3 ATOMS AND MOLECULES

CONCEPTS

1. **Law of conservation of mass :** Mass can neither be created nor can it be destroyed in a chemical reaction.
2. **Law of constant proportions :** In a pure substance same elements are always present in a definite proportion by weight.
3. **Atom :** Smallest unit of an element, which may or may not exist independently, but always takes part in a chemical reaction.
4. **Molecule :** Smallest unit of an element or a compound which always exists independently and retains the complete physical and chemical properties of the element or the compound.
5. **Atomicity of a molecule of an element :** It is the number of atoms which constitute one molecule of an element.
6. **Molecular formula :** The symbolic representation of the kind and the actual number of atoms in one molecule of a pure substance, may be an element or a compound.
7. **Atomic mass unit :** The mass of $\frac{1}{12}$ part of C-12 (isotope of carbon) is equivalent to one atomic mass unit.
8. **Gram-atomic mass :** The atomic mass of an element expressed in terms of grams.
9. **Atomic mass :** The number of times an atom of an element is heavier than $\frac{1}{12}$ part of C-12 (isotope of carbon).
10. **Molecular mass :** The number of times a molecule of a pure substance is heavier than $\frac{1}{12}$ part of C-12 (isotope of carbon).
11. **Gram-molecular mass :** The molecular mass of a pure substance expressed in grams.
12. **Mole :** A group of 6.022×10^{23} particles (atoms, molecules, ions, electrons, protons, neutrons, etc.) of a substance is called mole.
13. **Mole number :** It is a number which states, how many times one molecular mass comes in certain mass of a substance in grams.

I. SUMMATIVE ASSESSMENT

NCERT Questions with their answers

SECTION A : IN-TEXT QUESTIONS

Page 32

Q.1. In a reaction, 5.3 g of sodium carbonate reacted with 6 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.

Sodium carbonate + ethanoic acid → Sodium ethanoate + carbon dioxide + water.

Ans. Mass of reactants before experiment = Mass of sodium carbonate + Mass of ethanoic acid
= 5.3 g + 6 g = **11.3 g**

Mass of products after experiment = Mass of sodium ethanoate + Mass of carbon dioxide + Mass of water

= 8.2 g + 2.2 g + 0.9 g = **11.3 g**

As the mass of reactants (11.3 g) is equal to the mass of products (11.3 g), therefore, these masses are in agreement with the law of conservation of mass.

Q.2. Hydrogen and oxygen combine in the ratio of 1 : 8 by mass to form water. What mass of oxygen gas would be required to react completely with 3 g of hydrogen gas? **[2011 (T-II)]**

Ans. 1 g of hydrogen reacts with oxygen = 8 g

$\therefore$ 3 g of hydrogen reacts with oxygen = 8 × 3 g = **24 g**

Q.3. Which postulate of Dalton's atomic theory is the result of the law of mass conservation?

Ans. Atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction.

Q.4. Which postulate of Dalton's atomic theory can explain the law of definite proportions?

Ans. Atoms combine in the ratio of small whole numbers to form a compound.

Page 35

Q.1. Define atomic mass unit.

Ans. The mass of 1/12 part of C-12 (isotope of carbon) is equivalent to one atomic mass unit.

Q.2. Why is it not possible to see an atom with naked eyes?

Ans. The atomic radii of an atom is of the order 10^{-10} m to 10^{-9} m. It is too small, and hence, naked human eyes cannot see atoms.

Page 39

Q.1. Write down the formulae of :

(i) Sodium oxide (ii) Aluminium chloride

(iii) Sodium sulphide (iv) Magnesium hydroxide

Ans. (i) $2Na^+ + O^{2-} \rightarrow Na_2O$ (Sodium oxide)

(ii) $Al^{3+} + 3Cl^- \rightarrow AlCl_3$ (Aluminium chloride)

(iii) $2Na^+ + S^{2-} \rightarrow Na_2S$ (Sodium sulphide)

(iv) $Mg^{2+} + 2OH^- \rightarrow Mg(OH)_2$ (Magnesium hydroxide)

Q.2. Write down the names of compounds represented by the following formulae :

(i) $Al_2(SO_4)_3$ (ii) $CaCl_2$ (iii) K_2SO_4

(iv) KNO_3 (v) $CaCO_3$

Ans. (i) $Al_2(SO_4)_3$ is aluminium sulphate (ii) $CaCl_2$ is calcium chloride

(iii) K_2SO_4 is potassium sulphate (iv) KNO_3 is potassium nitrate

(v) $CaCO_3$ is calcium carbonate

Q.3. What is meant by the term chemical formula?

Ans. The symbolic representation of the kind and actual number of atoms in one molecule of a pure substance, may be an element or a compound is known as chemical formula.

Q.4 How many atoms are present in a :

(i) H_2S molecule, and (ii) PO_4^{3-} ion?

Ans. (i) 3 atoms are present in H_2S.

(ii) 5 atoms are present in PO_4^{3-}.

Page 40

Q.1. Calculate the molecular masses of :

(i) H_2 (ii) O_2 (iii) Cl_2 (iv) CO_2 (v) CH_4 (vi) C_2H_6 (vii)C_2H_4 (viii) NH_3 and (ix) CH_3OH.

Ans. (i) Molecular mass of H_2 = 2 × atomic mass of H = 2 × 1 *u* = **2 *u***

(ii) Molecular mass of O_2 = 2 × atomic mass of O = 2 ×16 *u* = **32 *u***

(iii) Molecular mass of Cl_2 = 2 × atomic mass of Cl = 2 ×35.5 *u* = **71 *u***

(iv) Molecular mass of CO_2 = 1 × atomic mass of C + 2 × atomic mass of O
= 1 × 12 *u* + 2 × 16 *u* = **44 *u***

(v) Molecular mass of CH_4 = 1 × atomic mass of C + 4 × atomic mass of H
= 1 × 12 *u* + 4 × 1 *u* = **16 *u***

(vi) Molecular mass of C_2H_6 = 2 × atomic mass of C + 6 × atomic mass of H
= 2 × 12 *u* + 6 × 1 *u* = **30 *u***

(vii) Molecular mass of C_2H_4 = 2 × atomic mass of C + 4 × atomic mass of H
= 2 × 12 *u* + 4 × 1 *u* = **28 *u***

(viii) Molecular mass of NH_3 = 1 × atomic mass of N + 3 × atomic mass of H
= 1 × 14 *u* + 3 × 1 u = **17 *u***

(ix) Molecular mass of CH_3OH= 1 × atomic mass of C + 4 × atomic mass of H
+ 1 × atomic mass of O
= 1 × 12 *u* + 4 × 1 *u* + 1 × 16 *u* = **32 *u***

Q.2. Calculate the formula unit masses of (i) ZnO, (ii) Na_2O, (iii) K_2CO_3.
[Zn = 65 u, O = 16 u, Na = 23 u, K = 39 u, C = 12 u]

Ans. (i) Formula unit mass of ZnO = 1 × atomic mass of Zn + 1 × atomic mass of O
= 1 × 65 *u* + 1 × 16 *u* = **81 *u***

(ii) Formula unit mass of Na_2O = 2 × atomic mass of Na + 1 × atomic mass of O
= 2 × 23 *u* + 1 × 16 *u* = **62 *u***

(iii) Formula unit mass of K_2CO_3 = 2 × atomic mass of K + 1 × atomic mass of C
+ 3 × atomic mass of O
= 2 × 39 *u* + 1 × 12 *u* + 3 × 16 u
= 78 *u* + 12 *u* + 48 *u* = **138 *u***

Page 42

Q.1. If one mole of carbon atoms weighs 12 grams, what is the mass (in grams) of 1 atom of carbon?

Ans. 1 mole (6.02×10^{23} atoms) of carbon weigh = 12 g

$$\therefore \quad \text{1 atom of carbon weigh} = \frac{12}{6.022 \times 10^{23}}\text{ g} = \mathbf{1.99 \times 10^{-23}\ g}$$

Q.2. Which has more number of atoms, 100 grams of sodium or 100 g of iron? (Given atomic mass of Na = 23 *u*, Fe = 56 *u*)

Ans. 23 g of sodium has atoms = N (Avogadro's number)

$\therefore$ 100 g of sodium has atoms = $\frac{100}{23}$ N = **4.3 N atoms**

Also 56 g of iron has atoms = N (Avogadro's number)

$\therefore$ 100 g of iron has atoms = $\frac{100}{56}$ N = **1.78 N atoms**

100 g of sodium has more atoms than 100 g of iron.

SECTION B : QUESTIONS AT THE END OF CHAPTER

Q.1. A 0.24 g sample of a compound of oxygen and boron was found by analysis to contain 0.096 g of boron and 0.144 g of oxygen. Calculate the percentage composition of the compound by weight.

Ans. % age of oxygen = $\frac{\text{wt. of oxygen}}{\text{wt. of sample}} \times 100 = \frac{0.144}{0.24} \times 100 =$ **60 %**

% age of boron = $\frac{\text{wt. of boron}}{\text{wt. of sample}} \times 100 = \frac{0.096}{0.24} \times 100 =$ **40 %**

Q.2. When 3.0 g of carbon is burnt in 8.00 g oxygen, 11.00 g of carbon dioxide is produced. What mass of carbon dioxide will be formed, when 3.00 g of carbon is burnt in 50.00 g of oxygen? Which law of chemical combination will govern your answer? **[2011 (T-II)]**

Ans. Weight of carbon dioxide produced from 3.0 g of carbon is 11.00 g.

The remaining oxygen, i.e., (50 – 8) = 42 g does not take part in the reaction.

The above data tells that the reaction between carbon and oxygen is governed by law of definite proportions.

Q.3. What are polyatomic ions? Give examples.

Ans. A charged particle formed by the union of two or more different atoms is called polyatomic ion.

Examples : Sulphate (SO_4^{2-}) ; Nitrate (NO_3^-); Phosphate (PO_4^{3-}) are polyatomic ions.

Q.4. Write the chemical formulae of the following :

(a) Magnesium chloride (b) Calcium oxide

(c) Copper nitrate (d) Aluminium chloride

(e) Calcium carbonate

Ans.

(a) Magnesium chloride	$Mg^{2+} + 2Cl^-$	$\longrightarrow$	$MgCl_2$
(b) Calcium oxide	$Ca^{2+} + O^{2-}$	$\longrightarrow$	CaO
(c) Copper nitrate	$Cu^{2+} + 2NO_3^-$	$\longrightarrow$	$Cu(NO_3)_2$
(d) Aluminium chloride	$Al^{3+} + 3Cl^-$	$\longrightarrow$	$AlCl_3$
(e) Calcium carbonate	$Ca^{2+} + CO_3^{2-}$	$\longrightarrow$	$CaCO_3$

Q.5. Give the names of the elements present in the following compounds :

(a) Quicklime (b) Hydrogen bromide

(c) Baking powder (d) Potassium sulphate

Ans. (a) Quicklime contains the elements calcium and oxygen.
(b) Hydrogen bromide contains the elements hydrogen and bromine.
(c) Baking powder consists of two compounds, i.e. baking soda (sodium hydrogen carbonate) and tartaric acid. The elements in baking soda are sodium, hydrogen, carbon and oxygen. In tartaric acid, the elements carbon, hydrogen and oxygen are present.
(d) Potassium sulphate contains the elements potassium, sulphur and oxygen.

Q.6. Calculate the molar mass of the following substances : **[2011 (T-II)]**
(a) Ethyne, (C_2H_2) (b) Sulphur molecule, (S_8)
(c) Phosphorus molecule, (P_4) (d) Hydrochloric acid, (HCl)
(e) Nitric acid, (HNO_3) [C = 12 *u*, H = 1 *u*, S = 32 *u*, P = 31 *u*, N = 14 *u*]

Ans. (a) Molar mass of ethyne, (C_2H_2) = 2 × atomic mass of C + 2 × atomic mass of H
= 2 × 12 *u* + 2 × 1 *u* = **26 *u***

(b) Molar mass of sulphur, (S_8) = 8 × atomic mass of S
= 8 × 32 *u* = **256 *u***

(c) Molar mass of phosphorus, (P_4) = 4 × atomic mass of P
= 4 × 31 *u* = **124 *u***

(d) Molar mass of hydrochloric acid, (HCl)
= 1 × atomic mass of H + 1 × atomic mass of Cl
= 1 × 1 *u* + 35.5 *u* = **36.5 *u***

(e) Molar mass of nitric acid, (HNO_3)
= 1 × atomic mass of H + 1 × atomic mass of N
+ 3 × atomic mass of O
= 1 × 1 *u* + 1 × 14 *u* + 3 × 16 *u* = **63 *u***

Q.7. What is the mass of :
(a) 1 mole of nitrogen atoms?
(b) 4 moles of aluminium atoms?
(c) 10 moles of sodium sulphite (Na_2SO_3)?
[N = 14 *u*, Al = 27 *u*, Na = 23 *u*, S = 32 *u*, O = 16 *u*]

Ans. (a) 1 mole of nitrogen atoms = 1 × gram atomic mass of nitrogen atom
= 1 × 14 g = **14 g**

(b) 4 moles of aluminium atoms = 4 × gram atomic mass of aluminium atoms
= 4 × 27 g = **108 g**

(c) 10 moles of sodium sulphite (Na_2SO_3) = 10 (2 × g-atomic mass of Na + 1 × g-atomic mass of sulphur + 3 × g-atomic mass of oxygen)
= 10 (2 × 23 g + 1 × 32 g + 3 × 16 g)
= 10 (46 g + 32 g + 48 g)
= 10 × 126 g = **1260 g**

Q.8. Convert into mole
(a) 12 g of oxygen gas
(b) 20 g of water
(c) 22 g of carbon dioxide [O = 16 *u*, H = 1 *u*, C = 12 *u*]

Ans. (a) 1 mole of oxygen (O_2) = 2 × 16 g = 32 g

$\because$ 32 g of oxygen = 1 mole

$\therefore$ 12 g of oxygen = $\frac{12}{32}$ mole = **0.375 mole**

(b) 1 mole of water (H_2O) = 2 × 1 g + 1 × 16 g = 18 g

$\because$ 18 g of water = 1 mole

$\therefore$ 20 g of water = $\frac{20}{18}$ mole = **1.11 mole**

(c) 1 mole of carbon dioxide(CO_2) = 1 × 12 g + 2 × 16 g = 44 g

$\because$ 44 g of carbon dioxide = 1 mole

$\therefore$ 22 g of carbon dioxide = $\frac{22}{44}$ mole = **0.5 mole**

Q.9. What is the mass of :

(a) 0.2 mole of oxygen atoms?

(b) 0.5 mole of water molecules? [O = 16 *u*, H = 1 *u*]

Ans. (a) 1 mole of oxygen atoms = 1 × 16 g = 16 g

$\therefore$ 0.2 mole of oxygen atoms = 16 g × 0.2 = **3.2 g**

(b) 1 mole of water (H_2O) molecules = 2 × 1 g + 1 × 16 g = 18 g

$\therefore$ 0.5 mole of water (H_2O) molecules = 18 g × 0.5 = **9.0 g**

Q.10. Calculate the number of molecules of sulphur (S_8) present in 16 g of solid sulphur. [S = 32 *u*]

Ans. 1 mole of sulphur (S_8) = 8 × 1 g-atomic mass of sulphur

= 8 × 32 g = 256 g

Also, 1 mole of S_8 molecules = 6.022×10^{23} molecules

Now, 256 g of S_8 molecules has = 6.022×10^{23} molecules

$\therefore$ 16 g of S_8 molecules has = $\frac{6.022 \times 10^{23} \times 16}{256}$ molecules = **3.76×10^{22} molecules**

Q.11. Calculate the number of aluminium ions present in 0.051 g of aluminium oxide. [Hint : The mass of an ion is same as that of an atom of the same element. Atomic mass of aluminium Al = 27 *u*]

Ans. Molecular formula of aluminium oxide is Al_2O_3

$\therefore$ Number of aluminium ions present in one molecule of aluminium oxide = 2

1 g-molecule (1 mole) of Al_2O_3 = 2 × g-atomic mass of Al + 3 × g-atomic mass of O

= 2 × 27 g + 3 × 16 g

= 54 g + 48 g = 102 g

Also 1 g-molecule (1 mole) of Al_2O_3 contains aluminium ions

= $2 \times 6.022 \times 10^{23}$

= 12.044×10^{23}

Now, 102 g of Al_2O_3 has number of aluminium ions

= 12.044×10^{23}

$\therefore$ 0.051 g of Al_2O_3 has number of aluminium ions

$= \frac{12.044 \times 10^{23} \times 0.051}{102}$ = **6.022×10^{20} ions**

ADDITIONAL QUESTIONS
(As Per CCE Pattern)

A. Very Short Answer Questions (1 Mark)

Previous Years' Questions

Q.1. State the postulate of Dalton's atomic theory which can explain the law of definite proportions? **[2011 (T-II)]**

Ans. The postulate of Dalton's atomic theory that explains the law of constant proportions is "atoms combine in the ratio of small whole numbers to form a compound."

Other Important Questions

Q.1. Find the ratio by mass of the combining elements in the compound C_2H_5OH.

Ans. The ratio by mass of the combining elements in the compound C_2H_5OH is
C : H : O = 12 : 3 : 8

Q.2. Give the formula of the compound formed by the elements calcium and fluorine.

Ans. Valency of calcium is +2 and that of fluorine is –1.
Formula of calcium fluoride is

(Elements) Ca F
(Valencies) 2 1 $\longrightarrow$ CaF_2

(Valencies are exchanged while forming compounds)

Q.3. What is the acid radical present in sodium peroxide?

Ans. The acid radical present in sodium peroxide (Na_2O_2) is peroxide radical (O_2^{2-}).

Q.4. Carbon and silicon have the same valency. What is the formula of sodium silicate?

Ans. Valency of silicon is 4 (same as carbon). Silicate radical is SiO_3^{2-}.
Formula of sodium silicate is :

(Elements / Radicals) Na SiO_3
(Valencies) 1 2 $\longrightarrow$ Na_2SiO_3

(Valencies are exchanged while forming compounds)

Q.5. What is the ratio by number of atoms in mercurous chloride?

Ans. Formula of mercurous chloride is HgCl. Ratio of the atoms of Hg and Cl in HgCl is 1 : 1.

Q.6. Name the element whose Latin name is Stibium.

Ans. Antimony

Q.7. What is the valency of a sulphide ion?

Ans. Valency of sulphide ion is –2.

Q.8. How many atoms of oxygen are present in 50g of $CaCO_3$? [Ca = 40, C = 12, O = 16]

Ans. Mol. wt. of $CaCO_3 = 40 + 12 + 3 \times 16 = 100$ g

100 g of $CaCO_3$ contains $= 3 \times 6.022 \times 10^{23}$ atoms of oxygen

$\therefore$ 50 g $CaCO_3$ will contain $= \dfrac{3 \times 6.022 \times 10^{23} \times 50}{100} =$ **9.033×10^{23}** atoms of oxygen

Q.9. Calculate the number of molecules of water present in 1 ml of water vapour at STP.

Ans. 22.4 *l* (22400 ml) water vapour at STP contains = 6.022×10^{23} molecules

$\therefore$ 1 ml of water vapour at STP will contain $= \dfrac{6.022 \times 10^{23} \times 1}{22400}$ molecules

$=$ **2.689×10^{19}** molecules

Q.10. What is the unit of measurement of atomic radius?

Ans. Atomic radius is measured in nanometer. (1 nanometer = 10^{-9}m)

Q.11. Why is potassium denoted by the symbol K?

Ans. Latin name of potassium is Kalium. The first letter of this name represents the symbol of potassium.

Q.12. A substance is made of only one kind of atom. Name the general term applied to the substance.

Ans. Element

Q.13. Define the term atom.

Ans. An atom is the smallest particle of an element that can take part in a chemical reaction. It may or may not exist independently.

Q.14. What is the formula of ferric nitrate?

Ans. $Fe(NO_3)_3$

Q.15. Name the compound represented by the formula $Ca_3(PO_4)_2$.

Ans. Calcium phosphate.

Q.16. Name the acid radical present in $NaClO_3$.

Ans. Chlorate radical.

Q.17. What is the concentration of hydrogen ions in 1 mol/dm^3 of sulphuric acid?

Ans. $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

1 mole of sulphuric acid (H_2SO_4) contains = 2 g of hydrogen ions.

$\therefore$ Concentration of hydrogen ions in 1 mole of sulphuric acid = 2 g/dm^3 of hydrogen ions.

Q.18. Calculate the formula mass of $Al_2(SO_4)_3$. [Al = 27, S = 32, O = 16]

Ans. Formula mass of $Al_2(SO_4)_3 = 27 \times 2 + (32 + 4 \times 16) \times 3 = 342$ *u*

Q.19. Define law of conservation of mass in a chemical reaction.

Ans. Law of conservation of mass states that, "mass can neither be created nor destroyed in a chemical reaction".

Q.20. What happens to an element 'Z' if its atom gains three electrons?

Ans. It forms Z^{3-} ion. $Z + 3e^- \rightarrow Z^{3-}$.

Q.21. There are 15 protons and 16 neutrons in the nucleus of an element. Calculate its atomic number and mass number.

Ans. Atomic number = Number of protons = 15

Mass number = Number of protons + Number of neutrons = 15 + 16 = 31

Q.22. What is the difference between Na and Na^+ in terms of number of electrons?

Ans. Na^+ ion is formed by the loss of one electron from an atom of sodium. Therefore, it has one electron less than Na.

Q.23. State the law of constant proportions.

Ans. Law of constant proportions states that "in a chemical substance, elements are always present in a definite proportion by weight".

Q.24. What is meant by 'relative atomic mass'?

Ans. Relative atomic mass of the atom of an element is defined as the average mass of the atom as compared to 1/12th the mass of one carbon-12 atom.

Q.25. Calculate the formula unit mass of Na_2CO_3.
[Atomic mass of Na = 23*u*, C = 12*u*, O = 16 *u*]

Ans. Formula unit mass of Na_2CO_3 = 2[Na] + [C] + 3[O]
= 2 × 23 + 12 + 3 × 16
= 46 + 12 + 48 = 106*u*

Q.26. Calculate the formula mass of $CuSO_4.5H_2O$.
[Given atomic mass of Cu = 63.5, S = 32]

Ans. Formula unit mass of $CuSO_4.5H_2O$ = [Cu] + [S] + 4[O] + 5 {2 × [H] + [O]}
= 63.5 + 32 + 4 × 16 + 5[2 × 1 + 16]
= 63.5 + 32 + 4 × 16 + 5[2 × 1 + 16]
= 249.5 *u*.

Q.27. Give an example of a triatomic molecule of an element.

Ans. Ozone (O_3)

Q.28. Calculate the mass of 1 molecule of oxygen.
[Given atomic mass of hydrogen = 1 *u* and oxygen 16 *u*]

Ans. 1 mole (6.022×10^{23} atoms) of oxygen weigh = 16 g

$\therefore$ 1 atom of oxygen will weigh = $\frac{16}{6.022 \times 10^{23}}$ g = **2.66×10^{-23} g**

Q.29. Write the chemical formula of the compound zinc hydroxide.

Ans. $Zn(OH)_2$

B. Short Answer Questions - I (2 Marks)

Previous Years' Questions

Q.1. 5 g of calcium combine with 2 g of oxygen to form a compound. Find the molecular formula of the compound. (Atomic mass of Ca = 40 u; O = 16 u) **[2011 (T-II)]**

Ans. Calcium and oxygen form the compound calcium oxide (CaO).

(Elements) Ca O
(Valencies) +2 –2 ⟶ CaO (Valencies are exchanged while forming molecules)

Q.2. (i) Name the body which approves the nomenclature of elements and compounds.
(ii) The symbol of sodium is written as Na and not as S. Give reason.

(iii) Name one element which form diatomic and one which form tetra atomic molecules. **[2011 (T-II)]**

Ans. (i) IUPAC (International Union of Pure and Applied Chemistry)

(ii) Latin name of sodium is Natrium. The first two letters (Na) of this name represents the symbol of sodium.

(iii) Oxygen forms diatomic molecules and phosphorus forms tetra atomic molecules.

Q.3. (i) State the law of constant proportions.

(ii) Show that water illustrates the law of constant proportions. **[2011 (T-II)]**

Ans. (i) According to the law of constant proportions "In a pure chemical substance, same elements are always present in a definite proportion by mass".

(ii) If pure samples of water are prepared from various sources and chemically analysed then it is found that

(a) The elements present in each sample are hydrogen and oxygen only.

(b) The ratio of weight of hydrogen to the weight of oxygen is 1 : 8.

Hence, water illustrates the law of constant proportions.

Q.4. (a) Calculate the number of molecules in 8 g of O_2.

(b) Calculate the number of moles in 52 grams of He (Helium). **[2011 (T-II)]**

$$\begin{bmatrix} \text{At. mass : O} = 16\text{ u} \\ \text{He} = 4\text{ u} \end{bmatrix}$$

Ans. (a) 1 mole of O_2 (32 g) contains = 6.022×10^{23} molecules

$\therefore$ 8 g of O_2 will contain = $6.022 \times 10^{23} \times \frac{8}{32}$ molecules

$= \mathbf{1.5055 \times 10^{23}}$ **molecules**

(b) Molecular mass of He = 4 g, 4 g of He = 1 mole

$\therefore$ 52 g of He = $\frac{1 \times 52}{4} =$ **13 mole**

Q.5. 2.8 g of nitrogen gas was allowed to react with 0.6 g of hydrogen gas to produce 3.4 g of ammonia. Show that these observations are in agreement with the law of conservation of mass. State the law of conservation of mass. **[2011 (T-II)]**

Ans. Nitrogen + Hydrogen $\longrightarrow$ Ammonia

Mass of reactants before experiment = Mass of nitrogen + mass of hydrogen

= 2.8 g + 0.6 g = 3.4 g

Mass of product after experiment = 3.4 g of ammonia

As the mass of reactants (3.4 g) is equal to the mass of product (3.4 g), therefore, these masses are in agreement with the law of conservation of mass.

According to this law of conservation of mass "mass can neither be created nor can it be destroyed in a chemical reaction".

Q.6. State law of conservation of mass. If 12 g of carbon is burnt in the presence of 32 g of oxygen, how much carbon dioxide will be formed? **[2011 (T-II)]**

Ans. According to law of conservation of mass "mass can neither be created nor can it be destroyed in a chemical reaction".

12 g of carbon and 32 g of oxygen will produce 44 g of carbon dioxide.

Q.7. Potassium chlorate decomposes, on heating, to form potassium chloride and oxygen. When 24.5 g of potassium chlorate is decomposed completely, then 14.9 g of potassium chloride is formed. Calculate the mass of oxygen formed. State the law of chemical combination which you have used in solving this problem. **[2011 (T-II)]**

Ans. According to law of conservation of mass, the weight of potassium chlorate is equal to the weight of formed products, potassium chloride and oxygen.

$$2\ KClO_3 \longrightarrow 2KCl + 3O_2$$
$$24.5\ g \qquad 14.9\ g \quad x$$

Weight of potassium chlorate = weight of potassium chloride + weight of oxygen

$$24.5\ g = (14.9 + x)\ g$$
$$x = (24.5 - 14.9)\ g$$
$$x = \mathbf{9.6\ g}$$

Q.8. State the law of constant proportion. Magnesium and oxygen combine in the ratio of 3 : 2 by mass to form magnesium oxide. How much oxygen is required to react completely with 12 g of magnesium? **[2011 (T-II)]**

Ans. According to the law of constant proportion "In a pure substance same elements are always present in a definite proportion by weight".

3 g of magnesium reacts with oxygen = 2 g

12 g of magnesium reacts with oxygen = $\frac{12 \times 2}{3} = \mathbf{8\ g}$

Q.9. Write the name of the compound repesented by the following formulae : **[2011 (T-II)]**

(a) $Al_2(SO_4)_3$ (b) $CaCl_2$ (c) KNO_3 (d) Mg_3N_2

Ans. (a) Aluminium sulphate (b) Calcium chloride

(c) Potassium nitrate (d) Magnesium nitride

Q.10. Write the chemical formula of : **[2011 (T-II)]**

(a) Aluminium phosphate (b) Sodium sulphide

Ans. (a) (Elements / Radicals) Al $\times$ PO_4

(Valencies) +3 –2

Chcmical formula is $Al_2(PO_4)_3$

(b) (Elements / Radicals) Na $\times$ S

(Valencies) +1 –2

Chemical formula is Na_2S

Q.11. (a) What is a cation? Give one example.

(b) Name the compounds represented by the following formulae

(1) KNO_3 (2) H_2S **[2011 (T-II)]**

Ans. (a) A positively charged ion is called cation.

Example : Sodium ion (Na^+)

(1) Potassium nitrate (2) Hydrogen sulphide

Q.12. Calculate number of moles in 34 g of NH_3 (Given atomic mass of N = 14 u; H = 1 u). **[2011 (T-II)]**

Ans. Atomic mass of $NH_3 = 14 + 3 \times 1 = 17$

17 g of NH_3 atoms = 1 mole

34 gm of NH_3 atoms = $\frac{34}{17} = \mathbf{2\ mole}$

Q.13. Write chemical formula of :
(a) Sodium carbonate (b) Ammonium chloride **[2011 (T-II)]**

Ans. (a) Sodium carbonate — Na_2CO_3
(b) Ammonium chloride — NH_4Cl

Q.14. (i) Define polyatomic ions and give an example.
(ii) Write the chemical formula of zinc nitrate. **[2011 (T-II)]**

Ans. (i) The group of atoms carrying an electric charge, is known as polyatomic ion.

Example : Nitrate ion (NO_3^-)

(ii) Zinc nitrate – Zn $(NO_3)_2$

Q.15. Write the names of compounds represented by the following formulae : **[2011 (T-II)]**
(i) KNO_3 (ii) $Al_2(SO_4)_3$ (iii) $MgCl_2$ (iv) $(NH_4)_2SO_4$

Ans. (i) Potassium nitrate (ii) Aluminium sulphate
(iii) Magnesium chloride (iv) Ammonium sulphate

Q.16. (a) Write down the names of compounds represented by the following formulae.
(i) $Ca(OH)_2$ (ii) K_2SO_4
(b) Give two examples of bivalent cations. **[2011 (T-II)]**

Ans. (a) (i) Calcium hydroxide (ii) Potassium sulphate
(b) Bivalent cation— Ca^{2+} and Mg^{2+}

Q.17. (a) Define atomicity.
(b) Give an example for an element, monoatomic and a polyatomic molecule. **[2011 (T-II)]**

Ans. (a) The number of atoms which constitute one molecule of an element, is called its atomicity.
(b) Element — Carbon
Monoatomic molecule— Helium (He)
Polyatomic molecule— Nitrogen (N_2)

Q.18. Calculate the number of moles in 17g of H_2O_2. (Atomic weight of H=1u, O=16u)
[2011 (T-II)]

Ans. Molecular mass of $H_2O_2 = 2 \times 1 + 2 \times 16 = (2 + 32)$ g = 34 g
34 g of H_2O_2 = 1 mole

17 g of $H_2O_2 = \frac{1 \times 17}{34}$ = **0.5 mole**

Q.19. Mention the two postulates of Dalton's atomic theory that explain (a) Law of conservation of mass (b) Law of constant proportions. **[2011 (T-II)]**

Ans. (a) The postulate of Dalton's atomic theory that explain the law of conservation of mass is "Atoms can neither be created nor be destroyed in a chemical reaction."
(b) The postulate of Dalton's atomic theory that explains the law of constant proportions is "atoms combine in the ratio of small whole numbers to form a compound."

Q.20. Give one word for the following : **[2011 (T-II)]**
(i) Positively charged ion.
(ii) A group of atoms carrying a charge.

Ans. (i) Cation (ii) Radical

Q.21. Which has more number of atoms? 100 g of N_2 or 100 g of NH_3 [N = 14, H = 1] **[2011 (T-II)]**

Ans.

$$100 \text{ g of } N_2 = \frac{100}{28} \text{ moles}$$

$$\text{No. of molecules present in 100 g of } N_2 = \frac{100}{28} \times 6.022 \times 10^{23}$$

$$\text{No. of atoms present in 100 g of } N_2 = \frac{100}{28} \times 2 \times 6.022 \times 10^{23} = 7.14 \times 6.022 \times 10^{23} \text{ atoms}$$

$$100 \text{ g of } NH_3 = \frac{100}{17} \text{ moles} = \frac{100}{17} \times 6.022 \times 10^{23} \text{ molecules}$$

$$= \left(\frac{100}{17} \times 6.022 \times 10^{23} \times 4\right) \text{ atoms}$$

$$= 23.6 \times 6.022 \times 10^{23} \text{ atoms}$$

$\therefore$ NH_3 would have more atoms.

Q.22. (a) What is molecular mass of substance?
(b) Calculate molecular mass of carbon dioxide gas. **[2011 (T-II)]**

Ans. (a) Molecular mass of a substance is the sum of atomic masses of all the atoms in the molecule of the substance.
(b) Molecular mass of $CO_2 = 12 + 2 \times 16 = 12 + 32 = 44$

Q.23. Calculate the mass of 3.011×10^{23} number of N atom.
(given atomic mass of nitrogen = 14) **[2011 (T-II)]**

Ans. 6.022×10^{23} atoms of nitrogen weigh = 14 g

$$3.011 \times 10^{23} \text{ atoms of nitrogen weigh} = \frac{14 \times 3.011 \times 10^{23}}{6.022 \times 10^{23}} = \mathbf{7\ g}$$

Other Important Questions

Q.1. In photosynthesis, 6 molecules of carbon dioxide combine with an equal number of water molecules through a complex series of reactions to give a molecule of glucose having a molecular formula, $C_6H_{12}O_6$. How many grams of water would be required to produce 18 g of glucose? Compute the volume of water so consumed, assuming the density of water to be 1 g cm^{-3}. [C = 12, H = 1, O = 16]

Ans. $6\ CO_2 + 6\ H_2O \xrightarrow[\text{sunlight}]{\text{chlorophyll}} C_6H_{12}O_6 + 6\ O_2$

Molecular mass of glucose = 6 [C] + 12 [H] + 6[O] = $6 \times 12 + 12 \times 1 + 6 \times 16 = 180$ g
Molecular mass of water = 2 [H] + [O] = $2 \times 1 + 16 = 18$ g
1 mole of glucose needs 6 moles of water.
180 g of glucose will need (6×18) g of water

1 g of glucose will need $\frac{108}{180}$ g of water

18 g of glucose would need $\frac{108}{180}$ × 18 g of water = **10.8 g**

Volume of water used = $\frac{\text{Mass}}{\text{Density}} = \frac{10.8\text{ g}}{1\text{ g cm}^3}$ = **10.8 cm^3**

Q.2. Raunak took 5 moles of carbon atoms in a container and Krish also took 5 moles of sodium atoms in another container of the same weight. (a) Whose container is heavier? (b) Whose container has more number of atoms? [Na = 23, C = 12]

Ans. (a) Mass of carbon atoms carried by Raunak = (5 × 12) g = 60 g
Mass of sodium atoms carried by Krish = (5 × 23) g = 115 g
Therefore, Krish's container is heavier than Raunak's.
(b) Both boys have the same number of atoms as they have the same number of moles of atoms.

Q.3. Compute the number of ions present in 5.85 g of sodium chloride. [Na = 23, Cl = 35.5]

Ans. Mol. wt of NaCl = 23 + 35.5 = 58.5 g
58.5 g of NaCl = 1 mole

5.85 g of NaCl = $\frac{1 \times 5.85}{58.5}$ = 0.1 mole

Each molecule of NaCl contains one Na^+ ion and one Cl^- ion = 2 ions
∴ Total moles of ions in 0.1 mole of NaCl = 2 × 0.1 = 0.2 moles
∴ No. of ions = 0.2 × 6.022 × 10^{23} = **1.2044 × 10^{23} ions**

Q.4. A gold sample contains 90% of gold and the rest copper. How many atoms of gold are present in one gram of this sample of gold? [Au = 197]

Ans. 1 g of the gold sample will contain = $\frac{90}{100}$ = 0.9 g of gold.

Number of moles of gold = $\frac{\text{Mass of gold}}{\text{Atomic mass of gold}} = \frac{0.9}{197} = 0.0046$

1 mole of gold contains = 6.022 × 10^{23} atoms
0.0046 mole of gold will contain = 0.0046 × 6.022 × 10^{23} = **2.77 × 10^{21} atoms**

Q.5. What are ionic and molecular compounds? Give examples.

Ans. Compounds which are produced by the combination of metals and non-metals contain charged species known as ions. A negatively charged ion is called an anion and a positively charged ion is known as a cation. Examples of ionic compounds are sodium chloride and calcium oxide.
Atoms of different elements combine together in definite proportion to form molecules of compounds.
Examples — ammonia, water and carbon dioxide.

Q.6. How many molecules are present in 1 ml of water?

Ans. Density of water = 1 g/cm^3
Mass of 1 ml of water = 1 g
Mol. wt. of water (H_2O) = 2 + 16 = 18
18 g of water contains 6.022 × 10^{23} molecules

1 g of water will contain $\frac{6.022 \times 10^{23}}{18}$ = **3.34 × 10^{22} molecules**

Q.7. What fraction of the mass of water is constituted by the neutrons?

Ans. Mass of 1 mole (Avogadro number) of neutrons ~ 1 g

$$\text{Mass of 1 neutron} = \frac{1}{N_A \text{ (Avogadro number)}} \text{ g}$$

$$\text{Mass of 1 molecule of water} = \frac{\text{Molar mass}}{N_A} = \frac{18}{N_A} \text{ g}$$

There are 8 neutrons in one atom of oxygen

$$\text{Mass of 8 neutrons} = \frac{8}{N_A}$$

$$\text{Fraction of mass of water due to neutrons} \sim \frac{8}{N_A} \;/\; \frac{18}{N_A} \sim \mathbf{\frac{8}{18}}$$

Q.8. Classify the following on the basis of their atomicity :

(i) chlorine (ii) phosphorus (iii) helium (iv) ozone

Ans.

	Molecules (of elements)	Atomicity
(i)	Chlorine (Cl_2)	2
(ii)	Phosphorus (P_4)	4
(iii)	Helium (He)	1
(iv)	Ozone (O_3)	3

Q. 9. State the number of atoms present in each of the following chemical species.

(a) CO_3^{2-} (b) PO_4^{3-} (c) P_2O_5 (d) CO

Ans. (a) CO_3^{2-} — 4 atoms (1 atoms of carbon + 3 atoms of oxygen)

(b) PO_4^{3-} — 5 atoms (1 atom of phosphorus + 4 atoms of oxygen)

(c) P_2O_5 — 7 atoms (2 atoms of phosphorus + 5 atoms of oxygen)

(d) CO — 2 atoms (1 atom of carbon + 1 atom of oxygen)

Q.10. Write the formula of the following compounds :

(a) Calcium sulphite (b) Sodium phosphate

(c) Ammonium carbonate (d) Magnesium nitride

Ans. (a) (Elements) Ca, SO_3 (Valencies) +2, –2 $\longrightarrow$ $CaSO_3$ (Valencies are exchanged while forming molecules)

(b) Na, PO_4 +1, –3 $\longrightarrow$ Na_3PO_4

(c) NH_4, CO_3 1, 2 $\longrightarrow$ $(NH_4)_2CO_3$

(d) Mg, N +2, –3 $\longrightarrow$ Mg_3N_2

Q.11. Select an element that is :

(a) ductile (b) conductor of electricity

(c) a constituent of water (d) liquid at room temperature

out of the following : Iodine, Bromine, Gold, Aluminium, Oxygen, Sodium.

Ans. (a) Gold (b) Aluminium (c) Oxygen (d) Bromine

Q.12. Calculate the number of moles of the following :
(a) 84 g of nitrogen atom
(b) 8.066×10^{23} number of nitrogen atom (given atomic mass of N = 14)

Ans. (a) 14 g of nitrogen atoms = 1 mole

$$84 \text{ g of nitrogen atom} = \frac{1 \times 84}{14} = \textbf{6 moles}$$

(b) 1 mole of nitrogen atoms = 6.022×10^{23} atoms

$$\therefore \quad 8.066 \times 10^{23} \text{ nitrogen atoms} = \frac{1 \times 8.066 \times 10^{23}}{6.022 \times 10^{23}} = \textbf{1.339 moles}$$

Q.13. In a molecule, hydrogen and oxygen are present in the ratio of 1 : 8 by mass. Deduce the molecular formula of the compound.
(Atomic mass of H = 1.0 *u*, O = 16.0 *u*)

Ans.

Element	Ratio by mass	Atomic mass (u)	Mass ratio/ atomic mass	Simplest ratio
H	1	1	$\frac{1}{1} = 1$	2
O	8	16	$\frac{8}{16} = \frac{1}{2}$	1

Thus, the ratio by number of atoms for water is H : O = 2 : 1

Q.14. (a) Define atomic mass unit.
(b) Hydrogen and oxygen combine in the ratio 1:8 by mass to form water. What mass of oxygen gas would be required to react completely with 4 g of hydrogen gas?

Ans. (a) One atomic mass unit is a mass unit equal to exactly one twelfth (1/12th) the mass of one atom of carbon-12.
(b) 1 g of hydrogen combines with 8 g of oxygen.

$$\therefore \text{ 4 g of hydrogen will combine with } \frac{8 \times 4}{1} = \textbf{32 g} \text{ of oxygen.}$$

C. Short Answer Questions - II (3 Marks)

Previous Years' Questions

Q.1. (a) Define the term mole.
(b) Calculate the no. of mole of sulphur (S_8) present in 16 g of solid sulphur. (Atomic mass of S = 32 *u*) **[2011 (T-II)]**

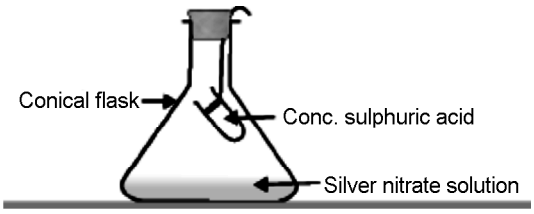
Ans. (a) A group of 6.022×10^{23} particles of a substance is called mole.
(b) Molecular mass of sulphur (S_8) = $32 \times 8 = 256$

$$\text{No. of moles of S} = \frac{\text{Mass of } S_8}{\text{Molecular mass of } S_8} = \frac{16}{256} = \textbf{0.0625 mole}$$

Q.2. With a labelled diagram describe an activity to demonstrate the law of conservation of mass. **[2011 (T-II)]**

Ans. (i) Pour about 20 ml of a solution of silver nitrate in a clean conical flask.

(ii) Take an ignition tube and tie a long thread to its neck. Half fill the ignition tube with conc. hydrochloric acid. Carefully lower the ignition tube in the conical flask, taking care that its contents do not spill in the silver nitrate solution. Fix a rubber cork in the mouth of the conical flask, so that the ignition tube remains suspended above the silver nitrate solution.



(iii) Find mass of the conical flask by a physical balance and record it.

(iv) Now tilt the conical flask so that the contents within it mix. You will notice that a curdy white precipitate is formed. It is because silver nitrate reacts chemically with hydrochloric acid to form curdy white silver chloride and nitric acid.

(v) Find the mass of the conical flask again and record it. You will notice that there is no change in the mass, thereby proving the law of conservation of mass.

Q.3. (i) State and explain the law of constant proportion taking an example of ammonia.

(ii) Write the symbol of an element A with atomic number thirteen and mass number 27 respectively.

(iii) Give definition of ion in your own words. **[2011 (T-II)]**

Ans. (i) According to the law of constant proportions "In a pure substance same elements are always present in a definite proportion by weight".

$$\underset{(2 \times 14) \\ = 28}{N_2} + \underset{3(2 \times 1) \\ = 6}{3H_2} \longrightarrow \underset{2(14 + 3 \times 1) \\ = 34}{2NH_3}$$

28 g of N_2 reacts with 6 g of H_2 to produce 34 gm of NH_3.

(ii) $^{27}_{13}A$

(iii) An ion is an electrically charged particle, which may have a positive or negative charge.

Q.4. (i) Mention the formula of sodium nitride.

(ii) Calculate the formula unit mass of $CaCO_3$.
(Given, Ca=40 u, C=12 u and O=16 u)

(iii) Calculate the mass of 10 moles of carbon dioxide. **[2011 (T-II)]**

Ans. (i) Sodium Nitride

Symbol Na N

Valency +1 –3

Formula — Na_3N

(ii) Formula unit mass of $CaCO_3$ = mass of 1 atom of calcium + mass of 1 atom of carbon + mass of 3 atoms of oxygen
= 1 (40) + 1 (12) + 3 (16) = 40 + 12 + 48 = 100 amu

(iii) Mass of 1 mole of CO_2 = 12 + 2 × 16 = 44 g
Mass of 10 moles of CO_2 = 10 × 44 = 440 g

Q.5. (a) What are polyatomic ions?

(b) Write the formulae and names of the compounds formed by combination of

(i) Fe^{3+} and SO_4^{2-} (ii) NH_4^{1+} and CO_3^{2-} **[2011 (T-II)]**

Ans. (a) The group of atoms carrying an electric charge is known as polyatomic ion.

(b) (i) Fe_{+3} $SO_{4\,-2}$

$Fe_2(SO_4)_3$ — Ferric sulphate

(ii) $NH_{4\,+1}$ $CO_{3\,-2}$

$(NH_4)_2CO_3$ — Ammonium carbonate

Q.6. Write the chemical formulae of the following.

(a) Potassium chloride (b) Magnesium hydroxide

(c) Ammonium sulphate **[2011 (T-II)]**

Ans. (a) Potassium chloride

Symbol K Cl

Valency +1 –1

Formula — KCl

(b) Magnesium hydroxide

Symbol Mg OH

Valency +2 –1

Formula — $Mg(OH)_2$

(c) Ammonium sulphate

Symbol Ammonium Sulphate

NH_4 SO_4

Valency +1 –2

Formula — $(NH_4)_2SO_4$

Q.7. (a) Define molar mass. What are its units?

(b) Write the names of compounds represented by the following formulas :

(i) K_2CO_3 (ii) Na_2SO_4 (iii) $Ca(HCO_3)_2$ (iv) H_2S **[2011 (T-II)]**

Ans. (a) Molar mass of any substance is the sum total of atomic masses of the constituting atoms. Its unit is amu (atomic mass unit).

(b) (i) Potassium carbonate (ii) Sodium sulphate

(iii) Calcium bicarbonate (iv) Hydrogen sulphide

Q.8. If the number of molecules in a given sample of sulphur dioxide (SO_2) is 3.011×10^{23}, calculate the following : **[2011 (T-II)]**

(i) the number of moles in the given sample.

(ii) mass of sulphur dioxide in the given sample.

(iii) number of oxygen atoms in the given sample. (Atomic mass of S = 32 u ; O = 16 u)

Ans. (i) 6.022×10^{23} number of molecules = 1 mole of SO_2

3.011×10^{23} number of molecules = $\frac{3.011 \times 10^{23}}{6.022 \times 10^{23}}$ = **0.5 mole**

(ii) Mass of sulphur dioxide = $(32 + 2 \times 16) = 64$ g

1 mole of SO_2 weigh = 64 g

0.5 mole of SO_2 weigh = **32 g**

(iii) Number of oxygen atom in 1 mole = 6.022×10^{23}
Number of oxygen atom in 0.5 mole = **3.022×10^{23} g**

Q.9. (a) Calculate the formula unit mass of Na_2CO_3.
(b) What is the mass of one mole of oxygen atom?
(c) Convert 12g of oxygen gas into mole. **[2011 (T-II)]**

Ans. (a) Formula unit mass of Na_2CO_3 = $(2 \times 23 + 12 + 3 \times 16) = 46 + 12 + 48 =$ **106 amu**
(b) Mass of one mole of oxygen atom = $2 \times 16 =$ **32 g**
(c) Molar mass of oxygen gas = $2 \times 16 = 32$ g
32 g of oxygen = 1 mole

12 g of oxygen = $\frac{12}{32}$ = **0.375 mole**

Q.10. Calculate the molar mass of the following compounds : **[2011 (T-II)]**
(a) Lead sulphate
(b) Calcium phosphate
[Given atomic masses of various elements Ca - 40, S - 32, O - 16, Pb - 207, P - 31]

Ans. (a) Molar mass of lead sulphate ($PbSO_4$) = $(207 + 32 + 4 \times 16)$ g = **303 g**
(b) Molar mass of calcium phosphate $Ca_3(PO_4)_2 = 3 \times 40 + 2\ (31 + 4 \times 16)$
$= 120 + 2\ (95) =$ **310 g**

Q.11. (a) What do the following abbreviations stand for? (i) 2O (ii) $3O_2$
(b) Which amongst the following has more number of atoms 11.5 g of sodium or 15 g of calcium? How?
[Given atomic mass of Na = 23, Ca = 40] **[2011 (T-II)]**

Ans. (a) (i) 2 atoms of oxygen (ii) 3 molecules of oxygen
(b) 23 g of Na contains = 6.022×10^{23} atoms

11.5 g of Na contains = $\frac{6.022 \times 10^{23} \times 11.5}{23}$ atom = 3.022×10^{23} atoms

40 g of calcium contains = 6.022×10^{23} atoms

15 g of calcium contains = $\frac{6.022 \times 10^{23} \times 15}{40}$ atoms = 2.26×10^{23} atoms

11.5 g of sodium contains more atoms than 15 g of calcium.

Q.12. Using criss cross method, write the chemical formula of copper chloride, calcium sulphate, sodium phosphate. **[2011 (T-II)]**

Ans. **Copper Chloride**
Symbol Cu — Cl
Valency +2 — –1
Formula — $CuCl_2$

Calcium Sulphate
Symbol Ca — SO_4
Valency +2 — –2
Formula — $CaSO_4$

Sodium Phosphate
Symbol Na — PO_4
Valency +1 — –3
Formula — Na_3PO_4

Q.13. A gas jar contains 1.7 g of ammonia gas. Calculate the following :
(i) Molar mass of ammonia.
(ii) How many moles of ammonia are present in the gas jar?
(iii) How many molecules of ammonia are present in the sample? **[2011 (T-II)]**

Ans. (i) Molar mass of ammonia = $14 + 3 \times 1 =$ **17**

(ii) 17 g of ammonia contain = 1 mole

1.7 g of ammonia contain = $\frac{1 \times 1.7}{17}$ = **0.1 mole**

(iii) 17 gm ammonia contains = 6.022×10^{23} molecules

1.7 gm ammonia contains = $\frac{6.022 \times 10^{23} \times 1.7}{17}$ = **6.022×10^{22} atoms**

Q.14. (a) Define the atomic mass unit.
(b) Write the chemical formulae of :
(i) Ammonium carbonate (ii) Sodium oxide
(c) Name the compound $Al_2(SO_4)_3$ and mention the ions present in it. **[2011 (T-II)]**

Ans. (a) The mass of 1/12 part of ^{12}C (isotope of carbon) is equivalent to one atomic mass unit or one unified atomic mass.

(b) (i) Ammonium carbonate

Symbol NH_4^+ CO_3^{2-}
Valency +1 –2
Formula — $(NH_4)_2\ CO_3$

(ii) Sodium oxide–

Symbol	Na	O
Valency	+1	–2

Formula — Na_2O

(c) $Al_2(SO_4)_3$ — Aluminium sulphate

Ions present in aluminium sulphate is aluminium ion (Al^{3+}) and sulphate ion $\left(SO_4^-\right)$.

Q.15. (a) Define atomicity.
(b) Calculate the number of atoms in the following compounds :
(i) Ozone (ii) Sodium chloride
(c) Give an example of polyatomic molecule of an element. **[2011 (T-II)]**

Ans. (a) The number of atoms which constitute one molecule of an element, is called its atomicity.
(b) (i) Ozone (O_3) contains 3 atoms.
(ii) Sodium chloride contain 2 atoms.
(c) Phosphorus (P_4) is a tetra-atomic molecule.

Q.16. Calculate number of atoms in 120 g of Ca :
(atomic mass of Ca = 40 u) **[2011 (T-II)]**

Ans. g-atomic mass of calcium = 40 g
40 g of calcium contains atoms = 6.022×10^{23}

120 g of calcium contains atoms = $\frac{6.022 \times 10^{23} \times 120}{40}$ = **18.066×10^{23} atoms**

Q.17. Calculate the following quantities in 5.6 g of nitrogen [Atomic mass of N = 14 u]
(a) Number of moles of N_2 (b) Number of molecules of N_2

(c) Number of atoms of nitrogen. **[2011 (T-II)]**

Ans. (a) Molar mass of N_2 = 2 (N) = 2(14) = 28 g/moles

$$\therefore \text{ No. of moles of } N_2 = \frac{\text{Mass of nitrogen}}{\text{Molar mass of nitrogen}} = \frac{5.6\text{ g}}{28\text{ g/moles}} = \mathbf{0.2\ moles}$$

(b) Number of molecules of N_2 = 6.022×10^{23} × No. of moles of nitrogen
= $6.022 \times 10^{23} \times 0.2 = \mathbf{1.204 \times 10^{23}\ molecules}$

(c) A nitrogen molecule contains 2 atoms of nitrogen.
∴ Number of nitrogen atoms = $2 \times 1.204 \times 10^{23}$ atoms = $\mathbf{2.4088 \times 10^{23}\ atoms}$

Q.18. (a) State the law of conservation of mass.

(b) What mass of silver nitrate will react with 5.85 g of sodium chloride to produce 14.35 g of silver chloride and 8.5 g of sodium nitrate? **[2011 (T-II)]**

Ans. (a) According to this law "mass can neither be created nor be destroyed".

(b) $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$

$108 + 14 + 3 \times 16 \quad 23 + 35.5 \quad 108 + 35.5 \quad 23 + 14 + 3 \times 16$

$= 170 \quad = 58.5 \quad = 143.5 \quad = 85$

58.5 g of NaCl reacts with 170 of $AgNO_3$ to produce 143.5 g of AgCl and 85 g of $NaNO_3$.

∴ 5.85 g of NaCl will react with 17.0 g of $AgNO_3$ to produce 14.35 g of AgCl and 8.5 g $NaNO_3$.

Q.19. Calculate the number of particles in each of the following :

(a) 48 g of Mg atoms (b) 8 g of O_2 molecules

(c) 0.1 mole of carbon atoms **[2011 (T-II)]**

Ans. (a) 1 mole of Mg atoms (24g) contains = 6.022×10^{23} atoms

48 g of Mg atoms will contain = $\frac{6.022 \times 10^{23} \times 48}{24}$ particles = $\mathbf{1.2044 \times 10^{24}\ atoms}$

(b) 1 mole of O_2 molecules (32g) contains = $\mathbf{6.022 \times 10^{23}\ molecules}$

∴ 8 g of O_2 molecules will contain = $6.022 \times 10^{23} \times \frac{8}{32}$ molecules
= $\mathbf{1.5055 \times 10^{23}\ molecules.}$

(c) 1 mole of carbon atoms = 6.022×10^{23} atoms

∴ 0.1 mole of carbon atoms = $6.022 \times 10^{23} \times 0.1 = \mathbf{6.022 \times 10^{22}\ atoms}$

Q.20. (a) Calculate the molar mass of HNO_3 (Atomic masses H = 1 *u*, O = 16 *u* and N = 14 *u*).

(b) Calculate the number of moles in 22 g of CO_2. (Atomic masses C = 12 *u*, O = 16 *u*, $N_A = 6.022 \times 10^{23}\ mol^{-1}$) **[2011 (T-II)]**

Ans. (a) Molecular mass of HNO_3 = 1[H] + [N] + 3 [O] = 1 + 14 + 3 × 16 = 63 *u*
Molar mass of HNO_3 = $\mathbf{63\ g\ mol^{-1}}$

(b) Molecular mass of CO_2 = 1 [C] + 2 [O] = 12 + 2 × 16 = 44 *u*
44 g of CO_2 = 1 mole

$$\therefore \text{ 22g of } CO_2 = \frac{1 \times 22}{44} = \mathbf{0.5\ mole}$$

Q.21. Calculate **[2011 (T-II)]**

(a) the mass of 1.0505×10^{23} molecules of carbon dioxide (CO_2)

(b) the number of molecules in 0.25 moles of NH_3

(c) the formula unit mass of Na_2SO_3

(Atomic mass : Na = 23 *u*, S = 32 *u*, O = 16 *u*, H = 1 *u*, $N_A = 6.022 \times 10^{23}$ mol^{-1})

Ans. (a) Molecular mass of $CO_2 = 12 + 2 \times 16 = 44$

6.022×10^{23} molecules of CO_2 will weigh = 44 g

$\therefore$ 1.0505×10^{23} molecules of CO_2 will weigh = $\frac{44 \times 1.0505 \times 10^{23}}{6.022 \times 10^{23}}$ g = **7.68 g**

(b) 1 mole of NH_3 contains 6.022×10^{23} molecules

$\therefore$ 0.25 moles of NH_3 will contain = $6.022 \times 10^{23} \times 0.25$ = **1.5055×10^{23} molecules**

(c) Formula unit mass of Na_2SO_3 = 2[Na] + 1[S] + 3[O]

= $2 \times 23 + 32 + 3 \times 16$ = **126 *u***

Q.22. Calculate : **[2011 (T-II)]**

(a) number of molecules in 90 g of H_2O

(b) number of mole in 19 g of H_2O_2

(Atomic mass : O = 16 *u*, H = 1 *u*, $N_A = 6.022 \times 10^{23}$ mol^{-1})

Ans. (a) Molecular mass of $H_2O = 2 \times 1 + 16 = 18$ g

18 g H_2O contains 6.022×10^{23} molecules

$\therefore$ 90 g of H_2O will contain $\frac{6.022 \times 10^{23} \times 90}{18}$ = **3.011×10^{24} molecules**

(b) Molecular mass of $H_2O_2 = 2 \times 1 + 2 \times 16 = 34$ g

34 g H_2O_2 = 1 mole

$\therefore$ 19 g of H_2O_2 = $\frac{1 \times 19}{34}$ mole = **0.559 mole**

Other Important Questions

Q.1. Calcium chloride when dissolved in water dissociated into its ions according to the following equation.

$CaCl_2$ (aq) $\rightarrow$ Ca^{2+} (aq) + $2Cl^-$ (aq)

Calculate the number of ions obtained from $CaCl_2$ when 222 g of it is dissolved in water.

Ans. 1 mole of $CaCl_2 = 40 + 2 \times 35.5 = 111$g

$\therefore$ 222 g of $CaCl_2$ is equivalent to 2 moles of $CaCl_2$.

1 mol of $CaCl_2$ gives = 3 moles of ions (1 mole of Ca^{2+} ions + 2 moles of Cl^- ions)

2 moles $CaCl_2$ will give = $3 \times 2 = 6$ moles of ions

Number of ions = Number of moles of ions $\times$ Avogadro number

= $6 \times 6.022 \times 10^{23} = 36.132 \times 10^{23}$ ions = **3.6132×10^{24} ions**

Q.2. Name all the elements present in the following compounds.

(i) Lead nitrate (ii) Ammonium phosphate (iii) Magnesium hydrogen carbonate

Ans. (i) Lead nitrate [$Pb(NO_3)_2$]

Elements present are — lead, nitrogen, oxygen

(ii) Ammonium phosphate $[(NH_4)_3PO_4]$
Elements present are — nitrogen, hydrogen, phosphorus, oxygen

(iii) Magnesium hydrogen carbonate $[Mg(HCO_3)_2]$
Elements present are — magnesium, hydrogen, carbon, oxygen

Q.3. Cinnabar (HgS) is a prominent ore of mercury. How many grams of mercury are present in 225 g of pure HgS? Molar mass of Hg and S are 200.6 g mol^{-1} and 32 g mol^{-1} respectively.

Ans. Molecular mass of HgS = 200.6 + 32 = 232.6 g mol^{-1}
Mass of Hg in 232.6 g of HgS = 200.6 g

Mass of Hg in 225 g of HgS = $\frac{200.6}{232.6} \times 225$ = **194.04 g**

Q.4. A sample of vitamin C is known to contain 2.58×10^{24} oxygen atoms. How many moles of oxygen atoms are present in the sample?

Ans. 1 mole of oxygen atoms = 6.022×10^{23} atoms
Number of oxygen atoms in the sample of vitamin C = 2.58×10^{24}

$\therefore$ Number of moles of oxygen atoms = $\frac{2.58 \times 10^{24}}{6.022 \times 10^{23}}$ = **4.28 mol** in the sample

Q.5. Fill in the missing data in the table.

Species	H_2O	Na atom
Property		
No. of moles	2	—
No. of particles	—	—
Mass	36 g	115 g

Ans. 1 mole of water contains = 6.022×10^{23} particles

$\therefore$ 2 moles of water will contain = $6.022 \times 10^{23} \times 2$
= 12.044×10^{23} particles = **1.2044×10^{24} particles**

23 g of sodium atom = 1 mol

$\therefore$ 115 g of sodium atom = $\frac{115}{23}$ = **5 moles**

1 mole of sodium atom contains = 6.022×10^{23} atoms

$\therefore$ 5 moles of sodium atom contain = $5 \times 6.022 \times 10^{23}$ = **30.110×10^{23} atoms**

Q.6. (i) Define one mole of an element.

(ii) What is the relation between mole and gram atomic mass of an element?

(iii) Gram atomic mass of an element X is 27 g. How many moles of X are in 54 g?

Ans. (i) 1 mole of the atom of an element is that quantity in number having a mass equal to its atomic mass in grams.

(ii) The mass of 1 mole of the atom of an element is equal to gram atomic mass of the element.

(iii) Gram atomic mass of X = 27 g

1 mole of X weighs = 27 g

54 g of X will be equal to = $\frac{54}{27}$ = **2 moles**

Q.7. Calculate :

(i) The percentage of hydrogen in ammonium sulphate [$(NH_4)_2\ SO_4$].
[N = 14 *u*, H = 1 *u*, S = 32 *u*, O = 16 *u*, Na = 23 *u*, C = 12 *u*]

(ii) The percentage composition of water present in washing soda [$Na_2CO_3 .\ 10H_2O$].

(iii) The mass of oxygen contained in 72 g of pure water.

Ans. (i) Molar mass of $(NH_4)_2SO_4$ = [(14 + 4) × 2] + 32 + (4 × 16) = 132

$$\% \text{ of hydrogen in } (NH_4)_2SO_4 = \frac{\text{Mass of hydrogen in } (NH_4)_2SO_4}{\text{Molar mass of } (NH_4)_2SO_4} \times 100$$

$$= \frac{8}{132} \times 100 = \mathbf{6.06\%}$$

(ii) Molar mass of washing soda [Na_2CO_3 . $10H_2O$]
= [2 × 23 + 12 + 3 × 16] + [10 × 18] = 286 g

% of water in [Na_2CO_3 . $10H_2O$] = $\frac{180}{286}$ × 100 = **62.93%**

(iii) Molar mass of water (H_2O) = 2 + 16 = 18 g
Mass of oxygen in 18 g H_2O = 16

Mass of oxygen in 72 g H_2O = $\frac{16}{18}$ × 72 = **64 g**

Q.8. What is the qualitative meaning of the symbol of chlorine (Cl) of atomic mass 35.5 u?

Ans. (a) The symbol Cl represents that one atom of chlorine is 35.5 times heavier than one atomic mass unit.

(b) The symbol Cl represents that its atomic mass is 35.5 *u*.

(c) The symbol Cl represents that one mole of Cl (35.5 g) will have 6.022 × 10^{23} atoms.

Q.9. (a) Define the term mole.

(b) Calculate the no. of (i) atoms (ii) molecules in 124 grams of phosphorus. (Given atomic mass P = 31.0 *u*, N_A = 6.022 × 10^{23} mol^{-1})

Ans. (a) Mole is the amount of substance that contains the same number of particles (atoms/ions/ molecules/formula units, etc.) as there are atoms in exactly 12 grams of carbon–12.

(b) (ii) 1 mole of phosphorus (P_4) = 4 × 31 = 124 g

1 mole or 124 g of phosphorus contains = **6.022 × 10^{23} molecules**

(i) 1 molecule of phosphorus (P_4) contains = 4 atoms

∴ 1 mole of phosphorus (P_4) contains = 4 × 6.022 × 10^{23} atoms

= **2.4088 × 10^{24} atoms**

Q.10. Calculate the number of molecules of carbon dioxide (CO_2) present in 4.4 g of CO_2.
[At. mass : C = 12.0, O = 16.0, N_A = 6.022 × 10^{23} mol^{-1}]

Ans. 1 mole of carbon dioxide = 1[C] + 2[O] = 12 + 2 × 16 = 44 g

44g of CO_2 (1 mol) contains 6.022×10^{23} molecules.

4.4 g of CO_2 will contain $\frac{6.022 \times 10^{23}}{44} \times 4.4$ molecules = **6.022×10^{22} molecules**

Q.11. What is Avogadro number? How many atoms of each element are present in 6.3 g of nitric acid (HNO_3)?

[H = 1.0, N = 14.0, O = 16, $N_A = 6.022 \times 10^{23}$ mol^{-1}]

Ans. The number of particles (atoms, molecules or ions) present in 1 mole of any substance is fixed with a value of 6.022×10^{23}. This number is called Avogadro number.

Molecular mass of HNO_3 = 1 + 14 + 3 × 16 = 63

63 g of HNO_3 = 1 mole

$\therefore$ 6.3 g of $HNO_3 = \frac{1 \times 6.3}{63} = 0.1$ mol

1 mol of HNO_3 contains 6.022×10^{23} atoms of H, 6.022×10^{23} atoms of N and $3 \times 6.022 \times 10^{23}$ atoms of oxygen.

$\therefore$ 0.1 mol of HNO_3 contain = $6.022 \times 10^{23} \times 0.1$ = **6.022×10^{22} atoms of H**

0.1 mol of HNO_3 contain = $6.022 \times 10^{23} \times 0.1$ = **6.022×10^{22} atoms of N**

0.1 mol of HNO_3 contain = $3 \times 6.022 \times 10^{23} \times 0.1$

atom of O = **1.8066×10^{23} atoms of O**

Q.12. (a) Define the term molecular mass.

(b) Determine the molecular mass of $ZnSO_4$.

(Given atomic mass of Zn = 65 *u*, S = 32 *u*, O = 16 *u*)

Ans. (a) The molecular mass of substance is the sum of the atomic masses of all the atoms in a molecule of the substance.

(b) Molecular mass of $ZnSO_4$ = 1[Zn] + 1 [S] + 4 [O] = 65 + 32 + 4 × 16 = **161*u***.

Q.13. (a) Write the names of the following compounds :

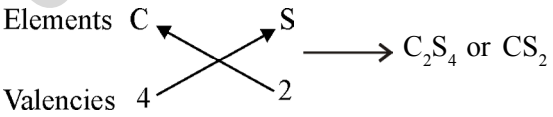
(i) $CaHCO_3$ (ii) $Mg(OH)_2$

(b) If the valency of carbon is 4 and that of sulphur is 2, write the formula of the compound formed between carbon and sulphur atoms. Also name the compound.

Ans. (a) (i) Calcium hydrogen carbonate or calcium bicarbonate

(ii) Magnesium hydroxide

(b)



$\longrightarrow C_2S_4$ or CS_2

Valencies are exchanged while forming molecules.

Q.14. (a) Calculate the number of molecules in 50 g of $CaCO_3$.

(b) Calculate the mass of 0.5 moles of nitrogen gas.

(c) Calculate the number of moles in 50 g of NaCl.

(Atomic mass : Ca = 40 *u*, C = 12 *u*, O = 16 *u*, N = 14 *u*, Na = 23 *u*, Cl = 35.5 *u*, $N_A = 6.022 \times 10^{23}$ mol^{-1})

Ans. (a) Molecular mass of $CaCO_3$ = 40 + 12 + 3 × 16 = 100 g
100 g of $CaCO_3$ (1 mole) contains 6.022×10^{23} molecules

50 g $CaCO_3$ will contain $\frac{6.022 \times 10^{23} \times 50}{100}$ = **3.011×10^{23} molecules**

(b) Molecular mass of nitrogen gas (N_2) = 2 × 14 = 28 g
1 mole of nitrogen gas weighs = 28 g

∴ 0.5 mole of nitrogen gas will weigh = $\frac{28 \times 0.5}{1}$ = **14 g**

(c) Molecular mass of NaCl = 23 + 35.5 = 58.5 g
58.5 g of NaCl = 1 mole

∴ 50 g of NaCl = $\frac{1 \times 50}{58.5}$ = **0.855 mole**

Q.15. (a) Calculate the number of moles in 112 g of iron.
(b) Calculate the mass of 0.5 moles of sugar ($C_{12}H_{22}O_{11}$).
(c) Calculate the number of atoms in 8 g of oxygen (O_2) molecules.
(Atomic mass : Fe = 56 *u*, H = 1 *u*, O = 16 *u*, $N_A = 6.022 \times 10^{23}$ mol^{-1})

Ans. (a) 56 g of iron = 1 mol.

∴ 112 g of iron = $\frac{1 \times 112}{56}$ = **2 moles**

(b) Molecular mass of sugar ($C_{12}H_{22}O_{11}$) = 12 × 6 + 22 × 1 + 11 × 16 = 270 g
1 mole of sugar weighs = 270 g

∴ 0.5 mole of sugar will weigh = $\frac{270 \times 0.5}{1}$ = **135 g**

(c) 1 mole oxygen atoms = 16 g

∴ 8 g of oxygen is equal to = $\frac{1 \times 8}{16}$ = **0.5 atom**

Q.16. What is meant by the term 'mole'? Calculate the number of moles in :
(a) 3.011×10^{23} atoms of C
(b) 32 g of oxygen gas
($N_A = 6.022 \times 10^{23}$ mol^{-1}, At. mass of O = 16 *u*, C = 12 *u*)

Ans. Mole is the amount of substance that contains the same number of particles as there are atoms in exactly 12 g of carbon–12.

(a) 1 mole of carbon contains Avogardo's number of atoms.
or 6.022×10^{23} atoms of carbon is equal to 1 mole

∴ 3.011×10^{23} atoms of carbon = $\frac{3.011 \times 10^{23}}{6.022 \times 10^{23}}$ = **0.5 mole**

(b) Molecular mass of oxygen gas (O_2) = 2 × 16 = 32 g
∴ 32 g of oxygen gas = **1 mole**

Q.17. (a) Write the names of the following compounds :
(i) $Al_2(SO_4)_3$ (ii) $ZnCl_2$

(b) Calculate the formula unit mass of :
(i) Na_2O (ii) K_2CO_3
[Atomic mass of Na = 23 *u*, K = 39 *u*, C = 12 *u*, O = 16 *u*]

Ans. (a) (i) Aluminium sulphate (ii) Zinc chloride

(b) (i) Formula unit mass of Na_2O = 2 × 23 + 16 = **62 *u***

(ii) Formula unit mass of K_2CO_3 = 2 × 39 + 12 + 3 × 16 = **138 *u***

Q.18. (a) Calculate the number of aluminium atoms present in 51 g of aluminium oxide (Al_2O_3).

(b) Calculate the molar mass of $AlCl_3$.
[Atomic mass of Al = 27 *u*, Cl = 35.5 *u*, O = 16.0 *u*; $N_A = 6.022 \times 10^{23}$ mol^{-1}]

Ans. (a) Molecular mass of Al_2O_3 = 2 × 27 + 3 × 16 = 54 + 48 = 102 g

102 g of Al_2O_3 = 1 mole of Al_2O_3

$\therefore$ 51 g of $Al_2O_3 = \frac{1 \times 51}{102} = 0.5$ mol of Al_2O_3

Now 1 mol of Al_2O_3 contains = 2 × 6.023 × 10^{23} atoms of aluminium

$\therefore$ 0.5 mol of Al_2O_3 will contain = 0.5 × 2 × 6.023 × 10^{23} atoms of aluminium

= **6.023 × 10^{23} atoms of aluminium**

(b) Molar mass of $AlCl_3$ = [Al] + 3[Cl] = 27 + 3 × 35.5 = **133.5 *u***

Q.19. Write the names of the compounds represented by the following formulae :

(a) $Mg(OH)_2$ (b) $CaCO_3$
(c) K_2SO_4 (d) $NaHCO_3$
(e) Na_2SO_3 (f) $(NH_4)_2SO_4$

Ans. (a) Magnesium hydroxide (b) Calcium carbonate
(c) Potassium sulphate (d) Sodium hydrogen carbonate
(e) Sodium sulphite (f) Ammonium sulphate

Q.20. Calculate number of atoms in 120 g of calcium and 120 g of iron. Which one has more number of atoms and how much is the difference?
(Given atomic mass of calcium = 40 *u*, iron = 56 *u*)

Ans. 40 g of calcium contains = 6.022 × 10^{23} atoms

$\therefore$ 120 g of calcium contains $= \frac{6.022 \times 10^{23} \times 120}{40} = 1.8066 \times 10^{24}$ atoms

56 g of calcium contains = 6.022 × 10^{23} atoms

$\therefore$ 120 g of iron contains $= \frac{6.022 \times 10^{23} \times 120}{56} = 1.29 \times 10^{24}$ atoms

$\therefore$ 120 g of calcium contains more atoms than 120 g of iron.

Q.21. (a) Write chemical formulae of the following compounds :
(i) Aluminium nitride (ii) Ammonium phosphate

(b) Name the element which shows variable valency. Write the formulae of its two chlorides.

Ans. (a) (i) AlN (ii) $(NH_4)_3PO_4$

(b) Copper shows variable valencies of 1 and 2.
CuCl and $CuCl_2$

Q.22. (a) Calculate the number of molecules in 4 g of methane.
(At. mass of C = 12, H = 1)
(b) Calculate the mass of 2 moles of NH_3 (At. mass of N = 14).

Ans. (a) Molecular mass of methane (CH_4) = 12 + 4 × 1 = 16 g
16 g of methane contain = 6.022×10^{23} molecules
∴ 4 g of methane contain = **1.5055×10^{23} molecules**

(b) Molecular mass of NH_3 = 14 + 3 × 1 = 17 g
1 mole of NH_3 = 17 g
2 mole of NH_3 = 17 × 2 = **34 g**

D. Long Answer Questions (5 Marks)

Previous Years' Questions

Q.1. Define the following terms with example.
(a) Atomicity (b) Anion (c) Molecular Mass
(d) Relative Formula Mass (e) Cation **[2011 (T-II)]**

Ans. (a) **Atomicity :** The number of atoms which constitute one molecule of an element, is called its atomicity.
Example : Nitrogen (N_2) contains two atoms hence it is a diatomic molecule.

(b) **Anion :** A negatively charged ion is called anion.
Example : Chloride ion (Cl^-)

(c) **Molecular Mass :** The number of times a molecule of a molecular compound (covalent compound) is heavier than 1/12 part of ^{12}C (isotope of carbon) is called its molecular mass. Molecular mass of any substance is sum total of atomic masses of the constituting atoms.
Example : Molecular mass of $C_6H_{12}O_6$ = Mass of 6 atoms of carbon + Mass of 12 atoms of hydrogen + Mass of 6 atoms of oxygen

(d) **Relative Formula Mass :** The number of times a unit formula of an ionic compound is heavier than 1/12 part of ^{12}C (isotope of carbon), is called, relative formula mass.
The unit formula mass of any substance, is the sum total of the atomic masses of the constituting atoms.
Formula unit mass of $CaCO_3$ = Mass of 1 atom of calcium + Mass of 1 atom of carbon + Mass of 3 atoms of oxygen

(e) **Cation :** A positively charged ion is called cation. Example : Sodium (Na^+)

Q.2. (i) Calculate the molecular mass of $CaCO_3$. (At mass Ca=40 u, C=12 u, O=16 u)
(ii) Verify by calculating that
(a) 5 moles of CO_2 and 5 moles of H_2O do not have the same mass.
(b) 240g of calcium and 240 g of magnesium elements have a mole ratio of 3 : 5.
(At mass H=1u, Ca= 40u, Mg=24u) **[2011 (T-II)]**

Ans. (i) Molecular mass of $CaCO_3$ = 40 + 12 + 3 (16) = 40 + 12 + 48 = **100 u**

(ii) (a) Molecular mass of CO_2 = 12 + 2 (16) = 12 + 32 = 44
Molecular mass of H_2O = 2(1) + 16 = 18

Mass of 5 moles of CO_2 = 44 × 5 = 220 g

Mass of 5 mole of H_2O = 5 × 18 = 90 g

So, they do not have the same mass.

(b) 40 g of calcium = 1 mole

240 g of calcium = $\frac{240}{40}$ = 6 moles

24 g of magnesium = 1 mole

240 g of magnesium = $\frac{240}{24}$ = 10 moles

Ratio of moles of 240 g of calcium and 240 g of magnesium = 6 : 10 or 3 : 5

Q.3. (a) Write the formula of the compounds formed by the following ions.

(i) Cr^{3+} and SO_4^{2-} (ii) Pb^{2+} and NO_3^{-1}

(b) State the significance of one mole.

(c) Which has more number of atoms 100g of sodium or 100g of iron?

(At mass Na = 23u, Fe = 56u) **[2011 (T-II)]**

Ans. (a) (i) Symbol Cr^{3+} SO_4^{2-}

Valency +3 –2

Formula — $Cr_2(SO_4)_3$

Symbol Pb^{2+} NO_3^{-1}

Valency +2 –1

Formula — $Pb(NO_3)_2$

(b) A group of 6.022×10^{23} particles (atoms, molecules, ions, electrons, protons, neutrons, etc) of a substance is called one mole of that substance.

Thus, 1 mole of atoms = 6.022×10^{23} atoms

1 mole of molecules = 6.022×10^{23} molecules

1 mole of ions = 6.022×10^{23} ions

1 mole of neutrons = 6.022×10^{23} neutrons

(c) 23 g of sodium has atoms = N (Avogadro's number)

$\therefore$ 100 g of sodium has atoms = $\frac{100}{23}$ N = **4.3 N atoms**

Also 56 g of iron has atoms = N (Avogadro's number)

$\therefore$ 100 g of iron has atoms = $\frac{100}{56}$ N = **1.78 N atoms**

100 g of sodium has more atoms than 100 g of iron.

Other Important Questions

Q.1. Compute the difference in masses of one mole each of aluminium atoms and one mole of its ions. (Mass of an electron is 9.1×10^{-28}g). Which one is heavier?

Ans. Molar mass of Al atoms = 27 g mol^{-1}

$Al - 3e^- \rightarrow Al^{3+}$

The mass of 3 moles of electrons = $3 \times 9.1 \times 10^{-28} \times 6.022 \times 10^{23}$ g = 1.64×10^{-3} g

Molar mass of Al^{3+} = (27 – 0.00164) g mol^{-1} = 26.9984 g mol^{-1}

Difference in mass of 1 mole of aluminium atoms and 1 mole of aluminium ions

= 27 – 26.9984 = **0.0016 g**

Aluminium atoms are heavier than aluminium ions.

Q.2. A silver ornament of mass 'm' gram is polished with gold equivalent to 1% of the mass of silver. Compute the ratio of the number of atoms of gold and silver in the ornament.

[Molar mass of gold = 197 g/mol, silver = 108 g/mol]

Ans. Mass of silver = m g

Mass of gold $\frac{m}{100}$ g

Number of atoms of silver = $\frac{\text{mass}}{\text{at. mass}} \times N_A = \frac{m}{108} \times N_A$

Number of atoms of gold $= \frac{m/100}{197} \times N_A$

Ratio of number of atoms of gold and silver = Au : Ag $= \frac{m}{100 \times 197} \times N_A : \frac{m}{108} \times N_A$

$= \frac{108}{100 \times 197} = 108 : 19700 =$ **1 : 182.41**

Q.3. A sample of ethane (C_2H_6) gas has the same mass as 1.5×10^{20} molecules of methane (CH_4). How many C_2H_6 molecules does the sample of the gas contain?

Ans. Mass of 1 molecule of $CH_4 = \frac{16}{N_A}$

Mass of 1.5×10^{20} molecules of $CH_4 = \frac{1.5 \times 10^{20} \times 16}{N_A}$ g

Mass of 1 molecule of $C_2H_6 = \frac{30}{N_A}$ g

$\therefore$ Number of molecules of ethane = $\frac{1.5 \times 10^{20} \times 16}{N_A} \times \frac{N_A}{30} = \mathbf{0.8 \times 10^{20}}$

Q.4. Write the formulae for the following and calculate the molecular mass for each one of them.

(a) Caustic potash (b) Baking powder (c) Limestone (d) Caustic soda (e) Ethanol

[K = 39, O = 16, H = 1, Na = 23, C = 12]

Ans. (a) KOH

Mol. mass = 39 + 16 + 1 = **56 *u***

(b) $NaHCO_3$

Mol. mass = 23 + 1 + 12 + 3 × 16 = **84 *u***

(c) $CaCO_3$

Mol. mass = 40 + 12 + 3 × 16 = **100 *u***

(d) NaOH

Mol. mass = 23 + 16 + 1 = **40 *u***

(e) C_2H_5OH

Mol. mass = 2 × 12 + 5 × 1 + 16 + 1 = **46 *u***

Q.5. (a) Calculate the number of molecules in 4g of methane.
(At. mass of C = 12, H = 1)

(b) Calculate the mass of 2 moles of NH_3 (At mass of N = 14).

Ans. (a) Molecular mass of methane = 12 + 1 × 4 = 16 g

16 g of CH_4 contains 6.022×10^{23} molecules.

$\therefore$ 4g of CH_4 contains $\frac{6.022 \times 10^{23} \times 4}{16}$ = **1.506×10^{23} molecules**

(b) 1 mole of NH_3 = molecular mass of NH_3 = 14 + 1 × 3 = 17 g

2 moles of NH_3 = 2 × 17 = **34 g**

Q.6. (a) Define one mole.

(b) Calculate number of moles in 36 gram of water (atomic mass of H = 1 and O = 6).

(c) Write the chemical formulae of the following compounds :
(i) Zinc phosphate (ii) Sodium chloride (iii) Magnesium hydroxide

Ans. (a) One mole is the amount of substance that contains the same number of particles (atoms/ ions/molecules/formula units, etc.) as there are atoms in exactly 12 grams of carbon–12.

(b) Molecular mass of water = 1 × 2 + 16 = 18

18 g of water is equal to = 1 mole

$\therefore$ 36 g of water = $\frac{1 \times 36}{18}$ = **2 moles**

(c) (i) Elements Zn PO_4 → $Zn_3(PO_4)_2$
Valencies +2 −3

(ii) Na Cl → NaCl
+1 −1

(iii) Mg OH → $Mg(OH)_2$
+2 −1

Q.7. (a) State the 'Law of conservation of mass'.

(b) Mention the postulate of Dalton's atomic theory that explains the law of constant proportions.

(c) Mention any two rules to write a chemical formula.

(d) Write chemical formulae for the following compounds :
(i) Calcium hydroxide (ii) Ammonium Sulphate

Ans. (a) Law of conservation of mass states that "mass can neither be created nor destroyed in a chemical reaction".

(b) The relative number and kinds of atoms are constant in a given compound.

(c) (i) The valencies or the charges on the ion must balance.
(ii) When a compound consists of a metal and a non-metal, the name or symbol of the metal is written first. For example, sodium chloride (NaCl).

(d) (i) $Ca(OH)_2$ (ii) $(NH_4)_2SO_4$

II. FORMATIVE ASSESSMENT

A. Science Quiz

(i) If 2 g of hydrogen is equal to 1 mole, how many grams of hydrogen are present in 0.01 moles?

Ans. 1 mole of hydrogen = 2 g

0.01 mole of hydrogen = $\frac{2 \times 0.01}{1}$ = **0.02 g**

(ii) 1 mole of oxygen weighs as much as 4 moles of helium. What is the ratio of atoms of oxygen to the atoms of helium?

Ans. 1 mole of any element contains = 6.022×10^{23} atoms

∴ Ratio of the atoms of oxygen present in 1 mole : Ratio of the atoms of helium present in 4 moles = **1 : 4**

(iii) 24 g of magnesium has as many atoms as 12g of carbon. How many moles of carbon will weigh as much as 24 g of magnesium?

Ans. 24 g of Mg = 1 mole of Mg = 6.022×10^{23} atoms of Mg

∴ 1 mole of any element contains 6.022×10^{23} atoms of that element.

12 g of carbon also contains 6.022×10^{23} atoms of carbon.

∴ 6.022×10^{23} atoms of C = **1 mole**

(iv) Name two non-metals that have lustre.

Ans. Iodine and graphite (an allotrope of carbon)

(v) Name a non-metal which occurs as liquid at room temperature.

Ans. Bromine

(vi) What is the difference between molecular mass and g-molecular mass of an element?

Ans. Molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance. It is thus, a relative mass of a molecule expressed in atomic mass unit.

g - molecular mass of an element is the molecular mass of the element expressed in grams.

Example — Molecular mass of oxygen = 32 *u*

Gram molecular mass of oxygen = 32 g

(vii) 1.70g of silver nitrate in solution form reacts with 0.585 g of sodium chloride in solution form. If the mass of sodium nitrate formed is 0.85 g, what is the mass of silver chloride formed?

Ans.

$AgNO_3$	+	NaCl	$\rightarrow$	AgCl	+	$NaNO_3$
$108 + 14 + 3 \times 16$		$23 + 35.5$		$108 + 35.5$		$23 + 14 + 3 \times 16$
= 170 g		= 58.5 g		= 143.5 g		= 85 g

170 g of $AgNO_3$ reacts with 58.5 g NaCl to produce 143.5 g AgCl and 85 g of $NaNO_3$.

∴ 1.70 g of $AgNO_3$ will react with 0.585 g of NaCl to produce 1.435 g of AgCl and 0.85 g of $NaNO_3$.

B. Group Activity

Objective : To prepare playing cards for making formulae from symbol.

1. Take a fresh pack of playing cards. On each of the cards paste white paper and allow it to dry.
2. Cut the excess paper with the help of scissors, so as to make it the exact size of the playing card.

3. Take three cards and write over them Na^+.
4. Similarly, on a set of three cards write NH_4^+, Ca^{2+}, Zn^{2+}, Cu^{2+}, Al^{3+}, Fe^{3+}, Cl^-, O^{2-}, OH^-, CO_3^{2-}, PO_4^{3-}, NO_3^- and S^{2-}.
5. Your playing card of 52 pieces is ready for playing.
6. Distribute the cards equally among four players. Start making a set of compounds, such as Na_2S, Al_2O_3, $ZnSO_4$, etc.
   The card or cards which do not fit can be discarded as you play the game of Rummy.
7. The player who makes the maximum number of formulae first is the winner.

C. Charts

1. Prepare a chart of all the elements in the order of their increasing atomic numbers. Clearly show the metals, metalloids and non-metals.

D. Collections

Collect five samples of metallic elements and two samples of non-metallic elements.