CHAPTER 1

Atoms and Molecules

18th century marked the recognition of difference between compounds and elements and scientists started thinking about combining and reactions of elements.

Antoine L Lavoisier laid the foundation of chemical science by establishing two important laws of chemical combination.

Laws of Chemical Combination

The following two laws are result of experimentations by Lavoisier and Joseph L Proust.

(i) Law of Conservation of Mass

It states that mass can neither be created nor be destroyed in a chemical reaction, *i.e.,* total mass of reactants must be equal to the total mass of products. It is also known as ***law of indestructibility of matter***.

For example, if 4.0 g of sodium carbonate reacts with 10 g of hydrochloric acid solution; it results in the formation of 2.5 g of carbon dioxide and 11.5 g of sodium chloride solution.

Here, Mass of reactants $= 4.0 + 10 = 14$ g

Mass of products $= 2.5 + 11.5 = 14$ g

(ii) Law of Constant Proportions

It states that, in a pure chemical substance, the elements are always present in definite proportions by mass. It is also known as ***law of definite proportions.***

For example, water from any source contains hydrogen and oxygen in the ratio of 1 : 8 by mass. Similarly, carbon dioxide always contains C and O in the ratio of 3 : 8. If a sample of CO_2 contains 36 g of carbon, then it is compulsory that it has 96 g oxygen.

This is calculated as $\frac{3}{8} = \frac{36}{x}$;

$$\therefore \quad x = \frac{36 \times 8}{3} = 96 \text{ g}$$

Topics Checklist

- ✓ Laws of Chemical Combination
- ✓ Dalton's Atomic Theory
- ✓ Atoms
- ✓ Molecules
- ✓ Ions
- ✓ Ionic Compounds
- ✓ Writing Chemical Formulae
- ✓ Molecular Mass and Mole Concept
- ✓ Percentage Composition

Dalton's Atomic Theory

Dalton's atomic theory provided an explanation for the law of conservation of mass and the law of definite proportions. According to Dalton's atomic theory, all matter (whether an element, a compound or a mixture), is composed of small particles, called ***atoms.***

The postulates of Dalton's atomic theory are

- Every matter is made of very small particles, called the ***atoms.***
- Atoms are indivisible particles which cannot be created or destroyed in a chemical reaction.
- Atoms of a given element are identical in mass as well as in chemical properties.
- Atoms of different elements have different masses and chemical properties.
- Atoms combine in the ratio of small whole numbers forming compounds.
- The relative number as well as kinds of atoms are constant in a given compound.

The major drawback of Dalton's atomic theory was that, it considered atom as indivisible particle but now it has been established that an atom can further be divided into electrons, protons and neutrons.

Check Point 1

1. 50 g of 10% lead nitrate is mixed with 50 g of 10% sodium chloride in a closed vessel. After sometime 6.83 g of lead chloride was precipitated. Besides, the reaction mixture contained 90 g of water and sodium nitrate. What is the amount of sodium nitrate formed?
2. Give one major drawback of Dalton's atomic theory of matter.
3. In a given sample of ammonia, 9 g hydrogen and 42 g nitrogen are present. In another sample, 5 g hydrogen is present. Calculate the amount of nitrogen in the second sample.

Atoms

Atoms are the smallest particles of an element which may or may not have independent existence but take part in a chemical reaction. These are the building blocks of all matter.

For example, atoms of hydrogen, oxygen, nitrogen, etc are not capable of independent existence whereas atoms of helium, neon, etc are capable of independent existence.

Size of Atoms

Atoms are very small and their radius is measured in **nanometres.**

$$1/10^9 \text{ m} = 1 \text{ nm} \text{ or } 1 \text{ m} = 10^9 \text{ nm}$$

Radius of hydrogen atom is 0.1 nm.

Modern Symbols of Atoms of Different Elements

Modern symbols for the elements were introduced by **JJ Berzelius.** These are defined as 'a short hand representation of the name of an element'.

Many of the symbols are the first one or two letters of the element's name in English. The first letter of a symbol is always written in capital letter and the second letter as a small letter.

For example, chlorine–Cl, zinc–Zn and aluminium–Al.

Symbols have been taken from the names of elements in different languages such as Latin, German Greek, etc.

For example,

Iron — Fe from Ferrum (*Latin name*)
Gold — Au from Aurum (*Latin name*)
Potassium — K from Kalium (*Latin name*)
Chlorine — Cl from Chloros (*Greek name*)
Cobalt — Co from Kobold (*German name*)
Sodium — Na from Natrium (*Latin name*)

Symbols for Some Elements

Element	Symbol	Element	Symbol	Element	Symbol
Aluminium	Al	Copper	Cu	Nitrogen	N
Argon	Ar	Fluorine	F	Oxygen	O
Barium	Ba	Gold	Au	Potassium	K
Boron	B	Hydrogen	H	Silicon	Si
Bromine	Br	Iodine	I	Silver	Ag
Calcium	Ca	Iron	Fe	Sodium	Na
Carbon	C	Lead	Pb	Sulphur	S
Chlorine	Cl	Magnesium	Mg	Uranium	U
Cobalt	Co	Mercury	Hg	Zinc	Zn
Chromium	Cr	Neon	Ne		

Atomic Mass

According to Dalton, each element had a characteristic **atomic mass.** But determining the mass of an individual atom was a relatively difficult task. **Relative atomic masses** were determined using the laws of chemical combinations and the compounds formed.

Relative Atomic Mass

It is defined as the number of times a given atom is heavier than 1/12th of mass of 1 atom of carbon-12 (C-12).

Atomic Mass Unit

It is defined as the mass of 1/12th of the mass of one atom of C-12 isotope. Earlier, it was abbreviated as **amu** but according to latest recommendation of IUPAC (International Union of Pure and Applied Chemistry), it is now written as **'u'–unified mass.**

Atomic Masses of Few Elements

Element	Atomic Mass (u)
Hydrogen	1
Carbon	12
Nitrogen	14
Oxygen	16
Sodium	23
Magnesium	24
Sulphur	32
Chlorine	35.5
Calcium	40

- *Atoms of most elements are not able to exist independently. Atoms form molecules and ions. These molecules or ions aggregate to form the matter.*

Check Point 2

1. Write *the atomic mass of following elements* Oxygen, Chlorine, Carbon, Hydrogen.
2. *Write symbols of the following elements* Silver, Chromium, Chlorine, Mercury, Lead, Copper, Gold, Aluminium.

Molecules

The smallest particle of a substance which is capable of independent existence is called a ***molecule.*** In general, molecule is a group of two or more atoms that are chemically bonded together. It shows all the properties of the substance.

Molecules of Elements

The molecules of an element are constituted by the same type of atoms. Molecules of many elements are made up of one atom of that element. *e.g.*, argon (Ar), helium (He), etc.

The molecules of the most of the non-metals are made up of more than one atoms.

For example, a molecule of oxygen consists of two atoms of oxygen. Ozone consists of three atoms of oxygen.

Atomicity

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

(*i*) **Monoatomic molecules** They consist of only one atom.
e.g., He, Ne, Ar, Xe, Fe, Al, etc.

(*ii*) **Diatomic molecules** They consist of two atoms.
e.g., $H_2, O_2, N_2, I_2, Br_2, Cl_2$, etc.

(*iii*) **Triatomic molecules** They consist of three atoms.
e.g., O_3.

(*iv*) **Tetraatomic molecules** They consist of four atoms. *e.g.*, P_4.

(*v*) **Polyatomic molecules** They consist of more than four atoms. *e.g.*, S_8.

Atomicity of Some Elements (Non-metal)

Name	Atomicity	Name	Atomicity
Argon	Monoatomic	Nitrogen	Diatomic
Helium	Monoatomic	Chlorine	Diatomic
Oxygen	Diatomic	Phosphorus	Tetra-atomic
Hydrogen	Diatomic	Sulphur	Poly-atomic

Molecules of Compounds

Atoms of different elements join together in definite proportions forming **molecules of compounds.**

For example, H_2O molecule is made up of hydrogen and oxygen elements in the ratio of 1 : 8 by mass.

Molecules of Some Compounds

Compounds	Combining Elements	Ratio by Mass
Water (H_2O)	Hydrogen and oxygen	1 : 8
Carbon dioxide (CO_2)	Carbon and oxygen	3 : 8
Hydrogen sulphide (H_2S)	Hydrogen and sulphur	1 : 16
Ammonia (NH_3)	Nitrogen and hydrogen	14 : 3
Sulphuric acid (H_2SO_4)	Hydrogen, sulphur, oxygen	1: 16 : 32
Glucose ($C_6H_{12}O_6$)	Carbon, hydrogen, oxygen	6: 1: 8
Baking powder ($NaHCO_3$)	Sodium, hydrogen, carbon, oxygen	23: 1: 12: 48
Common salt (NaCl)	Sodium, chlorine	23:35.5
Limestone ($CaCO_3$) or Calcium carbonate	Calcium, carbon, oxygen	40:12:48 or 10: 3: 12
Caustic soda (NaOH)	Sodium, oxygen, hydrogen	23: 16: 1
Caustic potash (KOH)	Potassium, oxygen, hydrogen	39: 16: 1
Ethanol (C_2H_5OH)	Carbon, hydrogen, oxygen	24: 6: 16 or 12: 3: 8
Methanol (CH_3OH)	Carbon, hydrogen, oxygen,	12: 4: 16: or 3: 1: 4
Ethyne (C_2H_2)	Carbon, hydrogen	24: 2 or 12: 1

Check Point 3

1. Give some examples containing more than four atoms. What are these called?
2. What is the difference between 2Cl and Cl_2?
3. Differentiate between atom and molecule.
4. How many kinds of atoms are present in a molecule of calcium carbonate ($CaCO_3$)?
5. The atomic masses of hydrogen, carbon, nitrogen and oxygen are 1u, 12u, 14u and 16 u, respectively. Show that the atoms of the following compounds combine in simple mass to atomic mass ratio : H_2O, CO_2 and NH_3.

Ions

The charged species are known as ***ions.*** These can be negatively or positively charged.

Ions are of following two types :

Cations

The positively charged ions which are attracted towards cathode in an electric field are known as ***cations.*** *e.g.,* Na^+, K^+, Ca^{2+}, Al^{3+}, etc.

Anions

The negatively charged ions which are attracted towards anode in an electric field are known as ***anions.*** *e.g.,* Cl^-, Br^-, O^{2-}, N^{3-}, etc.

Ionic Compounds

The compound which consists of ions is known as ***ionic compound.*** It contains ionic bonds, *e.g.,* NaCl, CaO, etc. Such compounds consist of a positively charged metal ion and negatively charged non-metal ion.

A group of atoms carrying a charge and behaving like one entity, is known as a ***polyatomic ion.*** It carries a fixed charge.

e.g., NO^-_3 (nitrate ion), CO_3^{2-} (carbonate ion) and SO_4^{2-} (sulphate ion), etc.

Valency

The combining power (or capacity) of an element is called its ***valency.*** Valency can be used to find out how the atoms of an element will combine with the atom (s) of another element to form a chemical compound.

Names, Symbols and Valency of Some Ions

Valency	Name of ion	Symbol	Non-metallic element	Symbol	Polyatomic ions	Symbol
1	Sodium Potassium Silver Copper (I)*	Na^+ K^+ Ag^+ Cu^+	Hydrogen Hydride Chloride Bromide Iodide	H^+ H^- Cl^- Br^- I^-	Ammonium Hydroxide Nitrate Hydrogen carbonate (bicarbonate)	NH_4^+ OH^- NO_3^- HCO_3^-
2	Magnesium Calcium Zinc Iron (II)* Copper (II)*	Mg^{2+} Ca^{2+} Zn^{2+} Fe^{2+} Cu^{2+}	Oxide Sulphide	O^{2-} S^{2-}	Carbonate Sulphite Sulphate	CO_3^{2-} SO_3^{2-} SO_4^{2-}
3	Aluminium Iron (III)*	Al^{3+} Fe^{3+}	Nitride	N^{3-}	Phosphate	PO_4^{3-}

* These elements show more than one valency. Here, the Roman numeral written in brackets shows their valency. These have covalent bonds.

- *The compounds which contain molecules are called molecular compounds. e.g.* H_2O, CH_4, *etc.*

Writing Chemical Formulae

The short way to represent a compound with the help of symbols and valency of elements is known as ***chemical formula.*** Chemical formula of a compound shows its constituent elements and the number of atoms of each combining element.

In ionic compounds, the charge on each ion is used to determine the chemical formula of a compound.

There are some rules for writing chemical formula

(*i*) The valencies or charges on the ion must be balanced.

(*ii*) When a compound consists of a metal and a non-metal, the name of the metal is written first and on the left whereas non-metal on the right.

For example, calcium oxide (CaO), sodium chloride (NaCl), iron sulphide (FeS), copper oxide (CuO), etc where oxygen, chlorine, sulphur are non-metals and are written on the right, whereas calcium, sodium, iron and copper are metals and are written on left.

(*iii*) When compound is formed with polyatomic ions, the ion is enclosed in a bracket before writing the number to indicate the ratio. In case the number of polyatomic ion is one, the bracket is not required.

For example, NaOH.

Formulae of Simple Compounds

To write the chemical formula for compounds, write the symbols of constituent elements and their valencies as shown below. Write the symbol of cation first followed by the symbol of anion. Then criss-cross their charges or valencies to get the formula.

The simplest compounds made up of two different elements are also called *binary compounds.*

For example,

Hydrogen sulphide

Symbols	H	S
Valencies	1	2
Formula	H_2S	

Carbon tetrachloride

Symbols	C	Cl
Valencies	4	1
Formula	CCl_4	

Magnesium chloride

Symbols	Mg	Cl
Charges	+2	–1
Formula	$MgCl_2$	

In other words, the positive and negative charges must balance each other and the overall structure must be neutral.

For example,

Calcium oxide

Symbols	Ca	O
Charges	+2	–2
Formula	Ca_2O_2 or CaO	

Aluminium oxide

Symbols	Al	O
Charges	+3	–2
Formula	Al_2O_3	

Sodium nitrate

Symbols	Na	NO_3
Charges	+1	–1
Formula	$NaNO_3$	

Potassium carbonate

Symbols	K	CO_3
Charges	+1	–2
Formula	K_2CO_3	

We use brackets when we have two or more of the same ions in the formulae.

For example,

Aluminium hydroxide

Symbols	Al	OH
Charges	+3	–1
Formula	$Al(OH)_3$	

Ammonium sulphate

Symbols	NH_4	SO_4
Charges	+1	–2
Formula	$(NH_4)_2SO_4$	

Check Point 4

1. *Give symbol and valency of the following ions*
   Hydroxide ion, carbonate ion, sulphate ion, bicarbonate ion, nitrate ion, ammonium ion, nitride ion and phosphate ion.
2. *Write the formulae for the following*
   (a) Ammonium carbonate (b) Potassium sulphate
   (c) Cupric chloride (d) Aluminium nitride
   (e) Calcium phosphate
3. The formula of sulphuric acid is H_2SO_4 and a metal chloride has its formula as MCl_3. Write the formula of metal sulphate.
4. *Write the name of the compounds, which are represented by the following formulae*
   $NaHCO_3$, $Ca(OH)_2$, CaO, KNO_3

Molecular Mass and Mole Concept

Molecular Mass

The **molecular mass** of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance. Therefore, the **relative molecular mass** of a molecule is expressed in **atomic mass units** (u).

For example, the relative molecular mass of water (H_2O) is 18 u, *which can be calculated as*

Atomic mass of hydrogen = 1 u

Atomic mass of oxygen = 16 u

H_2O contains two hydrogen atoms and one oxygen atom. *Therefore, molecular mass of water is*

$$= 2 \times 1 + 1 \times 16 = 18 \text{ u}$$

Example 1. *Calculate the molar mass of the following substances.*

(a) Ammonia (b) Hydrochloric acid
(c) Phosphorus molecule (d) Hydrogen molecule
(e) Oxygen molecule (f) Sulphur dioxide

Sol.

(a) Molar mass of ammonia

$$(NH_3) = 1 \times 14 + 3 \times 1 = 17 \text{ u}$$

(b) Molar mass of hydrochloric acid

$$(HCl) = 1 \times 1 + 1 \times 35.5 = 36.5 \text{ u}$$

(c) Molar mass of phosphorus molecule

$$(P_4) = 4 \times 31 = 124 \text{ u}$$

(d) Molar mass of hydrogen molecule $(H_2) = 2 \times 1 = 2$ u

(e) Molar mass of oxygen molecule $(O_2) = 2 \times 16 = 32$ u

(f) Molar mass of sulphur dioxide

$$(SO_2) = 32 + 2 \times 16 = 64 \text{ u}$$

Formula Unit Mass

It is the sum of the atomic masses of all atoms in a formula unit of a compound. We use the word formula unit for those substances whose constituent particles are ions.

Formula unit mass is calculated in the same manner as we calculate the molecular mass.

For example, formula unit mass for sodium chloride $(NaCl) = 1 \times 23 + 1 \times 35.5 = 58.5$ u.

Mole Concept

The mole is the amount of a substance which contains as many particles (atoms/ions/molecules/formula units, etc) as in 12 g of C-12.

One mole of any species (atoms, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecular mass in grams.

The number of particles present in 1 mole of any substance is fixed, equal to 6.022×10^{23}. This is a constant called the **Avogadro constant** or **Avogadro's number** (N_0).

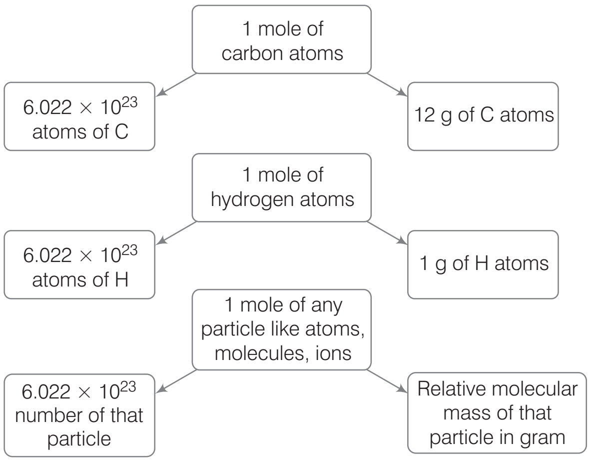
Mole is also defined as a number equal to the Avogadro constant, N_A (6.022×10^{23}).

$$\boxed{1 \text{ Mole} = 6.022 \times 10^{23} \text{ in number}}$$

The mass of 1 mole of a substance is equal to its relative atomic or molecular mass in gram.

The atomic mass or molecular mass of an element gives us the mass of one atom of that element in atomic mass units (u). To get the mass of 1 mole of an atom of that element we have to take the same numerical value but change the units from 'u' to 'g'.

Molar mass of atoms is also known as **gram atomic mass.** To find the gram molecular mass or molar mass we keep the numerical value same but change the units from 'u' to 'g'.



Relationship between mole, Avogadro number and molecular mass

Example 2. *Find the mass of*

(a) 1 mole of nitrogen atoms
(b) 8 moles of aluminium atoms
(c) 0.2 mole of oxygen atoms
(d) 2 moles of water molecules

Sol.

(a) Mass of 1 mole of nitrogen atoms = 14 g

(b) We know that,

mass of 1 mole of Al atoms = 27 g

$\therefore$ Mass of 8 moles of Al atoms $= 8 \times 27 = 216$ g

(c) Mass of 0.2 mole of oxygen atoms $= 0.2 \times 16 = 3.2$ g
($\because$ Mass of 1 mole of oxygen atoms = 16 g)

(d) Mass of 2 moles of water molecules $= 2 \times 18 = 36$ g
($\because$ Mass of 1 mole of water molecule = 18 g)

Example 3. *Find the number of moles of*

(a) 48 g of oxygen gas
(b) 18 g of H_2O molecules
(c) 22 g of CO_2 gas
(d) 51 g of NH_3 gas

Sol.

(a) Molecular weight of $O_2 = 2 \times 16 = 32$ u

i.e., 1 mole of $O_2 = 32$ g

$\because$ 32 g of O_2 = 1 mol

$$\therefore \quad 48 \text{ g of } O_2 = \frac{1 \times 48}{32} = \frac{3}{2} = 1.5 \text{ mol}$$

or, $\text{Number of moles} = \dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{48}{32} = 1.5 \text{ mol}$

(b) Molar mass of $H_2O = 2 \times 1 + 16 = 18$ g

$\therefore$ 18 g of $H_2O = 1$ mol

or, $\text{Number of moles} = \dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{18}{18} = 1 \text{ mol}$

(c) Molar mass of $CO_2 = 12 + 2 \times 16 = 44$ g

$\because$ 44 g of $CO_2 = 1$ mol

$\therefore$ 22 g of $CO_2 = \dfrac{1}{44} \times 22 = 0.5$ mol

or, $\text{Number of moles} = \dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{22}{44} = 0.5 \text{ mol}$

(d) Molar mass of $NH_3 = 14 + 3 \times 1 = 17$ g

$\because$ 17g of $NH_3 = 1$ mol

$\therefore$ 51g of $NH_3 = \dfrac{1}{17} \times 51 = 3$ mol

or, $\text{Number of moles} = \dfrac{\text{Given mass}}{\text{Molar mass}} = \dfrac{51}{17} = 3 \text{ mol}$

Example 4. *Calculate the number of aluminium ions which are present in 0.0051 g of aluminium oxide.*

Sol. Molar mass of 1 mole of aluminium oxide (Al_2O_3)

$= 2 \times 27 + 3 \times 16 = 54 + 48 = 102$ g

$\because$ 102 g of Al_2O_3 contains

$= 2 \times 6.022 \times 10^{23}$ Al^{3+} ions

$\therefore$ 0.0051 g of Al_2O_3 will contain

$$\frac{2 \times 6.022 \times 10^{23}}{102} \times 0.0051 \text{ ions}$$

$= 6.022 \times 10^{19}$ Al^{3+} ions

Percentage Composition

The **percentage composition** of a component in a compound is the percentage of the total mass of the compound that is due to that component. It is obtained by dividing mass due to component by the total mass of the compound and multiplying by 100, *i.e.,*

Percentage composition of component

$$= \frac{\text{Mass due to that component}}{\text{Total molar mass of compound}} \times 100$$

Example 5. *Calculate the percentage composition of carbon in CO_2.*

Sol. Molar mass of $CO_2 = 12 + 2 \times 16$

$= 44 \text{ g mol}^{-1}$

Mass due to carbon (C) = 12 g

Percentage composition of C $= \dfrac{12}{44} \times 100$

$= 27.3\%$

Check Point 5

1. What is Avogadro number ?
2. Write the weight of 1 mole of sodium atoms and 1 mole of oxygen molecules.
3. Calculate the molecular mass of MgO, C_2H_5OH and C_2H_2.
4. Calculate the percentage composition of glucose ($C_6H_{12}O_6$).

ANSWERS for Check Points

Check Point 1

1. 50 g of 10% lead nitrate means, solution contains $\left(50 \times \dfrac{10}{100} =\right)$ 5 g lead nitrate in (50 – 5 =) 45 g of water.
Similarly, 50 g of 10% sodium chloride means the solution contains 5 g of sodium chloride in 45 g of water.
Thus, total contents before reaction
= 5 + 5 + 45 + 45
= 100 g
After reaction, amount of water = 90 g
and amount of lead chloride = 6.83 g
According to law of conservation of mass,
Total amount of reactants = Total amount of products
100 = 90 + 6.83 + amount of sodium nitrate
$\therefore$ Amount of sodium nitrate = 100 – 90 – 6.83 = 3.17 g.

2. Major drawback of Dalton's atomic theory is that he postulated that atom is the smallest particle of matter. But now it is established that atom can further be sub-divided into smaller particles, known as electrons, protons and neutrons.

3. Ratio of hydrogen and nitrogen in the first sample of ammonia = 9 : 42 or 3 : 14.

According to 'law of definite proportions' in the second sample of ammonia, hydrogen and nitrogen should be in the ratio of 3 : 14.

Therefore, $\frac{H}{N} = \frac{3}{14} \Rightarrow \frac{5}{N} = \frac{3}{14}$

$$N = \frac{5 \times 14}{3} = 23.3 \text{ g}$$

Check Point 2

1.

Element	Atomic Mass (u)
Oxygen	16
Chlorine	35.5
Carbon	12
Hydrogen	1

2. Silver (Ag), Chromium (Cr), Chlorine (Cl), Mercury (Hg), Lead (Pb), Copper (Cu), Gold (Au), Aluminium (Al).

Check Point 3

1. Molecules which contain more than four atoms are called poly-atomic molecules. *For example*, sulphur (S_8), ethyl alcohol (C_2H_5OH), sugar ($C_{12}H_{22}O_{11}$), etc.

2. 2Cl indicates 2 atoms of chlorine and Cl_2 indicates one molecule of chlorine.

3. An 'atom' is the smallest particle of an element which may or may not have independent existence. *For example*, helium is an atom and exists as such. On the other hand, 'molecule' is the smallest particle of an element or compound, capable of independent existence. *For example*, hydrogen atom (H) cannot exist as such but exists as H_2, which is a molecule.

4. $CaCO_3$ is a heteroatomic molecule which contains three types of atoms, *i.e.,* one atom of calcium, one atom of carbon and three atoms of oxygen.

5.

Compound	Combining elements	Ratio by mass	Mass ratio/Atomic mass	Simple ratio
H_2O	H and O	1 : 8	$H = \frac{1}{1} = 1, O = \frac{8}{16} = \frac{1}{2}$	2 : 1
CO_2	C and O	3 : 8	$C = \frac{3}{12} = \frac{1}{4}, O = \frac{8}{16} = \frac{1}{2}$	1 : 2
NH_3	N and H	14 : 3	$N = \frac{14}{14} = 1, H = \frac{3}{1} = 3$	1 : 3

Check Point 4

1.

Ion	Symbol	Valency
Hydroxide	OH^-	–1
Carbonate	CO_3^{2-}	–2
Sulphate	SO_4^{2-}	–2
Bicarbonate	HCO_3^-	–1
Nitrate	NO_3^-	–1
Ammonium	NH_4^+	+1
Nitride	N^{3-}	– 3
Phosphate	PO_4^{3-}	– 3

2. (a) **Ammonium carbonate**

NH_4 (+1) ✕ CO_3 (–2)

$(NH_4)_2CO_3$

(b) **Potassium sulphate**

K (+1) ✕ SO_4 (–2)

K_2SO_4

(c) **Cupric chloride**

Cu (+2) ✕ Cl (–1)

$CuCl_2$

(d) **Aluminium nitride**

Al (+3) ✕ N (–3)

AlN

(e) **Calcium phosphate**

Ca (+2) ✕ PO_4 (–3)

$Ca_3(PO_4)_2$

3. For the formula of metal sulphate, valencies of metal ion and sulphate ion should be known. Valency of sulphate ion (SO_4^{2-}) is –2 and that of metal is +3 (because it combines with 3 chloride ions forming the formula MCl_3). Therefore, formula of metal sulphate is $M_2(SO_4)_3$.

4.

Chemical formulae		Chemical names
$NaHCO_3$	—	Sodium bicarbonate
$Ca(OH)_2$	—	Calcium hydroxide
CaO	—	Calcium oxide
KNO_3	—	Potassium nitrate

Check Point 5

1. It is 6.022×10^{23} and denoted by the symbol N_A.

2. Weight of 1 mole of sodium atoms = 23 g (atomic mass) and weight of 1 mole of oxygen molecules = 32 g (molecular mass).

3. Molecular mass of MgO = 24 + 16 = 40u

Molecular mass of C_2H_5OH

$= 2 \times 12 + 5 \times 1 + 16 + 1 = 46u$

Molecular mass of $C_2H_2 = 24 + 2 = 26u$

4. Molar mass of glucose

$(C_6H_{12}O_6) = 6 \times 12 + 12 \times 1 + 6 \times 16$

$= 72 + 12 + 96 = 180$ g

Percentage of carbon $= \frac{72}{180} \times 100 = 40\%$

Percentage of hydrogen $= \frac{12}{180} \times 100 = 6.66\%$

Percentage of oxygen $= \frac{96}{180} \times 100 = 53.33\%$