Iron	Fe	Zinc	Zn

Note. There is no need to memorise all the symbols at one go. With the passage of time and repeated usage, you will automatically be able to remember these symbols.

ATOMIC MASSES

The most remarkable concept which Dalton's atomic theory proposed was atomic mass. Each element has a characteristic atomic mass. This theory could explain the law of constant proportions on the basis of atomic masses so successfully that the scientists were prompted to measure the atomic masses of atoms. However, the atoms are extremely small particles and it is very difficult to determine their actual masses. For example, mass of one atom of hydrogen has been found to be 0.00000000000000000000000167 g $= 1.67 \times 10^{-24}$ g. Obviously, such a small mass cannot be determined even with the help of a very sensitive balance. To overcome, this problem, the atomic masses are expressed as *relative masses i.e.*, with reference to mass of a standard atom.

In fact, this was done on the basis of chemical combinations of elements to form compounds. For example, a compound is formed between carbon and oxygen. 3.0 g of carbon were combined with 4.0 g of oxygen. This means that oxygen contributed $\frac{4}{3}$ times as much mass towards the formation of compound (CO) as the carbon. If the substance is made up of molecules, each containing one atom of carbon and one atom of oxygen, then each oxygen atom must weigh $\frac{4}{3}$ times as much as one carbon atom. Suppose, we define atomic mass unit as equal to one carbon atom and assign carbon an atomic mass of 1.0 a.m.u., then oxygen would have atomic mass of $\frac{4}{3}$ or 1.33 a.m.u. However, it is more convenient to have these numbers as whole numbers (or as near to whole numbers). To solve the problem, scientists thought of different atomic mass units with passage of time.

Initially, scientists decided to choose **hydrogen atom** as the standard substance because it is the lightest of all the atoms known. Its atomic mass was taken as 1 a.m.u. Later on **oxygen** was fixed as standard because it is more reactive than hydrogen. The **atomic mass of an element is taken as the number of times an atom of it is heavier than $\frac{1}{16}$ th of an atom of oxygen.** This method was considered relevant because :

(*i*) oxygen reacted with a large number of elements and formed compounds.

(*ii*) this atomic mass unit gave masses of elements as whole numbers.

However, later on it was observed that all atoms of oxygen do not have same mass because naturally occurring oxygen was later found to be composed of a mixture of atoms of slightly different masses. These were called **isotopes** (discussed later).

In 1961, the International Union of Chemists selected the stable isotope of carbon (carbon-12) as the standard for comparing the atomic and molecular masses of elements and compounds. The atomic mass of the standard, the isotope carbon-12 of carbon is chosen to be 12. Thus, **atomic mass** may be defined as :

the average relative mass of an atom of the element as compared to an atom of carbon (carbon-12) taken as 12.

In other words, atomic mass expresses the number of times an atom of the element is heavier than a carbon atom taken as 12 or $\frac{1}{12}$ th of the mass of carbon atom. Therefore,

$$\text{Atomic mass} = \frac{\text{Mass of an atom}}{\frac{1}{12}\text{th mass of a carbon atom (carbon-12)}}$$

This scale of relative masses of atoms is called **atomic mass unit scale** and is abbreviated as a.m.u. Now, IUPAC has recommended a new symbol 'u' (unified mass) in place of a.m.u. The quantity of mass equal to $\frac{1}{12}$ th of the mass of an atom of carbon (carbon-12) is called **atomic mass unit.**

Table 2. Atomic masses of some common elements.

Element	Symbol	At. mass
Aluminium	Al	27
Arsenic	As	74.9
Argon	Ar	39.9
Antimony	Sb	122
Barium	Ba	137.3
Boron	B	10.8
Bromine	Br	79.9
Cadmium	Cd	112.4
Caesium	Cs	132.9
Calcium	Ca	40.1
Carbon	C	12
Chlorine	Cl	35.5
Chromium	Cr	52
Cobalt	Co	58.9
Copper	Cu	63.5
Fluorine	F	19
Gold	Au	197.0
Helium	He	4.0
Hydrogen	H	1.008
Iodine	I	126.9
Iron	Fe	55.8
Lead	Pb	207.2
Lithium	Li	6.9
Magnesium	Mg	24.3
Manganese	Mn	54.9
Mercury	Hg	200.6
Neon	Ne	20.1
Nickel	Ni	58.7
Nitrogen	N	14.0
Oxygen	O	16.0
Phosphorus	P	31
Platinum	Pt	195.1
Potassium	K	39.1
Radon	Rn	222
Scandium	Sc	44.9
Silicon	Si	28.1
Selenium	Se	79
Silver	Ag	107.9
Sodium	Na	23
Sulphur	S	32
Tin	Sn	118.7
Titanium	Ti	47.9
Tungsten	W	183.8
Uranium	U	238
Vanadium	V	50.9
Xenon	Xe	131.[illegible]
Zinc	Zn	65.[illegible]

Note. The atomic masses in the table are approximate. The exact values of all the elements are given in the beginning of the book. For calculations, these approximate values can be used.

Atomic mass unit = $\frac{1}{12}$ th the mass of a carbon-12 atom.

Hence, 1 atom of hydrogen has $\frac{1}{12}$ th the mass of standard carbon-12, so its atomic mass is 1 a.m.u. Similarly, it is observed that an atom of oxygen is 16 times heavier than $\frac{1}{12}$ th of the mass of carbon atom (1 a.m.u.), therefore, its atomic mass is 16 u.

The atomic masses of some common elements are given in Table 2.

DO YOU KNOW?

Concept of Average Atomic Mass

It may be noted that the word average has been used in the above definition. This is because most of the elements occur in nature as mixtures of atoms having different atomic masses. These different atoms of the same element having different atomic masses are called **isotopes**. Therefore, the average atomic mass of different types (isotopes) of the same element is taken as atomic mass. For example, chlorine occurs in nature in the form of two types of atoms (isotopes) with atomic mass 35 and 37 in the ratio of 3:1 respectively. Therefore, average atomic mass of chlorine is taken as:

$$\text{Average atomic mass of chlorine} = \frac{35 \times 3 + 37 \times 1}{3+1} = 35.5$$

Thus, we say that on an average, an atom of chlorine is 35.5 times heavier than 1/12th of the mass of carbon atom (C^{12}).

Mass of 1 amu !

1 amu is $\frac{1}{12}$ th of the mass of carbon -12 atom.

It has been found by experiments that the mass of carbon-12 atom is 1.9926×10^{-23} g.

$$\therefore \quad 1 \text{ amu} = \frac{1.9926 \times 10^{-23}\text{ g}}{12} = \mathbf{1.6605 \times 10^{-24} g}$$

HOW DO ATOMS OCCUR ?

Atoms of most elements donot occur independently. They aggregate (join together) in different ways to form matter that we are able to see, feel, or touch. The atoms may combine to form neutral molecules or charged ions which further form compounds. For example, atoms join together to form neutral molecules which may exist as elements or molecular compounds. The atoms may also form charged species called **ions** which form compounds known as **ionic compounds**. These basic types of aggregation of atoms is shown in Fig. 5.