THE MOLE

When chemists manufacture a substance they need to be able to calculate the amounts of reactants and products involved.

When we refer to amount we mean **the number of particles in a substance** (particles could be atoms, molecules, ions or electrons).

The amount of substance is measured in **MOLES**.

The mole can be thought of as a counting unit used by chemists. You will have come across some other counting units such as:

Pair = 2 things/entities
Dozen = things/ entities
Score = things/ entities
Gross = things/ entities
Mole = things/ entities

Definition:

1 mole is the amount of substance which contains as many particles as there are atoms in exactly 12g of carbon-12.

1 mole of any substance **contains 6.022 x 10^{23} particles**.
This number is called the **Avogadro Number** or **Avogadro Constant**. It has the symbol **L**, and units, **mol^{-1}**.

Even though a mole of any substance has the **same number of particles** as a mole of another substance, since atoms have different masses a mole of any one substance has a **different mass** to a mole of another substance.

Weighing out the A_r of an element in grams gives 1 mole of atoms.
Similarly, the M_r of a compound in grams gives 1 mole of entities.

So, 12g of C contains 6.022x10^{23} atoms of C (1 mol)
63.5g of Cu contains 6.022x10^{23} atoms of Cu (1 mol)
14g of N contains 6.022x10^{23} atoms of N (1 mol)
28g of N_2 contains 6.022x10^{23} molecules of N_2 (1 mol)

Exercise

Give the mass of:

(i) 1 mol S atoms

(ii) 1 mol Cl_2 molecules

(iii) 1 mol Fe atoms

Molar Mass

This is **the mass of 1 mole of a substance**. It has the symbol **M**, units **g mol^{-1}**.

It is used with elements, molecules and ionic compounds.

It is equal to the relative mass (A_r or M_r) expressed in grams.

So, the molar mass of water, H_2O is 2 x 1 + 16 = 18 g mol^{-1}.
This means 1 mole of water has a mass of 18 grams.

Chemists use moles to measure out reactants, or calculate the mass of product of a reaction.

The number of moles of a substance in a given mass of substance can be calculated if the chemical formula is known.

For **pure solid and liquid** elements and compounds the formula below is used:

$$\textbf{number of moles} = \frac{\textbf{mass/g}}{\textbf{molar mass/gmol}^{-1}}$$

Worked Examples

1. How many moles of Ca are there in 120g of Ca?

   A_r Ca = 40, therefore M Ca = 40gmol^{-1}

   $$\text{number of moles} = \frac{120\text{g}}{40\text{gmol}^{-1}} = 3.0 \text{ mol}$$

2. What mass of NaCl contains 10 moles of NaCl?

   To calculate a mass we need to rearrange the formula above.

   mass = number of moles x molar mass

   M_r NaCl = 23 + 35.5 = 58.5, therefore M NaCl = 58.5 gmol^{-1}

   mass = 10 mol x 58.5 gmol^{-1} = 585g

Questions

1. How many moles of each substance are contained in the following?

   (i) 69g Pb

   (ii) 70g Fe

   (iii) 5.30g Na_2CO_3

2. Calculate the mass of:

   (i) 0.013 mol Cl

   (ii) 3.00 mol Mg

   (iii) 2.00 mol SO_3

Exercise Complete the following table

Compound	Formula	molar mass /g mol^{-1}	Number of moles	Mass of compound /g
Water	H_2O	18	1	18 g
Ammonia	NH_3		1	
Carbon dioxide			0.5	
Methane	CH_4			64 g
Methanol	CH_3OH			16g
Hydrogen bromide	HBr			161.8g
Ethanol	C_2H_5OH		1.5	