THE MOLE

REVISION

6
C
* 12

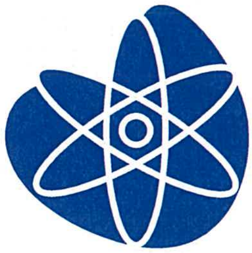
← Atomic Number (z) = No. of Protons in the nucleus.

← Mass Number = No. of Protons + No. of neutrons in the nucleus.

*This number may have decimal points due to the existence of isotopes.

ISOTOPES

Different kinds of atom of the same element are called **ISOTOPES**. Atoms of different isotopes of an element have



- the same number of protons in the nucleus.
- the same number of electrons in the electron cloud.
- different numbers of neutrons in the nucleus.
- different isotopes of the same element are chemically similar.

The **RELATIVE ATOMIC MASS** of an element is the ratio of the average mass of atoms of the element to 1/12 of the mass of an atom of the isotope ^{12}C.

$$\frac{\text{average mass of copper atoms}}{\text{mass of a } ^{12}\text{C atom}} = \frac{5.29}{1}$$

So, the relative atomic mass of copper, $A_r(Cu) = 5.29 \times 12.0 = 63.5$

A MOLE OF ATOMS

The number of atoms in exactly 12 g of isotope ^{12}C is the same as the number of atoms in

- 63.5 g of copper.
- 16.0 g of oxygen.
- 32.1 g of sulfurs.
- 197.0 g of gold.

➢A **MOLE** of atoms of an element is the amount of it in a sample whose mass in grams is numerically equal to the relative atomic mass or mass number.

➢A **MOLE** of atoms of any element is always the same number. This number is known as **AVAGADRO'S NUMBER (NA)** ⇨ **6.02×10^{23}.**

MOLAR MASS

The mass, in grams, of a mole of a substance is called its MOLAR MASS. The symbol for molar mass is M.

→ The molar mass of any ELEMENT is the mass number for that element in grams.

eg: M(Li) = 6·9 g mol $^{-1}$ M(C) = 12·0 g mol $^{-1}$ M(Ca) = 40·1 g mol $^{-1}$

→ The molar mass of any COVALENT MOLECULE is the sum of the individual molar masses of the elements in the molecule.

eg: $M(CO_2)$ = M(C) + M(O) x 2
= 12 + 16 x 2
= 44 g mol $^{-1}$

$M(N_2)$ = M(N) x 2 = 14 x 2
= 28 g mol $^{-1}$

→ The molar mass of any IONIC COMPOUND is the sum of the individual molar masses of the elements in the compound.

eg: M(NaCl) = M(Na) + M(Cl)
= 23·0 + 35·5 = 58·5 g mol $^{-1}$

$M(MgCl_2)$ = M(Mg) + M(Cl) x 2
= 24·3 + 35·5 x 2
= 24·3 + 71
= 95·3 g mol $^{-1}$

GENERAL EQUATION

→ The molar mass (M), the number of moles (n) and the amount of substance (m) that you have are related by the following equation:

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

* This equation could be represented in two other forms:

$$m = nM$$

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

* Given information about any two of these quantities you should be able to find the other.

Molar Mass (M)

The mass of one mole of any substance (element or compound) is defined as the **Molar Mass** (symbol, M) and has the unit gram per mole (g mol-1).

For example:

(a) M (helium atoms) = 4 g mol^{-1}

(b) M (silicon atoms) = 28 g mol^{-1}

(c) M (chlorine atoms) = 35.5 g mol^{-1}

(d) M (chlorine molecules) = 71 g mol^{-1}

The mass of substance (in grams), and the molar mass (g mol^{-1}) can be linked mathematically to find the number of moles of substance:

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

Examples: Study the setting out of the solutions to these examples:

(a) Calculate the number of moles of magnesium atoms in 6.3g of magnesium.

Solution: $n(Mg) = \frac{m}{M} = \frac{6.3}{24} = 0.26 \text{ mol}$

(b) Calculate the mass of 0.15 mole of sodium atoms.

Solution: $m(Na) = n \times M = 0.15 \times 23 = 3.45g$

(c) If 276g of substance X is equal to 6 mole of substance, determine the molar mass of X.

Solution:

$$6 = \frac{276}{M}$$

Therefore : $M = 276/6 = 46gmol^{-1}$

Try the questions below:

Exercise 11 To 3 SF

1. What is the mass of:

   (a) 1.00 mol of calcium atoms

   (b) 5.00 mol of lead atoms

   (c) 2.00 mol of iron atoms

   (d) 0.0530 mol of chlorine atoms

   (e) 109 mol of lithium atoms

2. How many moles of substance are present in:

   (a) 27.0 g of aluminium

   (b) 10.5 g of magnesium

   (c) 68.4 g of silicon

   (d) 12.8 g of gold

   (e) 15.6 g of krypton

Answers:

1. (a) 40.1 g
   (b) 1.04×10^3
   (c) 112
   (d) 1.88 g
   (e) 756 g

2. (a) 1.00 mol
   (b) 0.432 mol
   (c) 2.43 mol
   (d) 0.0650 mol
   (e) 0.186 mol

Moles and Numbers of Particles

One mole of any element contains the same number of atoms (Avogadro's Number). You can easily use the mole concept in chemistry without knowing the actual value of Avogadro's Number but the value of the constant has now long been determined.

Avogadro's Number $N_A = 6.023 \times 10^{23}$

Some examples to indicate the enormous size of this number appear later in these notes. The relationship between a mole and 6.02×10^{23} atoms of the element

A mole of atoms of an element = 6.02×10^{23} atoms of the element

A mole of molecules = 6.02×10^{23} molecules

A mole of footballs = 6.02×10^{23} footballs

A mole of (some defined particle) = 6.02×10^{23} particles

Consider these examples

(a) Calculate how many magnesium atoms are present in 2.5 mole of magnesium.

Solution:

Number of Mg atoms $= 2.5 \times 6.02 \times 10^{23} = 1.5 \times 10^{24}$ atoms.

(b) How many mole of Cl_2 molecules contains 1.25×10^{23} Cl_2 molecules?

Solution:

Number of mole of Cl_2 =

$$n(Cl_2) = \frac{1.25 \times 10^{23}}{6.02 \times 10_{23}} = 0.208 \text{ mol}$$

In general:

$$n = \frac{\text{number of particles (atoms/molecules)}}{6.023 \times 10^{23}}$$

Now consider this harder example:

How many gold atoms are present in 25.0 g pure gold coin?

Solution: m(Au) = 25.0 g

M(Au) = 197 g mol^{-1}

Solution: $n(Au) = \frac{25.0 \text{ g}}{197}$

= 0.127 mol $\times 6.023 \times 10^{23}$

= 7.65×10^{22} atoms.