Gram molecular mass of H_2	$= 2g$
Molecular mass of O_2	$= 32u$
Gram molecular mass of O_2	$= 32g$
Molecular mass of H_2O	$= 18u$
Gram molecular mass of H_2O	$= 18g$
Molecular mass of CO_2	$= 44u$
Gram molecular mass of CO_2	$= 44g$

Gram molecular mass is also called **gram molecule**

MOLE CONCEPT

We have learnt that according to law of definite proportions, in a chemical reaction definite number of atoms or molecules of one substance react with a definite number of atoms or molecules of another substance to form a compound. For example, consider the reaction :

$$2H_2 + O_2 \longrightarrow 2H_2O$$

In this reaction, two molecules of hydrogen combine with one molecule of oxygen to form two molecules of water. But how to just pick 2 molecules of hydrogen and one molecule of oxygen ? This is very difficult as such because atoms and molecules are very very small. To overcome this problem, a new term known as **mole** was introduced.

Quite commonly we use the unit dozen to count 12 articles irrespective of their nature. For example, one dozen books means 12 books, one dozen oranges means 12 oranges and one dozen pencils means 12 pencils and so on.

Similarly, 1 gross means 144 articles. For example, 1 gross pencils means 144 pencils. In a similar way, the chemists use the unit mole for counting atoms, molecules or ions.

A mole represents 6.022×10^{23} particles.

Thus,

1 mole (of anything) $= 6.022 \times 10^{23}$ in number

For example,

1 mole of atoms $= 6.022 \times 10^{23}$ atoms

1 mole of molecules $= 6.022 \times 10^{23}$ molecules

1 mole of ions $= 6.022 \times 10^{23}$ ions

Thus, the number of particles present in 1 mole of any substance is fixed *i.e.*, 6.022×10^{23}. This number is also called **Avogadro constant** or **Avogadro number**. It is represented by N_0. This is an experimentally obtained value and is named in honour of the Italian scientist **Amadeo Avogadro.**

MOLE IN TERMS OF MASS

Besides being related to a number, a mole has one more advantage over a dozen or a gross. This advantage is that **mass of 1 mole of a particular substance is also fixed.**

Mole and gram atomic mass

The mass of 1 mole of a substance is equal to its relative atomic or molecular mass in grams (g). Now atomic mass of an element gives us the mass of one atom of that element in atomic mass units (u). To get the molar mass *i.e.* mass of 1 mole 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.** For example,

Atomic mass of hydrogen = 1 u

Gram atomic mass of hydrogen = 1 g

Now 1 gram atomic mass of hydrogen or 1 g of hydrogen has 1 mole atoms i.e. 6.022×10^{23} atoms of hydrogen.

Similarly,

Atomic mass of oxygen = 16 u

$\therefore$ Gram atomic mass of oxygen = 16 g

or 16 u oxygen has only 1 atom of oxygen

16 g oxygen has 1 mole atoms *i.e.* 6.022×10^{23} atoms of oxygen

Thus,

1 mole of atoms of an element = Gram atomic mass of element or **Molar mass of element**

$= 6.022 \times 10^{23}$ atoms of element

The mass of 1 mole of atoms of some elements are given in Table 12

Table 12. Mass of 1 mole of atoms

Element	Mass	Contains
Carbon	12 g (1 gram atomic mass of C)	6.022×10^{23} C atoms or 1 mole of C atoms
Iron	55.8 g (1 gram atomic mass of Fe)	6.022×10^{23} Fe atoms or 1 mole of Fe atoms
Hydrogen	1 g (1 gram atomic mass of H)	6.022×10^{23} H atoms or 1 mole of H atoms
Oxygen	16 g (1 gram atomic mass of O)	6.022×10^{23} O atoms or 1 mole of O atoms

One mole of these elements are also shown in Fig. 6.

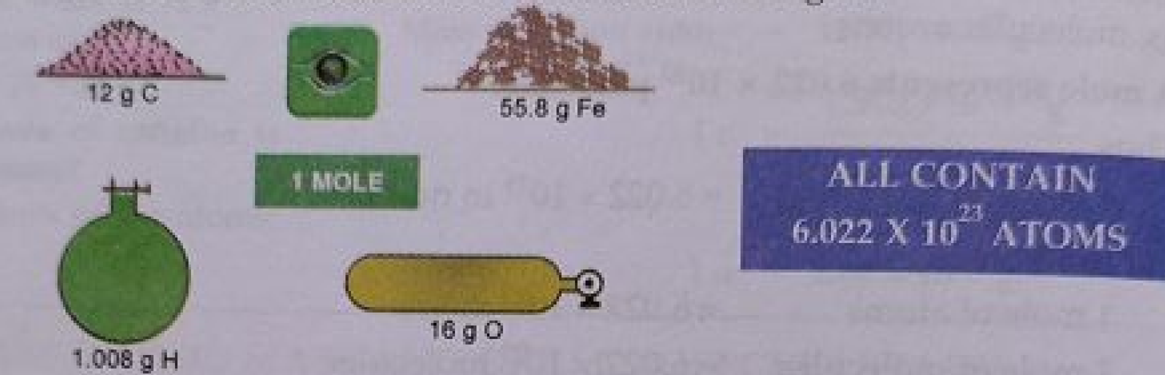

Fig. 6. Representation of 1 mole of some common elements.

Mole and molar mass

To find the gram molecular mass or molar mass of a molecule we keep the numerical value same as the molecular mass but simply change units from u to g. For example, as we have already calculated,

Molecular mass of H_2O = 18 u

Gram molecular mass of H_2O = 18 g

But gram molecular mass *i.e.*, 18 g contain 6.022×10^{23} molecules of H_2O

Thus,

18 u water has only 1 molecule of water

18 g water has 1 mole molecules of water *i.e.* 6.022×10^{23} molecules of water

Similarly,

Molecular mass of CO_2 = 44 u

Molar mass of CO_2 = 44 g

Molecular mass of SO_2 = 64 u

Molar mass of SO_2 = 64 g

Thus,

1 mole molecules of a substance = Gram molecular mass of substance or Molar mass of substance

= 6.022×10^{23} molecules of substance

The mass of one mole of molecules of some common molecules are shown in Fig. 7.

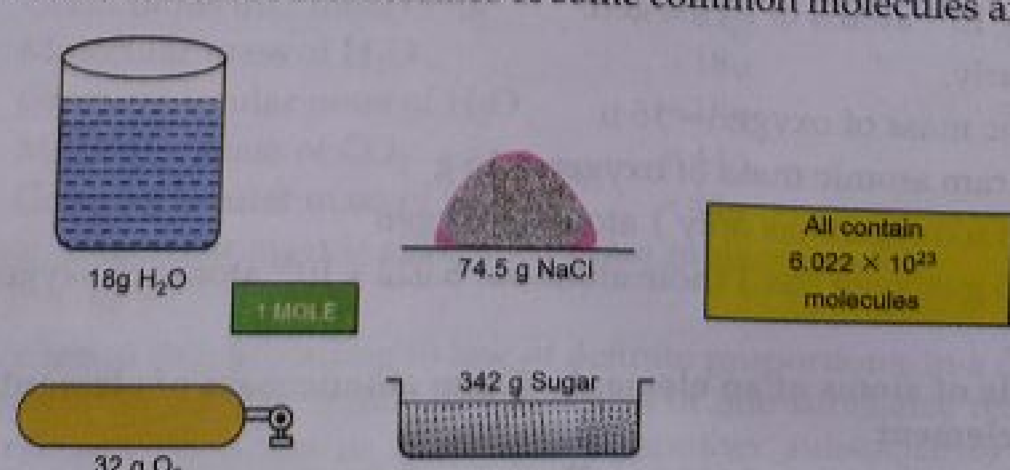

Fig. 7. Representation of one mole of some substances.

SUM UP

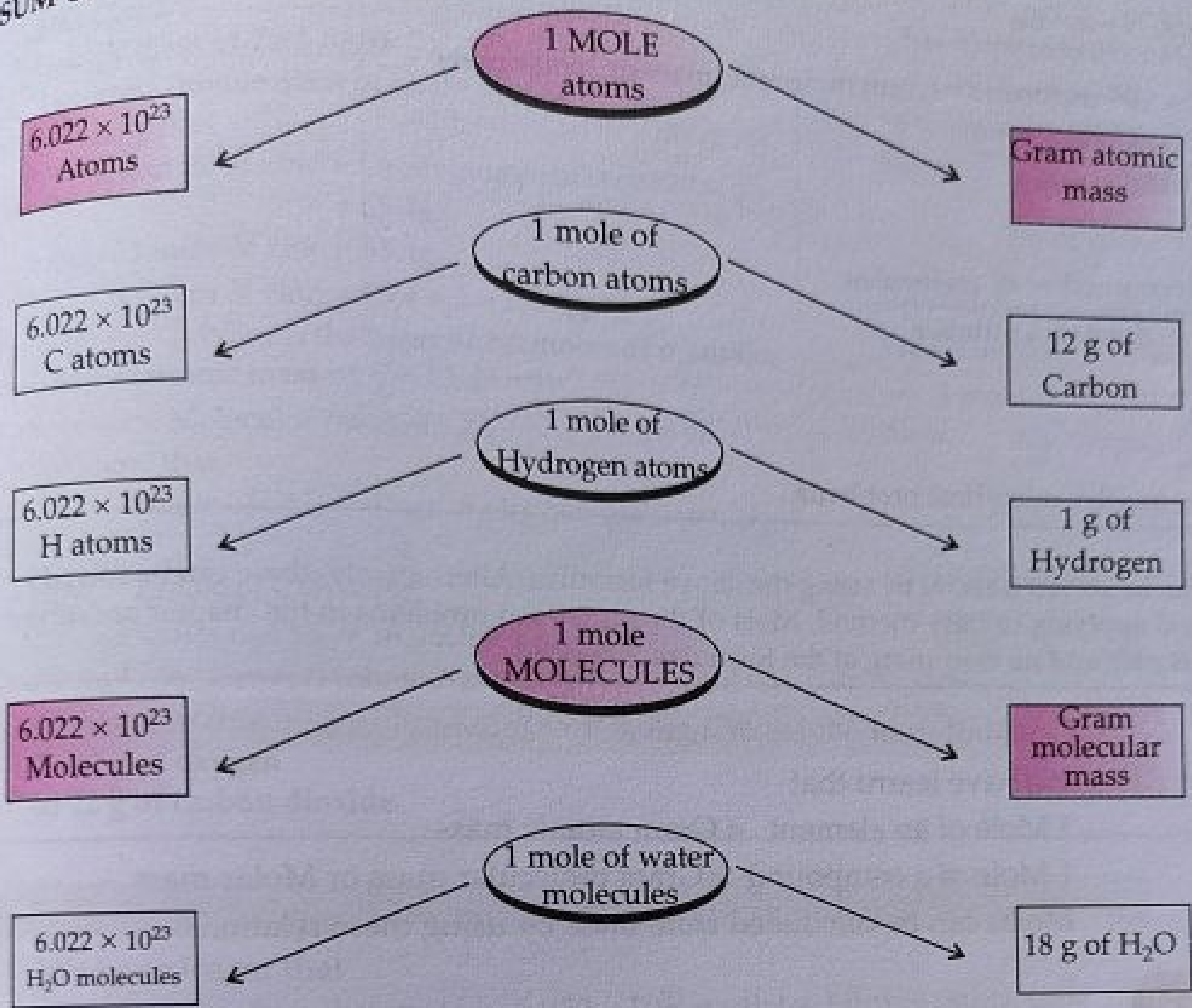

Fig. 8. Relationship between mole, Avogadro number and mass.

Thus, to count the atoms or molecules during reactions, mass can be related to number with the help of mole.

1 Mole = 6.022×10^{23} number = Relative mass in g

Thus, a mole is the chemist's counting unit.

REMEMBER

While doing numerical problems of mole concept, the following relations should be remembered :

Key for Symbols

No. of moles = n
Given mass = m
Molar mass = M
Given number of particles = N
Avogadro number of particles = N_0

Key Formulae

1 mole of atoms = 6.022×10^{23} atoms = Gram atomic mass or Molar mass of element

$$\text{Number of moles} = \frac{\text{Mass of element}}{\text{Molar mass}}$$

$$n = \frac{m}{M}$$

$$\text{Number of moles} = \frac{\text{Given number of atoms}}{\text{Avogadro number}}$$

$$n = \frac{N}{N_0}$$

These relations can be interchanged as

Mass of element, $m = n \times M$

or No. of particles of element, $N = n \times N_0$

Similarly,

1 mole of molecules = 6.022×10^{23} molecules = Gram molecular mass or Molar mass

$$\text{Number of moles} = \frac{\text{Mass of substance}}{\text{Molar mass}}$$

$$n = \frac{m}{M}$$

$$\text{Number of moles} = \frac{\text{Given number of molecules}}{\text{Avogadro number}}$$

$$n = \frac{N}{N_0}$$

or $m = n \times M$ and $N = n \times N_0$

... apply these formulae to solve numerical problems.

Important Note

The numerical problems can be solved directly by using the above formulae. Alternatively, these can be so