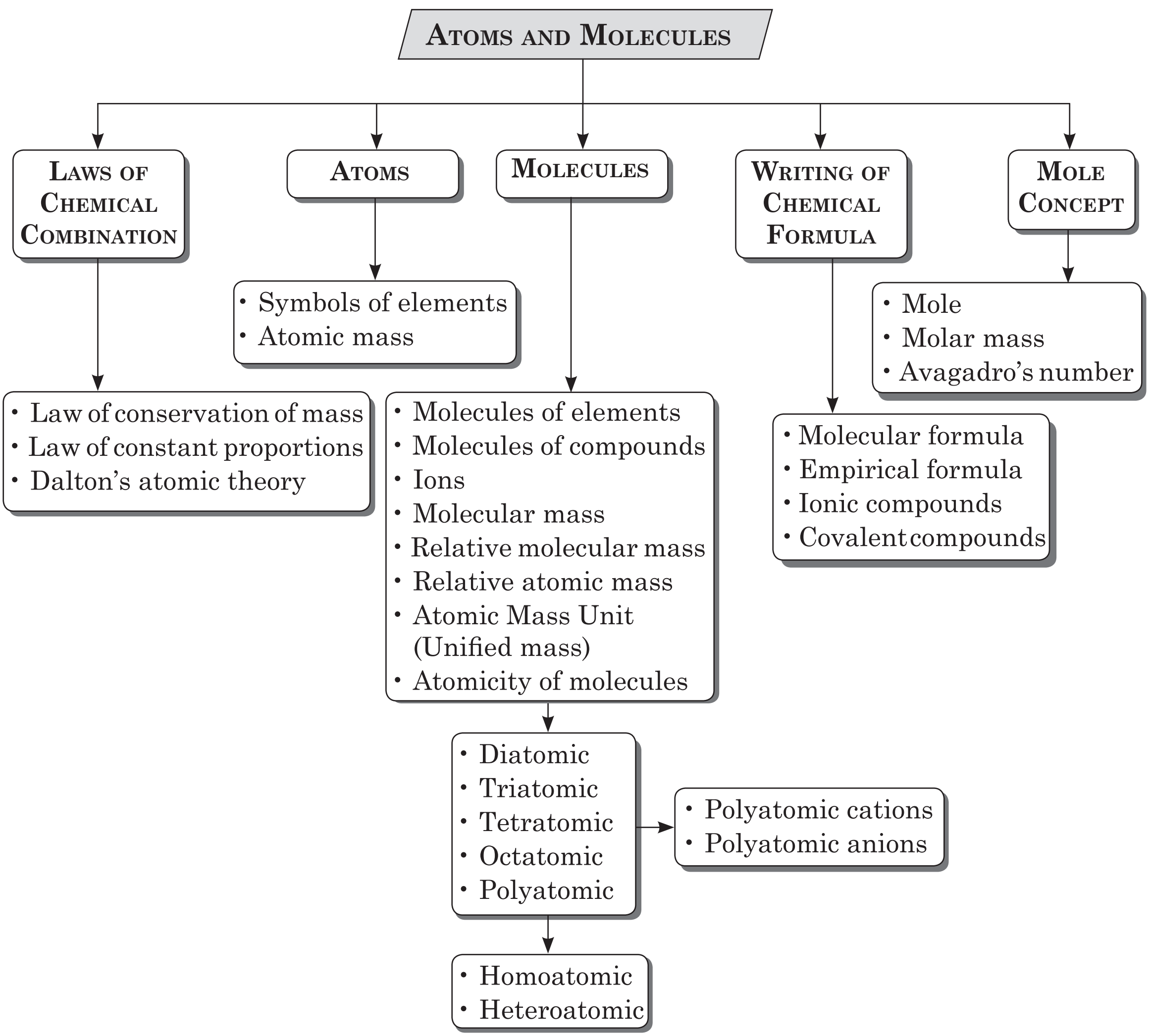
3 Atoms and Molecules

Topics Covered

3.1 Atoms, Symbols of Elements, Atomic mass, Molecules of Elements and Compounds, Ions, Writing Chemical Formula, Molecular Mass, Formula Unit Mass
3.2 Dalton Atomic Theory, Laws of Chemical Combination
3.3 Mole Concept

CHAPTER MAP



Quick Revision Notes

- Atoms are the smallest particles which can take part in a chemical reaction.
- Lavosier's Law of conservation of mass, states that "Matter can neither be created nor be destroyed".
- Proust invented the Law of constant proportions. It states that "In a chemical compound elements are always present in a definite proportion by mass."
- John Dalton gave "Dalton's atomic theory."
- A molecule is made up of two or more atoms and is capable of independent existence under ordinary conditions. It shows all the properties of a substance.
- IUPAC (International Union of Pure and Applied Chemistry) gave symbols of the atoms of the different elements.
- Atomicity is the number of atoms present in a molecule.
- Atomic mass is the mass of an atom of an element.
- Atomic mass unit (*u*) also called as unified mass has been accepted to express the atomic and molecular mass of the elements and the compounds.
- It is defined as $\frac{1}{12}$th of the mass of an atom of C-12. It is denoted by '*u*'.
- $1\ u = \frac{1}{12} \times \text{Mass of 1 atom of } {}^{12}_{6}\text{C}$
- $1\ u = 1.66 \times 10^{-27}$ kg
- Atomic mass of H = 1 *u*, N = 14 *u*, O = 16 *u*, C = 12 *u*, Na = 23 *u*, Mg = 24 *u*, Ca = 40 *u*, Cl = 35.5 *u*, Al = 27 *u*, Fe = 56 *u*.
- Atoms of most of the elements are very reactive and do not exist freely.
- He, Ne, Ar, Kr, Xe, Rn are the atoms of noble gases which are chemically least reactive and can exist as free as a single atom (monoatomic).
- Atoms of other elements combine together to form molecules or ions.
- Ions are electrically charged atoms. Positive ions are called cations whereas negative ions are called anions.
- Homoatomic molecules contain atoms of same elements, e.g. H_2, O_2, N_2, O_3, P_4, S_8.
- Heteroatomic molecules contain atoms of different elements, e.g. H_2O, NH_3, CH_4, H_2S, etc.
- The chemical formula of a compound shows the ratio of its constituent elements and the number of atoms of each combining element.
- Those ions which are made up of more than two atoms are called polyatomic ions.
- Molecular mass of a compound can be calculated as the sum of the atomic mass of each constituent element multiplied by the number of atoms of that element. It is expressed in '*u*'.
- Formula unit mass of a substance is the sum of atomic masses of atoms present in the formula unit of a compound.
- Mole is defined to be 6.022×10^{23} atoms, molecules or ions or particles of a substance.
- 1 mole of a atom of an element has a mass equal to the gram atomic mass of that element.
- Avogadro's number is equal to 6.022×10^{23} atoms, molecules or ions present in 1 mole of a substance.
- **Important Formulae:**

(*i*) Number of moles (n) = $\frac{\text{Given mass}}{\text{Molar mass}} = \frac{m}{\text{M}}$

(*ii*) Number of moles (n) = $\dfrac{\text{Given number of molecules}}{\text{Avogadro's Number}} = \dfrac{N}{N_0}$

$$\because \frac{m}{M} = \frac{N}{N_0}$$

$$\therefore \boxed{m = \frac{M \times N}{N_0}}$$

(*iii*) Percentage of an element in a compound

$$= \frac{\text{Total mass of an element in the compound}}{\text{Molar mass of the compound}} \times 100$$

(*iv*) Percentage of element = $\dfrac{\text{Given mass of element}}{\text{Given mass of compound}} \times 100$

1. Atoms, Symbols of Elements, Atomic mass, Molecules of Elements and Compounds, Ions, Writing Chemical Formula, Molecular Mass, Formula Unit Mass

Atoms

It is the smallest particle which may or may not exist freely. It is the smallest unit of an element which takes part in a chemical reaction.

Characteristics:

- Atoms are building blocks of matter.
- They are very small in size around 100 picometers (10^{-12} m)
- Atomic radius is measured in nanometers (1 nm = 10^{-9} m).
- Atoms of most of the elements do not exist freely.

Symbols of Element

- It is a symbolic representation of names of elements.
- Dalton was the first scientist to use the symbols of elements.
- He used symbols which meant a definite quantity of that element, that is, one atom of an element.
- Berzelius suggested that the symbols of elements can be made by first one or two letters of the name of elements.
- In the beginning, the names of elements were derived from the names of places from where they had been found for the first time, e.g. the name of copper was taken from Cyprus.
- Some names were taken from specific colours that the element posseses, e.g. Gold was taken from the English word meaning yellow.
- IUPAC approved the name of elements in those days.
- The symbols of some elements are first letters of their names and in many elements it is the first two letters. First letter is written in capital and second in small case, e.g. 'Al' for Aluminium, Co for Cobalt, etc.
- In some cases, symbols of elements are the first letter and other letter appearing in their name, e.g. Chlorine (Cl), Zinc (Zn).
- Some names of elements have been derived from the Latin, Greek or German words.
- Latin name of iron is Ferrum (Fe), Sodium is Natrium (Na), Potassium is Kalium (K).
- They represent one atom of an element, e.g. as shown in the following table:

Symbols of Some Elements

	Element	Symbol		Element	Symbol		Element	Symbol		Element	Symbol
1.	Aluminium	Al	12.	Fluorine	F	24.	Mercury	Hg	36.	Manganese	Mn
2.	Argon	Ar	13.	Hydrogen	H	25.	Iodine	I	37.	Gallium	Ga
3.	Arsenic	As	14.	Helium	He	26.	Iron	Fe	38.	Selenium	Se
4.	Boron	B	15.	Lithium	Li	27.	Zinc	Zn	39.	Indium	In
5.	Barium	Ba	16.	Nitrogen	N	28.	Tin	Sn	40.	Germanium	Ge
6.	Beryllium	Be	17.	Oxygen	O	29.	Potassium	K	41.	Krypton	Kr
7.	Bromine	Br	18.	Neon	Ne	30.	Silicon	Si	42.	Xenon	Xe
8.	Carbon	C	19.	Sodium	Na	31.	Sulphur	S	43.	Radon	Rn
9.	Calcium	Ca	20.	Magnesium	Mg	32.	Uranium	U			
10.	Chlorine	Cl	21.	Gold	Au	33.	Phosphorus	P			
11.	Cobalt	Co	22.	Silver	Ag	34.	Chromium	Cr			
12.	Copper	Cu	23.	Lead	Pb	35.	Nickel	Ni			

Atomic Mass

The mass of an atom is called its atomic mass.

- **Relative atomic mass:** It is defined as number of times the given atom of an element is heavier than 1/12th of the mass of atom of carbon-12 isotope.
  Relative atomic mass of an element is also defined as average mass of an atom as compared to 1/12th of the mass of one atom carbon-12, e.g.
  H = 1u, C = 12u, N = 14u, O = 16u, Na = 23u, Mg = 24u, Al = 27u, S = 32u, Cl = 35.5u, Ca = 40u, K = 39u, P = 31u, Cu = 63.5u, Zn = 65u, Fe = 56u
- **Unified mass (atomic mass unit):** It is equal to the mass of 1/12th of the mass of 1 atom of C–12 isotope.

Molecule of Elements

It is mostly a group of two or more atoms which are chemically bonded together, i.e. strongly held together by forces of attraction.

An atom is the smallest particle of an element which is capable of free existence.

Atoms of same or different elements join together to form a molecule. Molecules of the elements are of the following types:

- **Monoatomic:** These elements exist as single atoms, e.g. He, Ne, Al, Kr, Xe, Rn, Na, K, Fe, Al, Cu, C.
- **Diatomic:** These molecules of elements exist as two atoms bonded together, e.g. O_2, N_2, Br_2, Cl_2, H_2, I_2.
- **Triatomic:** These molecules of elements contain three atoms, e.g. Ozone (O_3)
- **Tetratomic:** These molecules of elements are made up of four atoms, e.g. P_4
- **Octatomic:** These molecules of elements are made up of eight atoms, e.g. S_8

Molecules of Compounds

Atoms of the different elements combine together in a definite proportion to form molecules of the compounds, e.g. H_2O (water), NH_3 (ammonia), CO_2 (Carbon dioxide), CH_4 (Methane), CO (Carbon monoxide).

Each molecule has atoms in a fixed ratio by mass, e.g. in H_2O it is 2 : 16 i.e., 1 : 8. In NH_3 the ratio is 14 : 3 by mass.

Binary Compounds: Those compounds which are made up of two different elements are called binary compounds. Some examples are as follows:

H Cl	H O	C Cl	Mg Cl	Al O	Na NO_3
1 1	1 2	4 1	+2 1–	+3 2–	+1 1–
HCl	H_2O	CCl_4	$MgCl_2$	Al_2O_3	$NaNO_3$

If valencies of two elements are the same, we can write the simplest ratio, e.g.

Ca O	Si O	C O	Ca OH	Na CO_3	NH_4 SO_4
2 2	4 2	4 2	2+ 1–	+1 2–	+1 2–
CaO	SiO_2	CO_2	$Ca(OH)_2$	Na_2CO_3	$(NH_4)_2SO_4$

Ions

The charged species are known as **ions**.

- Positively charged ions are called **cations**, e.g. K^+, Na^+, Ca^{2+}, Mg^{2+}, Al^{3+}, Fe^{2+}.
- Negatively charged ions are called **anions**, e.g. Cl^-, Br^-, I^-, O^{2-}, S^{2-}, N^{3-}.
- A group of atoms carrying a charge is called a **polyatomic ion**.
- Those compounds which are formed from ions of opposite charge in a fixed proportion are called **ionic compounds**, e.g. CaO has Ca^{2+} and O^{2-} ions in the ratio of 5 : 2, MgO has Mg^{2+} and O^{2-} ions in the ratio of 3 : 2, NaCl has Na^+ and Cl^- ions in ratio of 23 : 35.5 by mass.

Molecular Mass

It is the sum of atomic masses of all the atoms in a molecule of that substance, e.g. molecular mass of $H_2O = 2H + 1O = 2 \times 1 + 1 \times 16 = 18\ u$.

Formula Unit Mass

It is the sum of atomic mass of ions and atoms present in a formula unit of an ionic compound, e.g. NaCl has 23 + 35.5 = 58.5 *u* as its formula unit mass.

Rules for Writing Chemical Formula

1. We first write symbol of elements which are present in a compound.
2. Below the symbol of every element, we write its valency.
3. Now we cross over the valencies of combining atoms.
4. With first atom, we write the valency of second atom (as a subscript).
5. With second atom, we write the valency of first atom (as a subscript).
6. The valencies or charge on an atom must be balanced (equal).
7. When metals and non-metals are present in a compound, symbol of metals are written first and then non-metals are written on the right side.
8. Compounds which are formed with polyatomic ions has ions enclosed in a small bracket before writing the number to indicate the ratio of ions.

An ion has the same mass as the atom from which it is made by chemical formula. It is a symbolic representation of the composition of a compound.

Valency: It is defined as the number of electrons lost or gained or shared by an element.

- It helps to find out only how many atoms of an element are combined with the atoms of another element.
- Valency can be thought of as hands or arms of an element.

Valency	Name of ion	Symbol	Non-metallic element	Symbol	Polyatomic ions	Symbol
1.	Sodium	Na^+	Hydrogen	H^+	Ammonium	NH_4^+
	Potassium	K^+	Hydride	H^-	Hydroxide	OH^-
	Silver	Ag^+	Chloride	Cl^-	Nitrate	NO_3^-
	Copper (I)	Cu^+	Bromide	Br^-	Nitrite	NO_2^-
	Mercury (I)	Hg^+	Iodide	I^-	Hydrogen Carbonate	HCO_3^-
			Fluoride	F^-	Hydrogen Sulphate	HSO_4^-
					Hydrogen Sulphite	HSO_3^-
					Permanganate	MnO_4^-
2.	Magnesium	Mg^{2+}	Oxide	O^{2-}	Carbonate	CO_3^{2-}
	Lead	Pb^{2+}	Sulphide	S^{2-}	Sulphite	SO_3^{2-}
	Calcium	Ca^{2+}			Sulphide	S^{2-}
	Zinc	Zn^{2+}			Sulphate	SO_4^{2-}
	Copper (II)	Cu^{2+}			Chromate	CrO_4^{2-}
	Iron (II)	Fe^{2+}			Dichromate	$Cr_2O_7^{2-}$
	Mercury (II)	Hg^{2+}			Manganate	MnO_4^{2-}
3.	Aluminium	Al^{3+}	Nitride	N^{3-}	Phosphate	PO_4^{3-}
	Chromium (III)	Cr^{3+}	Phosphide	P^{3-}	Phosphite	PO_3^{3-}
	Iron (III)	Fe^{3+}			Chlorate	ClO_3^-
	Bismuth	Bi^{3+}			Meta-aluminate	AlO_2^-

- **Variable Valency:** Some elements show more than one valency called variable valency. A Roman numeral shows their valency in the brackets, e.g. Copper (I), Copper (II), Iron (II), Iron (III), Mercury (I), Mercury (II).

Exercise 3.1

I. Very Short Answer Type Questions (1 Mark)

1. What is meant by the term chemical formula? [*NCERT*]
2. How many atoms are present in a:
   (*i*) H_2S molecule (*ii*) PO_4^{3-} ion? [*NCERT*]
3. Name the unit in which atomic radius is measured. [*DOE*]
4. Define molecular mass. [*DOE*]
5. What is the formula unit mass? [*DOE*]
6. Name the element used as a standard for atomic mass unit. [*DOE*]
7. In what form does oxygen occur in nature? **[HOTS]** [*DOE*]
8. In what form noble gases exist in nature? **[HOTS]** [*DOE*]
9. What is the difference between 2H and H_2? **[HOTS]** [*DOE*]
10. Calculate formula unit mass of $Mg(NO_3)_2$. (Mg = 24 u, N = 14 u, O = 16 u) **[HOTS]**
11. Define the atomic mass unit. [*NCERT*]
12. Why is it not possible to see an atom with naked eyes? [*NCERT*]
13. Define atomicity. [*CBSE* **2010**] [*CBSE* **2015**]
14. How many atoms are present in one molecule of ozone? [*CBSE* **2010**]
15. Give an example of:
    (*a*) Triatomic,
    (*b*) Polyatomic molecules of elements. [*CBSE* **2015**] [*CBSE* **2012**]

16. Define law of constant proportion. [*CBSE* 2010]
17. What is the ratio between mass of carbon and oxygen in CO_2? (C = 12 *u* O = 16 *u*)
18. Name the anion and cation present in molecule of magnesium oxide. [*CBSE* 2012]
19. An element 'X' has valency 3. Write the formula of its oxide. [*CBSE* 2012] [HOTS]
20. Write the names of compounds (*a*) Ag_2O (*b*) CuS.
21. Write the symbol for following elements (*a*) Iron (*b*) Potassium [*CBSE* 2012]
22. Give the difference between a cation and an anion? [*CBSE* 2010]
23. Write the names of the following compounds:
    (*a*) $Al_2(SO_4)_3$ (*b*) NH_4OH [*CBSE* 2010]
24. Which of the following statements is not true about an atom?
    (*a*) Atoms are not able to exist independently.
    (*b*) Atoms are the basic units from which molecules and ions are formed.
    (*c*) Atoms are always neutral in nature.
    (*d*) Atoms aggregate in large numbers to form the matter that we can see, feel or touch.
25. The chemical symbol for nitrogen gas is:
    (*a*) Ni (*b*) N_2 (*c*) N^+ (*d*) N
    [*NCERT Exemplar*]
26. The chemical symbol for sodium is:
    (*a*) So (*b*) Sd (*c*) NA (*d*) Na
    [*NCERT Exemplar*]
27. Which of the following represents a correct chemical formula? Name it.
    (*a*) CaCl (*b*) $BiPO_4$ (*c*) $NaSO_4$ (*d*) NaS
    [*NCERT Exemplar*]
28. The oxide of 'Al' has a chemical formula Al_2O_3. State the valency of Al. [*CBSE* 2015]
29. What is the formula of ammonium chloride? [*CBSE* 2014]

II. Short Answer Type Questions–I (2 Marks)

30. Write down the formulae of:
    (*a*) sodium oxide (*b*) aluminium chloride
    (*c*) sodium suphide (*d*) magnesium hydroxide [*NCERT*]
31. (*a*) Calculate the relative molecular mass of water (H_2O).
    (*b*) Calculate the relative molecular mass of HNO_3.
32. Calculate the formula unit mass of $CaCl_2$.
33. What is atomicity? Explain with two examples. [*DOE*]
34. Calculate relative molecular mass of H_2 and NH_3 [Atomic mass of H = 1 *u*, N = 14 *u*] [*DOE*]
35. Give the names of the elements present in the following compounds:
    (*a*) Quicklime (*b*) Hydrogen bromide
    (*c*) Baking powder (*d*) Potassium sulphate [*NCERT*]
36. As per law of definite proportions, carbon and oxygen combine in the ratio of 3 : 8. Compute the mass of oxygen that would be required to react completely with 6 g of carbon.
    [*CBSE* 2016]
37. Find the formula unit mass of (*a*) $NaHCO_3$ (*b*) Na_2CO_3 [*CBSE* 2010]
38. Select the element that is (*a*) ductile, (*b*) conductor of electricity, (*c*) a constituent of water, (*d*) non-metal, liquid at room temperature. [*CBSE* 2010]
39. Hydrogen and Oxygen combine in the ratio 1 : 8 by mass for water. What mass of oxygen gas would be required to completely react with 4 g of hydrogen gas? [*CBSE* 2010]

40. Classify the following compounds as diatomic, triatomic and polyatomic molecule:
HCl, H_2, H_2O, NH_3 **[*CBSE* 2014]**

41. Write the cations and anions present (if any) in the following compounds:
(*a*) CH_3COONa (*b*) $NaCl$
(*c*) H_2 (*d*) NH_4NO_3 **[*NCERT Exemplar*]**

42. Which of the following symbols of elements are incorrect? Give their correct symbols.
(*a*) Cobalt—CO (*b*) Carbon—C (*c*) Aluminium—AL
(*d*) Helium—He (*e*) Sodium—So **[*NCERT Exemplar*]**

III. Short Answer Type Questions–II (3 Marks)

43. Write down the names of compounds represented by the following formula:
(*a*) $Al_2(SO_4)_3$ (*b*) $CaCl_2$ (*c*) K_2SO_4 (*d*) KNO_3
(*e*) $CaCO_3$. **[*NCERT*]**

44. Calculate the formula unit masses of ZnO, Na_2O, K_2CO_3. [Atomic mass of Zn = 65 u, O = 16 u Na = 23 u, K = 39 u, C = 12 u] **[*NCERT*]**

45. What is the difference between homoatomic and heteroatomic molecules? Illustrate with the help of four examples each? **[*NCERT*]**

46. A 0.24 g sample of 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. **[*NCERT*] [HOTS]**

47. When 3.0 g of carbon is burnt in 8.0 g oxygen, 11.0 g of carbon dioxide is produced. What mass of carbon dioxide will be formed when 3.0 g of carbon is burnt in 50.0 g of oxygen? Which law of chemical combination will govern your answer? **[*NCERT*] [*CBSE* 2012] [HOTS]**

48. What are polyatomic ions? Give examples. **[*NCERT*]**

49. Write the chemical formulae of the following.
(*a*) Magnesium chloride (*b*) Calcium oxide
(*c*) Copper nitrate (*d*) Aluminium chloride
(*e*) Calcium carbonate [*NCERT*]

50. The percentage of three elements, calcium, carbon and oxygen in a sample is given as
Ca = 40% C = 12% O = 48%
If law of constant proportion is true, what weights of these elements will be present in 1.5 g of another sample of calcium carbonate? [Atomic mass of Ca = 40 u, C = 12 u, O = 16 u]
[*CBSE* 2012]

51. How will you prove law of conservation of mass experimentally?

52. (*a*) When 5 g of calcium is burnt in 25 g of oxygen then 7 g of calcium oxide is produced. What mass of calcium oxide will be produced when 5 g of calcium is burnt in 20 g of oxygen? Which law of chemical combination will govern your answer? State the law.
(*b*) Write the chemical formula of calcium oxide .

53. Write the molecular formulae for the following compounds:
(*a*) Copper(II) bromide (*b*) Aluminium(III) nitrate
(*c*) Calcium(II) phosphate (*d*) Iron(III) sulphide
(*e*) Mercury(II) chloride (*f*) Magnesium(II) acetate
[*NCERT Exemplar*]

54. Give the formulae of the compounds formed from the following sets of elements:
(*a*) Calcium and fluorine (*b*) Hydrogen and sulphur
(*c*) Nitrogen and hydrogen (*d*) Carbon and chlorine
(*e*) Sodium and oxygen (*f*) Carbon and oxygen **[*NCERT Exemplar*]**

IV. Long Answer Type Questions **(5 Marks)**

55. Calculate the molecular masses of H_2, O_2, Cl_2, CO_2, CH_4, C_2H_6, C_2H_4, NH_3, CH_3OH. [Atomic Mass of H = 1 *u*, O = 16 *u*, Cl = 35.5 *u*, C = 12 *u*, N = 14 *u*] **[*NCERT*]**

56. Write the molecular formulae of all the compounds that can be formed by the combination of following ions:
Cu^{2+}, Na^{+}, Fe^{3+}, Cl^{-}, SO_4^{2-} , PO_4^{3-} **[*NCERT Exemplar*]**

57. Define the following terms:
(*a*) Atom (*b*) Molecule (*c*) Avogadro's number (*d*) Valency (*e*) Molar mass

Answers 3.1

1. It is a symbolic representation of a compound with the help of symbols of the elements and formula of radicals (polyatomic ions) and valencies.

2. (*i*) 3 (*ii*) 5

3. Nanometre (nm)

4. It is equal to the sum of masses of all the atoms present in a molecule.

5. It is the sum of masses of all the ions and polyatomic ions present in the formula unit of an ionic compound.

6. Carbon-12

7. It exist as O_2.

8. They exist as monoatomic molecules, e.g. He, Ne, Ar.

9. 2H represent 2 atoms of Hydrogen whereas H_2 represents a molecule of hydrogen gas.

10. Formula unit mass of $Mg(NO_3)_2$

$$= 1Mg + 2N + 6O$$
$$= 24 + 2 \times 14 + 6 \times 16$$
$$= 24 + 28 + 96 = 148\ u$$

11. It is defined as unit of mass equal to 1/12th of the mass of 1 atom of C-12 isotope.

12. It is because atom is very small (10^{-9} m), it cannot be seen by naked eye.

13. It is defined as the number of atoms present in a molecule.

14. O_3 has $3O^{-}$ atoms.

15. (*a*) O_3 (*b*) S_8

16. It states that chemical compounds have elements which are combined in a fixed ratio by mass.

17. CO_2
12 : 32
3 : 8 by mass

18. Mg^{2+} is the cation , O^{2-} is the anion.

19.
$$\begin{array}{cc} X & O \\ 3 & 2 \end{array}$$
X_2O_3

20. (*a*) Silver(I) Oxide (*b*) Copper(II) Sulphide

21. (*a*) Fe (*b*) K

22. Cation is a positively charged ion in which number of protons are greater than electrons. Anion is a negatively charged ion in which number of electrons are greater than protons.

23. (*a*) Aluminium sulphate (*b*) Ammonium hydroxide

24. (*a*) Atoms are not able to exist independently is not true because some of the atoms can exist independently e.g. He, Ne.

25. (*b*) N_2 gas

26. (*d*) Na

27. (*b*) $BiPO_4$

$$\begin{array}{cc} Bi & PO_4 \\ 3 & 3 \\ \multicolumn{2}{c}{BiPO_4} \end{array}$$

28. 3

29.

$$\begin{array}{cc} NH_4 & Cl \\ +1 & 1- \\ \multicolumn{2}{c}{NH_4Cl} \end{array}$$

30. (*i*)

$$\begin{array}{cc} Na & O \\ +1 & 2- \\ \multicolumn{2}{c}{Na_2O} \end{array}$$

(*ii*)

$$\begin{array}{cc} Al & Cl \\ +3 & 1- \\ \multicolumn{2}{c}{AlCl_3} \end{array}$$

(*iii*)

$$\begin{array}{cc} Na & S \\ +1 & 2- \\ \multicolumn{2}{c}{Na_2S} \end{array}$$

(*iv*)

$$\begin{array}{cc} Mg & OH \\ +2 & 1- \\ \multicolumn{2}{c}{Mg(OH)_2} \end{array}$$

31. (*a*) Molecular mass of H_2O = 2 × Mass of 1 atom of H + Mass of 1 atom of O

$= 2 \times 1 + 16 = 18\ u$

(*b*) Molecular mass of HNO_3 = Mass of 1 atom of H + Mass of 1 atom of N + Mass of 3 atoms of O

$= 1 \times 1 + 1 \times 14 + 3 \times 16$

$= 1 + 14 + 48 = 63\ u$

32. Formula unit mass of $CaCl_2$ = Atomic mass of Ca + 2 × Atomic mass of Cl

$= 40 + 2 \times 35.5 = 40 + 71 = 111\ u$

33. Atomicity is defined as the number of atoms in a molecule. For example:
H_2 is a diatomic molecule, and O_3 is a triatomic molecule.

34. Molecular mass of $H_2 = 1 \times 2 = 2\ u$

Molecular mass of $NH_3 = 1 \times 14 + 3 \times 1 = 14 + 3 = 17\ u$

35. (*a*) Quicklime (CaO) contains calcium and oxygen.

(*b*) Hydrogen Bromide (HBr) contains Hydrogen and Bromine.

(*c*) Baking Powder ($NaHCO_3$) contains Sodium, Hydrogen, Carbon and Oxygen.

(*d*) Potassium sulphate (K_2SO_4) contains Potassium, Sulphur and Oxygen.

36. 3 g of carbon reacts with 8 g of oxygen.

$\therefore$ 6 g of carbon reacts with $\frac{8}{3} \times 6 = 16$ g of oxygen

37. Formula unit mass of $NaHCO_3$

$= Na + H + C + 3O$

$= 23 + 1 + 12 + 3 \times 16$

$= 23 + 1 + 12 + 48 = 84\ u$

Formula unit mass of Na_2CO_3

$= 2\ Na + 1\ C + 3\ O$

$= 2 \times 23 + 1 \times 12 + 3 \times 16$

$= 46 + 12 + 48 = 106\ u$

38. (*a*) Copper (*b*) Aluminium (*c*) Hydrogen and Oxygen (*d*) Bromine

39. 1 g of hydrogen combines with 8 g of oxygen

$\therefore$ 4 g of hydrogen combines with $8 \times 4 = 32$ g of oxygen.

40. Diatomic: HCl, H_2

Triatomic: H_2O

Polyatomic: NH_3

41. (*a*) CH_3COO^- is the anion and Na^+ is the cation
(*b*) Na^+ is the cation and Cl^- is the anion
(*c*) It does not form ions.
(*d*) NH_4^+ is the cation and NO_3^- is the anion

42. (*a*) Cobalt—Co (*b*) Carbon–C
(c) Aluminium—Al (*d*) Helium—He
(*e*) Sodium—Na

43. (*i*) Aluminium Sulphate (*ii*) Calcium Chloride (*iii*) Potassium Sulphate
(*iv*) Potassium Nitrate (*v*) Calcium Carbonate.

44. Formula unit mass of

$$\begin{aligned} ZnO &= 1\,Zn + 1\,O \\ &= 1 \times 65 + 1 \times 16 \\ &= 65 + 16 = 81\ u \end{aligned}$$

Formula unit mass of

$$\begin{aligned} Na_2O &= 2\,Na + 1\,O \\ &= 2 \times 23 + 1 \times 16 \\ &= 46 + 16 = 62\ u \end{aligned}$$

Formula unit mass of

$$\begin{aligned} K_2CO_3 &= 2\,K + 1C + 3\,O \\ &= 2 \times 39 + 1 \times 12 + 3 \times 16 \\ &= 78 + 12 + 48 = 138\ u \end{aligned}$$

45. Molecules of an element having atoms of the same element, e.g. H_2, O_3, P_4, S_8 are called heteroatomic molecules.
Molecules of a compound having atoms of different elements combined in a fixed (definite) proportion by mss, e.g. H_2O, NH_3, CH_4, SO_2 are called heteroatomic molecules.

46. $$\%\text{ of Oxygen} = \frac{\text{Mass of Oxygen}}{\text{Mass of Compound}} \times 100 = \frac{0.144}{0.24} \times 100 = \frac{144}{240} \times 100 = 60\%$$

$$\%\text{ of Boron} = \frac{\text{Mass of Boron}}{\text{Mass of Compound}} \times 100 = \frac{0.096}{0.24} \times 100 = \frac{96}{240} \times 100 = 40\%$$

47. $$\underset{12\,g}{C} + \underset{32\,g}{O_2} \rightarrow \underset{12+2\times16\,=44\,g}{CO_2}$$

12 g of carbon reacts with 32 g of oxygen to form 44 g of CO_2
3 g of carbon will react with 8 g of oxygen to form 11g of CO_2.
Out of 50 g, 42 g of oxygen will remain unreacted. [$\therefore$ 50 g – 8 g = 42 g]
The answer is governed by the Law of constant proportions.

48. Those ions which are made up two or more type of atoms are called polyatomic ions, e.g. NH_4^+, PO_4^{3-}

49. (*a*) Mg Cl
+2 1–
$MgCl_2$

(*b*) Ca O
+2 2–
CaO

(*c*) Cu NO_3
+2 1–
$Cu(NO_3)_2$

(*d*) Al Cl
+3 1–
$AlCl_3$

(*e*) Ca CO_3
+2 2–
$CaCO_3$

50. The other compound will also contains the same percentage of elements in its consitution, i.e.
Ca = 40% C = 12% = O = 48%

$$\therefore\ \%\text{ of Ca} = \frac{\text{Mass of Calcium}}{\text{Mass of compound}} \times 100$$

$$40 = \frac{\text{Mass of calcium}}{1.5} \times 100$$

$$\text{Mass of Ca} = \frac{40 \times 1.5}{100} = 0.6 \text{ g}$$

$$\% \text{ of C} = \frac{\text{Mass of C}}{\text{Mass of compound}} \times 100$$

$$12 = \frac{\text{Mass of C}}{1.5} \times 100$$

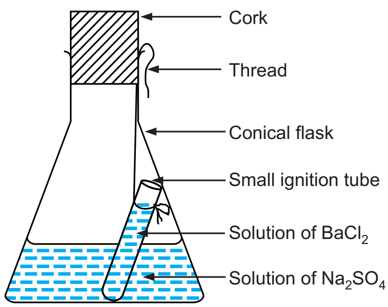
$$\text{Mass of C} = \frac{1.5 \times 12}{100} = 1.8 \text{ g, and}$$

$$\% \text{ of O} = \frac{\text{Mass of oxygen}}{\text{Mass of compound}} \times 100$$

$$48 = \frac{\text{Mass of oxygen}}{1.5} \times 100$$

$$\therefore \text{Mass of oxygen} = \frac{48 \times 1.5}{100} = \frac{72}{100} = 0.72 \text{ g}$$

51.
- Take dilute solution of sodium sulphate in a conical flask
- Measure initial mass of solution.
- Take dilute solution of Barium chloride in an ignition tube and set up the apparatus as shown in the figure.



- Calculate the mass of reactants.
- Tilt the ignition tube so that reactants can mix to form the product.
- Measure the final mass of the products.
- Observe the final mass of products.

Observation: Mass of reactants = Mass of products.

Conclusion: Law of conservation of mass is verified experimentally.

52. $2Ca + O_2 \rightarrow 2CaO$

2×40 g of calcium reacts with 32 g of oxygen to form 2×56 g of CaO

5 g of calcium reacts with $\frac{32}{80} \times 5$ g of oxygen to form $\frac{2 \times 56}{2 \times 40} \times 5$ g of CaO.

5 g of calcium will react with 2 g of oxygen to form 7 g of calcium oxide.

$\therefore$ 25 – 2 = 23 g O_2 will remain unreacted

In the second case 20 – 2 = 18 g of oxygen will remain unreacted. 7 g of CaO will be formed.

Law of constant proportions governs the answer (*b*) Ca O

+2 −2

CaO is the formula of calcium oxide.

53. (*a*) $CuBr_2$
(*b*) $Al(NO_3)_3$
(*c*) $Ca_3(PO_4)_2$
(*d*) Fe_2S_3
(*e*) $HgCl_2$
(*f*) $Mg(COOCH_3)_2$

54. (*a*) CaF_2
(*b*) H_2S
(*c*) NH_3
(*d*) CCl_4
(*e*) Na_2O
(*f*) CO_2

55. Molecular mass of $H_2 = 2 \times 1 = 2\ u$
Molecular mass of $O_2 = 2 \times 16 = 32\ u$
Molecular mass of $Cl_2 = 2 \times 35.5 = 71\ u$
Molecular mass of CO_2 = Atomic mass of C + 2 × Atomic mass of O
$= 12 + 2 \times 16 = 12 + 32 = 44\ u$
Molecular mass of CH_4 = Atomic mass of C + 4 × Atomic mass of H
$= 1 \times 12 + 4 \times 1 = 12 + 4 = 16\ u$
Molecular mass of C_2H_6 = 2 × Atomic mass of C + 6 × Atomic mass of H
$= 2 \times 12 + 6 \times 1 = 24 + 6 = 30\ u$
Molecular mass of C_2H_4 = 2 × Atomic mass of C + 4 × Atomic mass of H
$= 2 \times 12 + 4 \times 1 = 24 + 4 = 28\ u$
Molecular mass NH_3 = Atomic mass of N + 3 × Atomic mass of H
$= 14 + 3 \times 1 = 14 + 3 = 17$ u
Molecular mass of CH_3OH
= Atomic mass of C + 4 × Atomic mass of H + Atomic mass of O $= 12 \times 1 + 4 \times 1 + 16$
$= 12 + 4 + 16 = 32\ u$

56. (*a*) $CuCl_2$, $CuSO_4$, $Cu_3(PO_4)_3$
(*b*) $NaCl$, Na_2SO_4, Na_3PO_4
(*c*) $FeCl_3$, $Fe_2(SO_4)_3$, $FePO_4$

57. (*a*) **Atoms:** It is the smallest particle which may or may not exist freely. It is the smallest unit of an element which take part in a chemical reaction.
(*b*) **Molecules:** Atoms of same or different elements join together to form a molecule.
(*c*) **Avagadro's number:** It is equal to 6.022×10^{23} per mol.
(*d*) **Valency:** Valency is defined as the combining capacity of an atom of element.
(*e*) **Molar mass:** Molar mass is defined as the mass of 1 mole of the substance (in grams).

2. Dalton Atomic Theory, Laws of Chemical Combination

Dalton's Atomic Theory:

- Matter is made up of small and indestructible particles called atoms.
- Atoms are indivisible particles, which cannot be created or destroyed.
- Atoms of a given element are identical in mass and chemical properties.
- Atoms of different elements have different atomic mass and different properties.
- Atoms combine in the ratio of small whole numbers to form compounds.
- The relative number and kind of atoms are always constant in a given compound.

Law of Conservation of Mass: It states "Matter can neither be created nor be destroyed by a chemical reaction". Mass of products must be equal to the mass of reactants in a chemical reaction.

Law of Constant Proportions: It states that "In a chemical compound the elements are always present in definite proportion by mass."

Exercise 3.2

I. Very Short Answer Type Questions (1 Mark)

1. Which postulate of Dalton's atomic theory is the result of the law of conservation of mass? [*NCERT*]
2. Which postulate of Dalton's atomic theory can explain the law of definite proportions?
3. What is the full form of IUPAC? [*NCERT*] [*DOE*]
4. Name the scientist who gave the atomic theory of matter.
5. What are building blocks of matter? [*DOE*]
6. Name two laws of chemical combination. [*DOE*]
7. State the law of conservation of mass.
8. State the law of constant proportions.

II. Short Answer Type Questions (2 Marks)

9. 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 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. [*NCERT*]
10. 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? [*NCERT*]
11. Write the main postulates of Dalton's atomic theory. **[DOE]**

Answers 3.2

1. 'Atoms are indivisible particles, which can neither be created nor destroyed in a chemical reaction.'
2. Atoms of elements combine in the ratio of small whole numbers to form compounds.
3. International Union of Pure and Applied Chemistry.
4. Dalton
5. Atoms
6. (*i*) Law of conservation of mass (*ii*) Law of constant proportions
7. It states that 'Matter can neither be created nor destroyed'.
8. It states that 'In a chemical compound, elements are always present in definite proportion by mass.'
9. Mass of reactants:
   = Mass of Na_2CO_3 + Mass of CH_3COOH
   = 5.3 + 6.0 = 11.3 g
   Mass of products:
   = Mass of CO_2 + Mass of H_2O + Mass of CH_3COONa
   = 2.2 + 0.9 + 8.2 = 11.3 g
   $\because$ Mass of reactants = Mass of products.
10. 1 g of H_2 reacts with 8 g of oxygen.
    3 g of H_2 will react with $8 \times 3 = 24$ g of oxygen.
    $\therefore$ Law of conservation of mass is followed.

11. The main postulates are:
    - All matter is made up of small particles called atoms.
    - Atoms are indivisible particles, which cannot be created or destroyed.
    - Atoms of a given element are identical in mass and chemical properties.
    - Atoms of different elements have different atomic masses and different properties.
    - Atoms combine in the ratio of small whole numbers to form compounds.
    - The relative number and the kind of atoms are constant in a given compound.

3.3 Mole Concept

Mole: It is defined as a counting unit for the amount of substance which is equal to 6.022×10^{23} particles. It is also equal to the molar mass of an element or the compound. It has a unit symbol: mol.

Molar mass: The atomic mass and molecular mass which is expressed in grams per mol unit is called molar mass.

Avagadro's Number (Avagadro's Constant): It is equal to 6.022×10^{23} per mol.

- 1 u is a mass of 1 atom of Hydrogen
- 1 g is the molar mass of hydrogen atom where it has 6.022×10^{23} atoms.
- 1 mole = Atomic mass in grams
- 1 mole = Molecular mass in grams
- Number of moles = $\dfrac{\text{Given mass}}{\text{Molar mass}}$
- Number of moles = $\dfrac{\text{Given number of atoms or molecules}}{6.022 \times 10^{23}}$

Exercise 3.3

I. Very Short Answer Type Questions (1 Mark)

1. How many atoms are there in 1 gram of hydrogen? **[*CBSE* 2012]**
2. What is meant by Avagadro's constant?

II. Short Answer Type Questions–I (2 Marks)

3. If one mole of carbon atoms weighs 12 gram, what is the mass (in gram) of 1 atom of carbon? [Atomic mass of C = 12 u] **[HOTS]**
4. What is the mass of:
   (*a*) 0.2 mole of oxygen atoms?
   (*b*) 0.5 mole of water molecules? [Atomic mass of O = 16 u, H = 1 u]
5. Calculate the number of molecules of sulphur (S_8) present in 16 g of solid sulphur. [Atomic mass of S = 32 u]
6. (*a*) Calculate the number of moles in 34 g of NH_3 [N = 14 u, H = 1 u]
   (*b*) Calculate number of molecule in 8 g dioxygen gas [O = 16 u] **[*CBSE* 2011]**
7. Calculate mass of 1 molecule of oxygen gas. **[*CBSE* 2010]**
8. The mass of single atom of an element is 2.65×10^{-23} g. Calculate its atomic mass. **[*CBSE* 2010][HOTS]**
9. Which of the following correctly represents 360 g of water?
   (*i*) 2 moles of H_2O (*ii*) 20 moles of water
   (*iii*) 6.022×10^{23} molecules of water (*iv*) 1.2044×10^{25} molecules of water
   (*a*) (*i*) (*b*) (*i*) and (*iv*)
   (*c*) (*ii*) and (*iii*) (*d*) (*ii*) and (*iv*) **[HOTS]**

10. Which of the following would weigh the highest?
(*a*) 0.2 mole of sucrose ($C_{12} H_{22} O_{11}$) (*b*) 2 moles of CO_2
(*c*) 2 moles of $CaCO_3$ (*d*) 10 moles of H_2O **[HOTS]**

11. Which of the following has maximum number of atoms?
(*a*) 18g of H_2O (*b*) 18g of O_2
(*c*) 18g of CO_2 (*d*) 18g of CH_4

12. Which of the following contains maximum number of molecules?
(*a*) 1g of CO_2 (*b*) 1g of N_2
(*c*) 1g of H_2 (*d*) 1g of CH_4

III. Short Answer Type Questions–II (3 Marks)

13. Calculate the number of moles for the following:
(*i*) 52 g of He (finding mole from mass)
(*ii*) 12.044×10^{23} number of He atoms (finding mole from number of particles).
[Atomic mass of He = 4 *u*] [*NCERT*]

14. Calculate the mass of the following:
(*i*) 0.5 mole of N_2 gas (mass from mole of molecule)
(*ii*) 0.5 mole of N atoms (mass from mole of atom)
(*iii*) 3.011×10^{23} number of N atoms (mass from number)
(*iv*) 6.022×10^{23} number of N_2 molecules (mass from number)
[Atomic mass of N = 14 *u*]

15. Calculate the number of particles in each of the following:
(*i*) 46 g of Na atoms (number of atoms from mass)
(*ii*) 8 g of O_2 molecules (number of molecules from mass)
(*iii*) 0.1 mole of carbon atoms (number from given moles)
[Atomic mass of Na = 23 *u*, 0 = 16 *u*, C = 12 *u*]

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

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

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

19. Calculate number of molecules of phosphorus (P_4) present in 248 g of solid phosphorus. [Given atomic mass: P = 31 *u*, $N_A = 6.022 \times 10^{23}$ per mole] **[*CBSE* 2012]**

20. The atomic mass of calcium is 40 *u*. What will be the total number of calcium atoms in 0.4 *u* of calcium? **[*CBSE* 2016]**

21. 3.42 g of sucrose ($C_{12} H_{22} O_{11}$) is dissolved in 18 g of H_2O in a beaker. Calculate the total number of oxygen atoms in the solution. **[HOTS]**

22. Compute the difference in masses of 10^3 mole each of Mg atoms and Mg^{2+} ions (Mass of electron = 9.1×10^{-31} kg) **[HOTS]**

23. A sample of (C_2H_6) has the same mass as 1.5×10^{20} molecules of CH_4. How many C_2H_6 molecule does the sample of gas contain? **[HOTS]**

IV. Long Answer Type Questions (5 Marks)

24. Calculate the molar mass of the following substances:

(*a*) Ethyne, C_2H_2 (*b*) Sulphur molecule, S_8

(*c*) Phosphorus molecule, P_4 (Atomic mass of phosphorus = 31)

(*d*) Hydrochloric acid, HCl

(*e*) Nitric acid, HNO_3

[Atomic mass of C = 12 *u*, H = 1 *u*, S = 32 *u*, Cl = 35.5 *u*, N = 14 *u*, O = 16 *u*, P = 31 *u*]

25. Calculate the number of aluminium ions present in 0.051 g of aluminium oxide.
(*Hint:* The mass of an ion is the same as that of an atom of the same element. Atomic mass of Al = 27 u) [Atomic mass of Al = 27u, O = 16u] **[HOTS]**

26. (*a*) Calculate the number of oxygen atoms in 0.1 mole of $Na_2\,CO_3.10\,H_2O$

(*b*) If one mole of sulphur weighs 32 grams, what is the mass in grams of 1 atom of sulphur? **[HOTS][*CBSE* 2015]**

(*c*) Identity the correct formula of ammonium sulphate?
$(NH_4)\,(SO_4)_3$, $(NH_4)_2\,SO_4$, $NH_4\,(SO_4)_2$.

Answers 3.3

1. 1 g Hydrogen has 6.022×10^{23} atoms

2. It is a constant representing the no. of particles present in one mole of a substance and it is equal to 6.022×10^{23} atoms/molecules/ions

3. Mass of 1 atom $= \dfrac{\text{Molar mass}}{6.022 \times 10^{23}} = \dfrac{12\text{ g}}{6.022 \times 10^{23}} = 1.99 \times 10^{-23}\text{g}$

4. (*a*) Mass of Oxygen atoms
= No. of moles of oxygen × Molar mass = 0.2 × 16 g = 3.2 g

(*b*) Mass of H_2O molecule = No. of moles of H_2O × Molar mass
= 0.5 × (2 + 16) = 0.5 × 18 = 9 g

5. Number of molecules $= \dfrac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23} = \dfrac{16}{8 \times 32} \times 6.022 \times 10^{23}$

6. (*a*) Number of moles $= \dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{34}{1\text{N} + 3\text{H}} = \dfrac{34}{14 + 3 \times 1} = \dfrac{34}{17} = 2$ moles

(*b*) Number of molecule $= \dfrac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23}$

$$= \frac{8}{32} \times 6.022 \times 10^{23} = 1.5055 \times 10^{23} \text{ molecules}$$

7. Mass of 1 molecule $= \dfrac{\text{Molar mass}}{6.022 \times 10^{23}} = \dfrac{32}{6.022 \times 10^{23}} = 5.32 \times 10^{-23}\text{g}$

8. Mass of 1 atom $= \dfrac{\text{Atomic mass}}{6.022 \times 10^{23}}$

$$2.65 \times 10^{-23}\text{ g} = \frac{\text{Atomic mass}}{6.022 \times 10^{23}}$$

Atomic mass $= 2.65 \times 10^{-23} \times 6.022 \times 10^{23} = 15.96\text{ g mol}^{-1}$

9. (*d*) (*ii*) and (*iv*)

Number of moles = $\dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{360}{18} = 20$ moles

6.022×10^{23} molecules of H_2O weigh = 18 g

1 molecule of H_2O weigh = $\dfrac{18}{6.022 \times 10^{23}}$

1.2044×10^{25} molecules of H_2O weigh = $\dfrac{18}{6.022 \times 10^{23}} \times 1.2044 \times 10^{25} = 360$ g

10. (*a*) 0.2 mole of $C_{12}H_{12}O_{11}$

$= 0.2 \times (12 \times 12 + 22 \times 1 + 16 \times 11)$

$= 0.2 \times (144 + 22 + 176) = 0.2 \times 342 = 171$ g

(*b*) 2 moles of $CO_2 = 2 \times 44 = 88$ g

(*c*) 2 moles of $CaCO_3 = 2 \times 100 = 200$ g

(*d*) 10 moles of $H_2O = 10 \times 18 = 180$ g

So, (*c*) 2 moles of $CaCO_3$ has highest weight.

11. (*a*) 18 g of $H_2O = \dfrac{18}{18} \times 3 \times 6.023 \times 10^{23} = 18.069 \times 10^{23}$ atoms

(*b*) 18 g of $O_2 = \dfrac{18}{32} \times 6.022 \times 10^{23} \times 2 = 6.77 \times 10^{23}$ atoms

(*c*) 18 g of $CO_2 = \dfrac{18}{44} \times 6.022 \times 10^{23} \times 3 = 7.34 \times 10^{23}$ atoms

(*d*) 18 g of $CH_4 = \dfrac{18}{16} \times 5 \times 6.022 \times 10^{23} = 3.387 \times 10^{24}$ atoms

So, (*d*) 18 g of CH_4 will have maximum number of atoms.

12. (*a*) Number of molecules of $CO_2 = \dfrac{1}{44} \times 6.022 \times 10^{23}$

$= \dfrac{60.22}{44} \times 10^{22} = 1.369 \times 10^{22}$ molecule

(*b*) Number of molecules of $N_2 = \dfrac{1}{28} \times 6.022 \times 10^{23}$

$= \dfrac{60.22}{28} \times 10^{22} = 2.15 \times 10^{22}$ molecule

(*c*) Number of molecules of $H_2 = \dfrac{1}{2} \times 6.022 \times 10^{23}$

$= 3.011 \times 10^{23}$ molecule

(*d*) Number of molecules of $CH_4 = \dfrac{1}{16} \times 6.022 \times 10^{23}$

$= \dfrac{60.22}{16} \times 10^{22} = 3.77 \times 10^{22}$ molecules

Ans. (*c*) 1 g of H_2 has maximum number of molecules.

13. (*i*) Number of moles = $\dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{52}{4} = 13$ moles

(*ii*) Number of moles = $\dfrac{\text{Given number of atoms}}{6.022 \times 10^{23}} = \dfrac{12.044 \times 10^{23}}{6.022 \times 10^{23}} = 2$ moles

14. (*i*) Mass = Number of moles × Molar mass = 0.5 × (2 × 14) = 14 g

(*ii*) Mass = Number of mole × Molar mass = 0.5 × 14 = 7 g

(*iii*) Mass = $\dfrac{\text{Number of particle}}{6.022 \times 10^{23}} \times$ Molar mass $= \dfrac{3.011 \times 10^{23}}{6.022 \times 10^{23}} \times 14 = 7$ g

(*iv*) Mass = $\dfrac{\text{Number of particle}}{6.022 \times 10^{23}} \times$ Molar mass $= \dfrac{6.022 \times 10^{23}}{6.022 \times 10^{23}} \times 28 = 28$ g

15. (*i*) Number of atoms = $\dfrac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23}$

$$= \frac{46}{23} \times 6.022 \times 10^{23} = 12.044 \times 10^{23} \text{ atoms}$$

(*ii*) Number of molecules = $\dfrac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23}$

$$= \frac{8}{32} \times 6.022 \times 10^{23} = 1.505 \times 10^{23} \text{ molecule}$$

(*iii*) Number of atoms = Number of mole × 6.022×10^{23}

$= 0.1 \times 6.022 \times 10^{23} = 6.022 \times 10^{22}$ atoms

16. Number of Na atoms = $\dfrac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23}$

$$= \frac{100}{23} \times 6.022 \times 10^{23} = \frac{60.22}{23} \times 10^{24}$$

$= 2.61 \times 10^{24}$ atoms

Number of Fe atoms = $\dfrac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23} = \dfrac{100}{56} \times 6.022 \times 10^{23}$

$$= \frac{60.22}{56} \times 10^{24} = 1.07 \times 10^{24} \text{ atoms}$$

∴ 100 g of Na has more numbers of atoms.

17. (*a*) 1 mole of Nitrogen atoms = 14 g

(*b*) Mass = Number of moles × Molar mass

= 4 × 27 = 108 g

(*c*) Mass = Number of moles × Molar mass of $Na_2\,SO_3$

= 10 × (2Na + 1S + 3O)

= 10 × (2 × 23 + 1 × 32 + 3 × 16)

= 10 × (46 + 32 + 48)

= 10 × (126) = 1260 g

18. (*a*) Number of moles = $\dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{12}{32} = \dfrac{3}{8} = 0.375$ mole (*b*) Number of moles = $\dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{20}{18} = \dfrac{10}{9} = 1.11$ moles.

(*c*) Number of moles = $\dfrac{\text{Given mass}}{\text{Molar mass of } CO_2} = \dfrac{22}{12+32} = \dfrac{22}{44} = \dfrac{1}{2} = 0.5$ moles

19. Number of P_4 molecules = $\dfrac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23}$

$$= \frac{248}{4 \times 31} \times 6.022 \times 10^{23} = 2 \times 6.022 \times 10^{23}$$

$$= 12.044 \times 10^{23} \text{ molecules}$$

20. Number of Ca-atoms:

$$= \frac{\text{Given mass (in } u)}{\text{Atomic mass (in } u)} = \frac{0.4\ u}{40\ u} = 10^{-2} \text{ atoms} = 0.01 \text{ atoms}$$

21. Number of moles of $C_{12}H_{22}O_{11} = \dfrac{3.42}{342} = 0.01$ moles

Number of oxygen atoms = $11 \times 0.01 \times 6.022 \times 10^{23} = 0.6624 \times 10^{23}$

Number of moles of $H_2O = \dfrac{18}{18} = 1$ mole

Number of oxygen atoms = 6.022×10^{23} atoms

Total no. of oxygen atoms = $(6.022 + 0.624) \times 10^{23} = 6.682 \times 10^{23}$ oxygen atoms

22.

$$\underset{\substack{1 \text{ mole} \\ 1000 \text{ moles}}}{Mg} \longrightarrow \underset{\substack{1 \text{ mole} \\ 1000 \text{ moles}}}{Mg^{2+}} + \underset{\substack{2 \text{ mole} \\ 2000 \text{ moles}}}{2e^-}$$

Mass of 1 electron = 9.1×10^{-31} kg

Mass of $2000 \times 6.022 \times 10^{23}$ electrons

$= 2000 \times 6.022 \times 10^{23} \times 9.1 \times 10^{-31}$ kg

$= 109.6 \times 10^{26-31}$

$= 109.6 \times 10^{-5}$ kg $= 1.096 \times 10^{-3}$ kg

23. 6.022×10^{23} molecules of CH_4 will weigh = 16 g

$= 1.5 \times 10^{20}$ molecule of CH_4 will weigh

$$= \frac{16}{6.022 \times 10^{23}} \times 1.5 \times 10^{20} = \frac{24.0}{6.022} \times 10^{-3} = 4 \times 10^{-3} \text{g}$$

30 g of C_2H_6 contains 6.022×10^{23} molecules

4×10^{-3} g C_2H_6 contains

$$= \frac{6.022 \times 10^{23}}{30} \times 4 \times 10^{-3} = \frac{24.088}{3} \times 10^{19} = 8.029 \times 10^{19} \text{ molecules}$$

24. (*a*) Molar mass of $C_2H_2 = 2 \times$ atomic mass of C + $2 \times$ atomic mass of H

$= 2 \times 12 + 2 \times 1 = 24 + 2 = 26$ g mol^{-1}

(*b*) Molar mass of $S_8 = 8 \times$ atomic mass of S $= 8 \times 32 = 256$ g mol^{-1}

(*c*) Molar mass of $P_4 = 4 \times$ atomic mass of P $= 4 \times 31 = 124$ g mol^{-1}

(*d*) Molar mass of HCl = 1 atomic mass of H + 1 atomic mass of Cl = 1 + 35.5 = 36.5 g mol^{-1}

(*e*) Molar mass of $HNO_3 = 1 \times 1 + 14 + 3 \times 16 = 1 + 14 + 48 = 63$ g mol^{-1}

25. $Al_2O_3 \rightarrow 2Al^{3+} + 3O^{2-}$

$$\text{Number of molecules of } Al_2O_3 = \frac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23}$$

$$= \frac{0.051}{\text{Molar mass of } Al_2O_3} \times 6.022 \times 10^{23}$$

$$= \frac{0.051}{2Al + 3O} \times 6.022 \times 10^{23} = \frac{0.051}{2 \times 27 + 3 \times 16} \times 6.022 \times 10^{23}$$

$$= \frac{0.051}{102} \times 6.022 \times 10^{23} = \frac{51}{102} \times 6.022 \times 10^{20} = 3.011 \times 10^{20}$$

Number of Al^{3+} ions = 2 × no. of molecules of Al_2O_3 = 2 × 3.011 × 10^{20} = 6.022 × 10^{20} Al^{3+} ions.

26. (*a*) 1 mole of $Na_2CO_3 \cdot 10H_2O$ contains

= 13 × 6.022 × 10^{23} atoms of oxygen

∴ 0.1 mole of $Na_2CO_3 \cdot 10H_2O$ contains

= 13 × 6.022 × 10^{23} × 0.1 = 7.8286 × 10^{23} atoms

(*b*) $\text{Mass of 1 atom of Sulphur} = \frac{\text{Molar mass}}{6.022 \times 10^{23}} = \frac{32}{6.022 \times 10^{23}} = 5.33 \times 10^{-23}$ g

(*c*) $(NH_4)_2SO_4$ is the formula for Ammonium sulphate.

VALUE BASED QUESTIONS

1. Mrs. Anuradha's house maid fainted while moping the floor. Mrs. Anuradha took her to doctor. Doctor told her that she is suffering from anaemia. She should take green leafy vegetables along with the medicines. Anuradha also helped her maid financially.

(*i*) What values are associated with Mrs. Anuradha?

(*ii*) Which metal deficiency leads to anaemia?

(*iii*) What is the role of iron in our body?

2. Ram's grandfather has difficulty in walking, Ram took him to a doctor. Doctor told him, he has deficiency of calcium which is needed for strong bones. He advised him to take milk and milk products everyday and take sufficient sunlight.

(*i*) What values are associated with Ram?

(*ii*) Why should he take milk everyday?

(*iii*) Why should we sit in sunlight everyday?

3. In which type of reactions the law of conservation of mass is not applicable? **[HOTS]**

Answers

1. (*i*) She is a kind-hearted and a helpful person.

(*ii*) Iron

(*iii*) Iron is present in Haemoglobin which acts as a oxygen career.

2. (*i*) He is a kind-hearted and is concerned about the health of his grandfather.

(*ii*) Milk is a rich source of calcium.

(*iii*) Sunlight helps in the formation of vitamin D in our body which is essential for strong bones and absorption of calcium.

3. Nuclear reactions.

Practical Based Questions

Experiment 5: *To determine the physical and chemical changes in a reaction.*

Carry out the following reactions and classify them as physical or chemical changes

(*i*) *Iron with copper sulphate solution in water,*

(*ii*) *Burning of magnesium ribbon in air,*

(*iii*) *Zn with dil.* H_2SO_4,

(*iv*) *Heating of copper sulphate crystals, and*

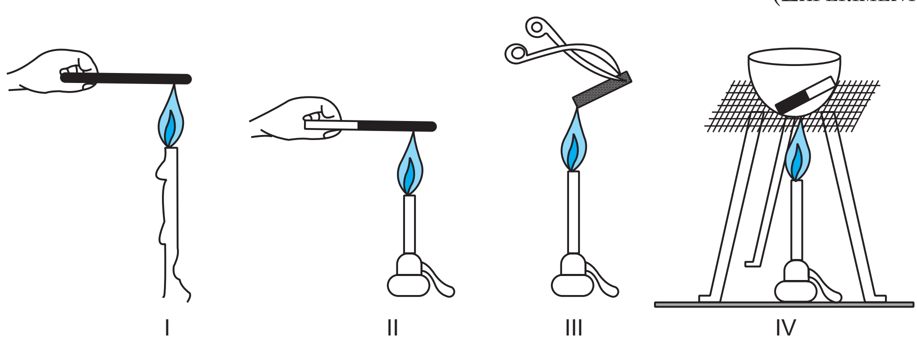
(*v*) *Sodium sulphate with barium chloride in the form of their solution in water.*

Q1. What happens when Zn metal reacts with dilute H_2SO_4? How will you test the gas formed? (Experimental Skills)

Ans. Hydrogen gas will be evolved and $ZnSO_4$ solution will be formed.

Test: If we bring a burning matchstick near the gas, it will burn with a 'pop' sound.

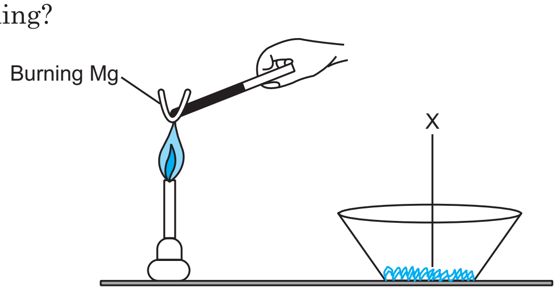
Q2. Four students used different ways of burning magnesium ribbon during an experiment as shown below. The correct way has been followed by which student: (Experimental Skills)



Ans. **III** student is using the correct way. Tong should be used so that hand does not get burnt by touching the hot magnesium ribbon.

It should be heated at the top of the flame which is the hottest part of the flame.

Q3. What is 'X' in the figure given below? Why should we rub magnesium ribbon with a sand paper before burning? (Reasoning Skills)



Ans. 'X' is magnesium oxide. Magnesium ribbon is rubbed with sand paper so as to remove magnesium oxide layer which may prevent its combustion.

Q4. What do we observe when water is added to an anhydrous copper sulphate and why? (Reasoning Skills) [*CBSE* 2012]

Ans. Dirty white colour changes to blue colour due to the formation of hydrated copper sulphate.

$$CuSO_4(s) + 5H_2O(l) \rightarrow \underset{\text{(Blue)}}{CuSO_4.5H_2O}$$

Q5. What do you observe on burning the magnesium ribbon? What will be the effect on red litmus solution added to the product obtained? (Observation Skills) [*CBSE* 2014]

Ans. White ash (MgO) will be formed. Mg burns with white dazzling light. The solution of MgO in water will turn red litmus blue.

Q6. What will be your observation, when crystals of copper sulphate are heated? (Observation Skills) [*CBSE* 2012]

Ans. (*i*) Blue colour of the crystals changes into dirty white.

(*ii*) Crackling sound is produced.

(*iii*) Water droplets are seen along the sides of the tube.

Q7. What will happen when sodium sulphate solution is added to a barium chloride solution? Write the chemical reaction involved. (Observation, Conceptual Skills) [*CBSE* 2016]

Ans. White precipitate will be formed due to Barium sulphate

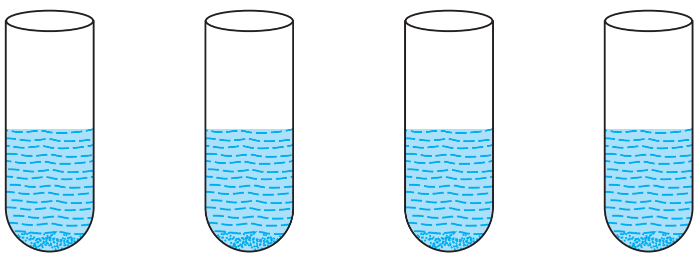
$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$$

Q8. What will happen if an iron nail is put in the copper sulphate solution? Write the chemical reaction involved in this. (Conceptual Skills)

Ans. The colour of the solution will change from blue to pale green, reddish brown copper metal will be get deposited on the iron nail.

$$Fe(s) + \underset{\text{(Blue)}}{CuSO_4\,(aq)} \rightarrow \underset{\text{(pale green)}}{FeSO_4(aq)} + \underset{\text{(reddish brown)}}{Cu(s)}$$

Q9. When a solution of sodium sulphate is added to the solution of braium chloride, we immediately get a precipitate as shown in the test tube below. Name the precipitate formed. (Conceptual Skills) [*CBSE* 2011]



A
White ppt
of NaCl

B
White ppt
of $BaSO_4$

C
Yellow ppt
of $BaSO_4$

D
Grey ppt
of NaCl

Ans. B, white precipitate of $BaSO_4$ will be formed.

Q10. An iron nail was dipped in a salt solution of 'A'. After sometime a brown substance is deposited on an iron nail. Identify the salt 'X' and the initial and final colour of the solution after the reaction. (Thinking Skills)

Ans. 'X' is copper sulphate. Initially its colour is blue. The final colour of the solution will become pale green after the reaction.

Experiment 6: *To verify the law of conservation of mass in a chemical reaction.*

Q1. To verify the law of conservation of mass, Prema took a spring balance of least count 0.5 g to weigh the beaker. When she weighed it, the pointer stopped at 65th division. What is the mass of beaker? (Experimental Skills) [*CBSE* 2012]

Ans. Mass = Least count × Number of division

= 0.5 g × 65 = 32.5 g.

Q2. To verify the law of conservation of mass in a chemical reaction. What should be the form of Na_2SO_4 and $BaCl_2$ and why? (EXPERIMENTAL SKILLS)

Ans. Both should be in the form of aqueous solution so that the reaction between ions can take place to form white precipitate of $BaSO_4$ and aqueous solution of NaCl.

Q3. Name the apparatus needed to experimentally verify the law of conservation of mass. (EXPERIMENTAL SKILLS)

Ans. Conical flask, Ignition tube, physical balance, thread, cork are needed.

Q4. For which type of reactions the law of conservation of mass is not applicable and why? (REASONING SKILLS)

Ans. It is not applicable for Nuclear reactions.

It is because in nuclear reaction loss of mass is converted into energy. The mass of reactants is not equal to mass of products.

Q5. What should be equal in weight in an experiment to verify the law of conservation of mass? (CONCEPTUAL SKILLS) [*CBSE* 2012]

Ans. Both reactants and products must be equal in weight to prove that law, i.e.

Mass of reactants = Mass of products.

Q6. After carrying out the experiment of conservation of mass with the help of the following reaction: $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$. Reena was asked to identify the chemical formula of the precipitate formed and write its name. (CONCEPTUAL SKILLS) [*CBSE* 2012]

Ans. White precipitate of $BaSO_4$ (Barium sulphate) is formed.

Q7. A reaction between barium chloride and sodium sulphate was carried out in a sealed conical flask. The masses of the reactants and the products were measured carefully. After the experiment, it was concluded that: [*CBSE* 2012]

(*a*) mass of barium chloride = mass of sodium chloride
(*b*) mass of sodium chloride = mass of sodium sulphate
(*c*) mass of (barium chloride + sodium sulphate) = mass of (barium sodium + sodium chloride)
(*d*) mass of (barium chloride + sodium chloride) = mass of (barium sulphate + sodium sulphate)

Which is the correct statement? (CONCEPTUAL SKILLS)

Ans. (*c*) is the correct statement because Mass of reactants = Mass of products.

Q8. In a chemical reaction, the sum of the masses of reactants and products remain unchanged. What is this law called? Who discovered this law? (CONCEPTUAL SKILLS) [*CBSE* 2012]

Ans. It is called the law of conservation of mass. Lavosier discovered this law.

Q9. In a chemical reaction, the mass of products is 56 g. One of the reactant has a mass equal to 26 g, what will be mass of the other reactant? (NUMERICAL SKILLS) [*CBSE* 2016]

Ans. Mass of reactants = Mass of products

$$x + 26 = 56 \text{ g}$$
$$x = 56 - 26 = 30 \text{ g}$$

Q10. Four students A, B, C and D verified the law of conservation of mass in a chemical reaction of barium chloride and sodium sulphate. All of them took 107.2 g of barium chloride and 116.1 g of sodium sulphate solution and mixed them in a beaker of mass 150 g. They reported their results as follows: [*CBSE* 2012]

Student	Colurless mixture after mixing	Mass of reaction mixture in the beaker including mass of beaker
A	White precipitate	383.3 g
B	Brown precipitate	393.3 g
C	White precipitate	373.3 g
D	Brown precipitate	363.3 g

Which of the followng observation is correct? (NUMERICAL SKILLS)

Ans. Mass of reactants + beaker = 103.2 + 116.1 + 150 = 373.3 g
White precipitate will form.
Mass of products = 373.3 g
'C' is correct.

IMPORTANT FORMULAE

1.
$$A + B \rightarrow AB$$
$$\text{Mass of reactants} = \text{Mass of products}$$
$$m_A + m_B = m_{AB}$$

2. In H_2O, $\dfrac{m_H}{m_o} = \dfrac{2}{16} = \dfrac{1}{8}$

3. Molecular mass of $H_2O = 2 \times$ Mass of hydrogen atom + Mass of oxygen atom $= 2 \times 1 + 16 = 18$ u

4. Formula unit mass of $CaCl_2$ = Mass of Ca + 2 × Mass of chlorine atom = 40 + 2 × 35.5 = 111 u

5. Molar mass of water = 18 g

6. 1 mole = 6.022×10^{23} atoms/ion/molecule

7. Number of moles (n) = $\dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{m}{M}$

8. Number of moles(n) = $\dfrac{\text{Given number of particle}}{\text{Avogadro's Number}} = \dfrac{N}{N_0}$

9. $\boxed{\dfrac{m}{M} = \dfrac{N}{N_o}}$ $\boxed{m = \dfrac{N \times M}{N_o}}$

10. Mass of 1 particle = $\dfrac{\text{Molar mass}}{N_o} = \dfrac{\text{Molar mass}}{6.022 \times 10^{23}}$

11. Percentage of element = $\dfrac{\text{Total Mass of Element}}{\text{Molar Mass of Compound}} \times 100$

12. Calculation of Empirical formula

S. No	Elements	%age	Atomic mass	No. of Moles % / Atomic mass	Divide by least	Simple ratio
1 2 3						

13.
$$\text{(EF) Empirical Formula weight} = \text{Total Mass of elements in Empirical Formula}$$
$$\text{(MF) Molecular weight} = \text{Total mass of elements in Molecular Formula}$$
$$\boxed{n = \dfrac{\text{Molecular weight}}{\text{Empirical Formula weight}} \times 100} \quad \boxed{MF = n \times EF}$$

IMPORTANT NUMERICAL PROBLEMS

1. In a reaction 5.3 g of sodium carbonate reacts with 6 g of ethanoic acid. The product formed are CO_2, 0.9 g of H_2O and 8.2 of sodium ethanoic. Calculate the mass of CO_2 formed.
2. Calculate the mass of H_2O formed by reaction of 3 g of H_2 with 29 g of oxygen. Calculate mass of unreacted oxygen. **[HOTS]**
3. Calculate the number of iron atoms in a piece of iron weighing 5.6 g.
   [Atomic mass of Fe = 56]
4. Mass of 1 molecule of a substance is 5.32×10^{-23} g. Calculate its molecular mass.
5. Calculate the mass of 1 atom of oxygen. [Atomic mass = 16 u]
6. Calculate the mass of 0.5 mole of P_4 molecule. [Atomic mass of P = 31 u]
7. Calculate the number of Hydrogen molecule in 8 g of H_2.
8. Calculate the molar mass of $CuSO_4.5H_2O$. [Cu = 63.5 u, S = 32 u, O = 16 u, H = 1 u, O = 16 u]
9. Calculate the mass of 1 molecule of oxygen. [O = 16 u]
10. Calculate the number of atoms in
    (*i*) 52 mole of He (*ii*) 52 *u* of He (*iii*) 12 g of He **[HOTS]**
11. What is the mass of 5 mole of chlorine gas. [Cl = 35.5 *u*] **[HOTS]**
12. Find the mass of
    (*i*) 0.2 mole of N atoms (*ii*) 1.4 mole of Al atoms.
    (*iii*) 0.5 mole of HCl molecule [N = 14*u*, Al = 27*u*, H = 1*u*, Cl = 35.5*u*] [*CBSE* 2017]

Solutions

1. Mass of Na_2CO_3 + Mass of ethanoic acid = Mass of CO_2 + mass of H_2O + Mass of CH_3COONa

$$5.3 + 6.0 = x + 0.9 + 8.2$$
$$x = 11.3 - 9.1 = 2.2 \text{ g.}$$

2. 2 g of hydrogen combines with 16 g of oxygen.

3 g of hydrogen combines with $= \frac{16}{2} \times 3 = 24$ g of oxygen.

Mass of unreacted oxygen = 29 – 24 = 5

Mass of water formed = Mass of hydrogen reacted + mass of oxygen reacted

= 3 + 24 = 27 g

3. Number of atoms (N) $= \frac{m}{M} \times N_o = \frac{5.6}{56} \times 6.022 \times 10^{23} = 6.022 \times 10^{22}$ atoms

4. Molecular mass

= Mass of 1 molecule × $6.022 \times 10^{23} = 5.32 \times 10^{-23}$ g × $6.022 \times 10^{23} = 32$ g mol^{-1} = 32*u*

5. Mass of 1 atom $= \frac{\text{Molar mass}}{6.022 \times 10^{23}} = \frac{16}{6.022 \times 10^{23}} = 2.66 \times 10^{-23}$ g

6. 1 mole of $P_4 = 4 \times 31 = 124$ g

0.5 mole of $P_4 = 124 \times 0.5 = 62$ g

7. Number of molecule

$$= \frac{\text{Given mass}}{\text{Molar mass}} \times 6.022 \times 10^{23} = \frac{8}{2} \times 6.022 \times 10^{23}$$
$$= 24.088 \times 10^{23} \text{ molecule} = 2.4088 \times 10^{24} \text{ molecule}$$

8. Molar mass of $CuSO_4.5H_2O$

= Atomic mass of Cu + Atomic mass of S + 4 × Atomic mass of O + 5 (Molar mass of H_2O)

$= 63.5 + 32.0 + 4 \times 16 + 5(2 + 16)$
$= 63.5 + 32.0 + 64 + 5 \times 18 = 249.5 \text{ g mol}^{-1}$

9. Mass of 1 molecule $= \dfrac{\text{Molar mass}}{6.022 \times 10^{23}} = \dfrac{32}{6.022 \times 10^{23}} = 5.33 \times 10^{-23}$ g

10. (*i*) Number of He atoms

$= \text{Number of mole} \times 6.022 \times 10^{23} = 52 \times 6.022 \times 10^{23}$
$= 313.144 \times 10^{23} = 3.13 \times 10^{25}$ atoms

(*ii*) Number of He atoms $= \dfrac{\text{Given mass in } u}{\text{Atomic mass in } u} = \dfrac{52u}{4u} = 13$ atoms

(*iii*) Number of He atoms $= \dfrac{m}{\text{M}} \times \text{N}_o = \dfrac{52}{4} \times 6.022 \times 10^{23} = 13 \times 6.022 \times 10^{23}$

$= 78.286 \times 10^{23} = 7.83 \times 10^{24}$ atoms.

11. Mass of 5 moles of Cl_2 = Number of moles × Molar mass = 5 × (35.5 × 2) = 5 × 71 = 355 g.

12. (*i*) 1 mole of N atoms = 14 g
0.2 mol of N atoms = 14 × 0.2 = 2.8 g
(*ii*) Mass of 1.4 mol of Al atoms = No. of moles × Atomic mass = 1.4 × 27 = 37.8 g
(*iii*) Mass of 0.5 mole of HCl = No. of moles × Molecular mass = 0.5 × 36.5 = 18.25 g

IMPORTANT SYMBOLS OF ELEMENTS

Element	Symbol	Element	Symbol	Element	Symbol	Element	Symbol	Element	Symbol	Element	Symbol
1. Hydrogen	H	8. Oxygen	O	15. Phosphorus	P	Barium	Ba	Iodine	I	Bromine	Br
2. Helium	He	9. Fluorine	F	16. Sulphur	S	Cobalt	Co	Lead	Pb	Selenium	Se
3. Lithium	Li	10. Neon	Ne	17. Chlorine	Cl	Nickel	Ni	Silver	Ag	Gallium	Ga
4. Beryllium	Be	11. Sodium	Na	18. Argon	Ar	Copper	Cu	Tin	Sn	Scandium	Sc
5. Boron	B	12. Magnesium	Mg	19. Potassium	K	Zinc	Zn	Chromium	Cr	Germanium	Ge
6. Carbon	C	13. Aluminium	Al	20. Calcium	Ca	Iron	Fe	Manganese	Mn		
7. Nitrogen	N	14. Silicon	Si								

IMPORTANT FORMULAE

Formulae of Binary Compounds

Ammonia	NH_3	Hydrogen Sulphide	H_2S	Nitrogen pentoxide	N_2O_5	Methane	CH_4	Glucose	$C_6H_{12}O_6$
Carbon dioxide	CO_2	Water	H_2O	Phosphorus pentoxide	P_2O_5	Carbon disulphide	CS_2	Urea	NH_2CONH_2
Carbon monoxide	CO	Phosphine	PH_3	Phosphorus pentachloride	PCl_5	Ethylalcohol	C_2H_5OH	Cane sugar	$C_{12}H_{22}O_{11}$
Nitrogen monoxide	NO	Sulphur trioxide	SO_3	Carbontetra chloride	CCl_4	Methyl alcohol	CH_3OH	Hydrogen Cyanide	HCN
Nitrogen dioxide	NO_2	Sulphuric acid	H_2SO_4	Chloro methane	CH_3Cl	Benzene	C_6H_6	Urea	NH_2CONH_2
Nitrogen trioxide	N_2O_3	Nitric acid	HNO_3	Chloroform	$CHCl_3$	Ethane	C_2H_6	Butane	C_4H_{10}

Formula of Ionic Compounds

Cations / Anions	Na^+	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	Cr^{3+}	Cu^{2+}	Zn^{2+}	Fe^{2+}	Fe^{3+}	Pb^{2+}
Cl^-	$NaCl$	KCl	$CaCl_2$	$MgCl_2$	$AlCl_3$	$CrCl_3$	$CuCl_2$	$ZnCl_2$	$FeCl_2$	$FeCl_3$	$PbCl_2$
Br^-	$NaBr$	KBr	$CaBr_2$	$MgBr_2$	$AlBr_3$	$CrBr_3$	$CuBr_2$	$ZnBr_2$	$FeBr_2$	$FeBr_3$	$PbBr_2$
I^-	NaI	KI	CaI_2	MgI_2	AlI_3	CrI_3	CuI_2	ZnI_2	FeI_2	FeI_3	PbI_2
CO_3^{2-}	Na_2CO_3	K_2CO_3	$CaCO_3$	$MgCO_3$	$Al_2(CO_3)_3$	$Cr_2(CO_3)_3$	$CuCO_3$	$ZnCO_3$	$FeCO_3$	$Fe_2(CO_3)_3$	$PbCO_3$
HCO_3^-	$NaHCO_3$	$KHCO_3$	$Ca(HCO_3)_2$	$Mg(HCO_3)_2$	$Al(HCO_3)_3$	$Cr(HCO_3)_3$	$Cu(HCO_3)_2$	$Zn(HCO_3)_2$	$Fe(HCO_3)_2$	$Fe(HCO_3)_3$	$Pb(HCO_3)_2$
SO_4^{2-}	Na_2SO_4	K_2SO_4	$CaSO_4$	$MgSO_4$	$Al_2(SO_2)_3$	$Cr_2(SO_4)_3$	$CuSO_4$	$ZnSO_4$	$FeSO_4$	$Fe_2(SO_4)_3$	$PbSO_4$
SO_3^{2-}	Na_2SO_3	K_2SO_3	$CaSO_3$	$MgSO_3$	$Al_2(SO_3)_3$	$Cr_2(SO_3)_3$	$CuSO_3$	$ZnSO_3$	$FeSO_3$	$Fe_2(SO_3)_3$	$PbSO_3$
N^{3-}	Na_3N	K_3N	Ca_3N_2	Mg_3N_2	AlN	CrN	Cu_3N_2	Zn_3N_2	Fe_3N_2	FeN	Pb_3N_2
P^{3-}	Na_3P	K_3P	Ca_3P_2	Mg_3P_2	AlP	CrP	Cu_3P_2	Zn_3P_2	Fe_3P_2	FeP	Pb_3P_2
PO_4^{3-}	Na_3PO_4	K_3PO_4	$Ca_3(PO_4)_2$	$Mg_3(PO_4)_2$	$AlPO_4$	$CrPO_4$	$Cu_3(PO_2)_2$	$Zn_3(PO_4)_2$	$Fe_3(PO_4)_2$	$FePO_4$	$Pb_3(PO_4)_2$
S^{2-}	Na_2S	K_2S	CaS	MgS	Al_2S_3	Cr_2S_3	CuS	ZnS	FeS	Fe_2S_3	PbS
O^{2-}	Na_2O	K_2O	CaO	MgO	Al_2O_3	Cr_2O_3	CuO	ZnO	FeO	Fe_2O_3	PbO
OH^-	$NaOH$	KOH	$Ca(OH)_2$	$Mg(OH)_2$	$Al(OH)_3$	$Cr(OH)_3$	$Cu(OH)_2$	$Zn(OH)_2$	$Fe(OH)_2$	$Fe(OH)_3$	$Pb(OH)_2$
HSO_4^-	$NaHSO_4$	$KHSO_4$	$Ca(HSO_4)_2$	$Mg(HSO_4)_2$	$Al(HSO_4)_3$	$Cr(HSO_4)_3$	$Cu(HSO_4)_2$	$Zn(HSO_4)_2$	$Fe(HSO_4)_2$	$Fe(HSO_4)_3$	$Pb(HSO_4)_3$
NO_2^-	$NaNO_2$	KNO_2	$Ca(NO_2)_2$	$Mg(NO_2)_2$	$Al(NO_2)_3$	$Cr(NO_2)_3$	$Cu(NO_2)_2$	$Zn(NO_2)_2$	$Fe(NO_2)_2$	$Fe(NO_2)_3$	$Pb(NO_2)_2$
CN^-	$NaCN$	KCN	$Ca(CN)_2$	$Mg(CN)_2$	$Al(CN)_3$	$Cr(CN)_3$	$Cu(CN)_2$	$Zn(CN)_2$	$Fe(CN)_2$	$Fe(CN)_3$	$Pb(CN)_2$
CH_3COO^-	CH_3COONa	CH_3COOK	$(CH_3COO)_2Ca$	$(CH_3COO)_2Mg$	$(CH_3COO)_3Al$	$(CH_3COO)_3Cr$	$(CH_3COO)_2Cu$	$(CH_3COO)_2Zn$	$Fe(COOCH_3)_2$	$Fe(COOCH_3)_3$	$(CH_3COO)_2Pb$
NO_3^-	$NaNO_3$	KNO_3	$Ca(NO_3)_2$	$Mg(NO_3)_2$	$Al(NO_3)_3$	$Cr(NO_3)_3$	$Cu(NO_3)_2$	$Zn(NO_3)_2$	$Fe(NO_3)_2$	$Fe(NO_3)_3$	$Pb(NO_3)_2$
F^-	NaF	KF	CaF_2	MgF_2	AlF_3	CrF_3	CuF_2	ZnF_2	FeF_2	FeF_3	PbF_2

COMMON ERRORS

Errors	Corrections
• Children usually write wrong symbols of Tin, Antimony, Silver, Gold, Lead, Tungsten.	☞ Tin (Sn), Antimony (Sb), Silver (Ag), Gold (Au), Lead (Pb), Tungsten (W).
• Children write wrong formulae of a compound.	☞ Learn all the valencies of elements and radicals.
• Children do not write formula in numerical problem.	☞ Correct Formula must be written before starting a numerical.
• Children do not differentiate between '*u*' and '*g*'.	☞ Mass of 1 atom is in *u*. Atomic mass in grams represents mass of 6.022×10^{23} atoms.
• Children solve numericals of mole concept wrongly.	☞ Read the question carefully and find out what is given and what is to be calculated? Which formula will be useful? Apply the formula and do the correct calculation.
• Children do not write units in answer.	☞ Units must be written.
• Children calculate wrong molecular mass of a compound.	☞ Count the total number of atoms carefully and then multiply them carefully with atomic mass.
• In $CuSO_4.5H_2O$, children multiply mass of $CuSO_4$ with mass of $5H_2O$.	☞ Mass of $CuSO_4$ needs to be added to mass of $5H_2O$.
• Children get confused in mole concept.	☞ Understand each and every formula carefully and apply them at suitable place.

REVISION CHART

Atoms

An atom is the basic unit of a chemical element. Atoms are made up of three particles: protons, neutrons and electrons.

Atomic Mass

Mass of an atom

Relative atomic mass: Number of times the given atom of an element is heavier than 1/12th of the mass of atom of C-12.

Unified mass: Equal to the mass of 1/12th mass of C-12 isotope.

Symbols of Element

- Symbolic representation of the name of an element.
- Dalton was the first scientist to use symbols.

Writing of Chemical Formula

Ca OH

2+ 1–

$Ca(OH)_2$

Molecules

- Two or more atoms chemically bonded together.
- Smallest particle of an element/compound capable of independent existence.
- Molecular mass is sum of atomic masses of all atoms in a molecule.

Molecules of Elements

Monoatomic, e.g. He, Ne, Al, Kr, Na, etc.

Diatomic, two atoms bonded together, e.g. O_2, N_2, Cl_2, H_2, I_2, etc.

Triatomic molecules has three atoms, e.g., O_3.

Tetratomic four atoms, e.g. P_4.

Octatomic eight atoms, e.g. S_8.

Molecules of Compounds

Atoms of different elements combine together in a definite proportion, e.g. H_2O, NH_3, CO_2, CH_4, CO, etc.

Binary compounds are made up of different elements, e.g. HCl, CCl_4, $MgCl_2$, Al_2O_3 etc.

Ions are the particles with anions (–ve), e.g. Cl^-, Br^- or cations (+ve), e.g. Na^+, Ba^{+2}.

Formula unit mass is the sum of atomic masses of ions and atoms present in the formula unit for an ionic compound, e.g. NaCl.

Avogadro's number

It is equal to **6.022×10^{23} per mol**.

Mole Concept

One mole is equal to the molar mass of an element or the compound.

Molar mass: Atomic or molecular mass, expressed in grams.

Laws of Chemical Combination

Established by **Lavoiser** and **Proust**. It governs the combination of substance to form products.

Law of Conservation of Mass

"Matter can neither be created nor destroyed in a chemical reaction.

Mass of reactants = Mass of product

Law of Constant proportion

"Pure chemical compounds, elements are always present in a definite proportion by mass."

Postulates of Dalton's Atomic Theory

- Every matter is made up of tiny particles called **atoms**.
- Atoms are indivisible, neither can be created nor destroyed.
- Atoms of same element are identical in mass and chemical properties.
- Atoms of different element have different atomic mass and properties.
- Atoms combine in the ratio of whole numbers to form a compound.