compound $\text{K}_4[\text{Fe}(\text{CN})_6]$ is calculated using $\text{K}=39, \text{Fe}=56, \text{C}=12, \text{N}=14$. Its value is: (a) 368 u, (b) 412 u, (c) 184 u, (d) 298 u
- Answer Key (Olympiad MCQs):** 1-(a), 2-(b), 3-(a), 4-(b), 5-(b), 6-(b), 7-(c), 8-(a), 9-(a), 10-(a), 11-(b), 12-(a), 13-(c), 14-(a), 15-(b), 16-(b), 17-(d), 18-(a), 19-(a), 20-(a)

Subjective Questions (20 Items)

1. An element X combines with oxygen to form two distinct oxides, A and B. Oxide A contains 63.2% of X, and Oxide B contains 46.7% of X by mass. Show that these data validate the Law of Multiple Proportions within the Class 9 conceptual domain by finding the whole-number ratio of oxygen masses combining with a fixed mass of X.
2. A mixture of 5.00 g of Hydrogen gas and an unknown mass of Oxygen gas is exploded in a sealed container. After the reaction returns to room temperature, it is found that all the oxygen has reacted to form water, leaving behind 1.00 g of unreacted Hydrogen gas. Calculate the mass of Oxygen originally present in the mixture and the mass of water formed, using the laws of chemical combination.
3. A metal M forms a compound with the formula $\text{M}(\text{HCO}_3)_2$. Deduce the formula of its oxide, silicate (SiO_3^{2-}), ferricyanide ($[\text{Fe}(\text{CN})_6]^{3-}$), and dichromate ($\text{D}_2\text{O}_7^{2-}$ equivalent).
4. Analyze why Dalton's choice of defining the atomic mass unit relative to Hydrogen initially had to be changed to Oxygen, and finally to Carbon-12. Explain the operational advantages of using Carbon-12 in terms of isotopic stability and chemical combinations.

5. A 2.50 g sample of a hydrated copper sulfate crystal ($\text{CuSO}_4 \cdot x\text{H}_2\text{O}$) is heated strongly in a crucible until it turns into an anhydrous white powder. The mass of the anhydrous powder is found to be 1.60 g. Deduce the value of x using atomic masses: $\text{Cu}=63.5 \text{ u}$, $\text{S}=32 \text{ u}$, $\text{O}=16 \text{ u}$, $\text{H}=1 \text{ u}$.
6. An element A combines with Chlorine to form a compound ACl_5 . The same element forms an oxide containing 43.6% of A by mass. Find the empirical formula of the oxide and deduce the atomic mass of A.
7. Calculate the total mass unit value of all the polyatomic anions present in 3 formula units of Ammonium Magnesium Phosphate Hexahydrate $[\text{NH}_4\text{MgPO}_4 \cdot 6\text{H}_2\text{O}]$.
8. Provide a rigorous explanation for why the law of conservation of mass holds true at a sub-microscopic level during a chemical reaction according to Dalton's atomic theory, and explain why a nuclear transmutation process does not obey this law.
9. An element X forms an ion X^{5+} under extreme conditions. It reacts with an element Y that forms a stable Y^{2-} ion. Write the chemical formula of the compound. If the formula unit mass of X_2Y_5 is 270 u and the atomic mass of Y is 32 u, find the atomic mass of X.
10. Explain why the formula unit of an ionic compound like Calcium Fluoride (CaF_2) represents a ratio in a massive continuous network crystal lattice rather than an independent, isolated molecular entity.
11. A 10.0 g sample of an organic compound containing only Carbon, Hydrogen, and Nitrogen is analyzed. It contains 40.0% Carbon and 6.7% Hydrogen by mass, with the remainder being Nitrogen. Determine its empirical formula.
12. A metal M forms an entry in a mineral analysis with a formula $\text{M}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$. If the formula unit mass of this hydrated double-salt component is 948 u, find the atomic mass of M and identify the trivalent metal.
13. Explain the precise difference between the mass of 1 atom of Oxygen, 1 molecule of Oxygen gas, and 1 molecule of Ozone using proper chemical notation and atomic mass units.
14. Calculate the percentage composition by mass of each element present in a molecule of Caffeine ($\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$). (Given $\text{C}=12 \text{ u}$, $\text{H}=1 \text{ u}$, $\text{N}=14 \text{ u}$, $\text{O}=16 \text{ u}$).
15. A gaseous oxide of nitrogen contains 30.43% Nitrogen and 69.57% Oxygen by mass. Find the simple whole-number ratio of atoms in this compound and deduce its formula. What is its atomicity?
16. A complex radical is represented as $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$. Show how the net charge of +2 arises on this polyatomic cation, assuming the Cobalt atom has a valency/charge of +3, each ammonia molecule (NH_3) is neutral, and the chloride group carries a charge of -1.
17. Calculate the formula unit mass of Potassium Permanganate (KMnO_4) and Sodium Dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7$). (Given $\text{K}=39 \text{ u}$, $\text{Mn}=55 \text{ u}$, $\text{O}=16 \text{ u}$, $\text{Na}=23 \text{ u}$, $\text{Cr}=52 \text{ u}$).
18. A sample of contaminated limestone contains Calcium Carbonate (CaCO_3) and inert sand silica impurities. When 20.0 g of this sample is heated, it yields 6.6 g of Carbon Dioxide gas. Calculate the percentage purity of CaCO_3 in the limestone sample.
19. Explain why structural formulas and valency balancing concepts work perfectly for predicting stable compound formulas but fail to predict the physical states (solid, liquid, or gas) of those compounds.
20. An element X forms a stable chloride XCl_3 . When X is treated with a solution containing an abundance of carbonate ions, a precipitate forms. Deduce the chemical formula of this carbonate precipitate and calculate its formula unit mass if the atomic mass of X is 27 u.