# Masses and Moles

## Formula masses (Ar and Mr)

The $A_r$ is the **relative atomic mass** in the periodic table. The $A_r$ values of the atoms in a formula are added to get the **formula mass** or $M_r$ (sometimes called molecular mass)

$$H_2SO_4 = 1\times2 + 32 + 16\times4 = 98$$
$$Mg(NO_3)_2 = 24 + (14 + 3\times16)\times2 = 148$$

## Percentage Calculations

If you need to find the percentage of an element in a compound, you use the formula:

$$\text{Percentage} = \frac{\text{Ar x No of atoms}}{\text{Mr of compound}} \times 100$$

**e.g.**

Find the percentage of nitrogen in ammonium nitrate ($NH_4NO_3$)

Mr of N = 15

No of N atoms = 2

Mr of ammonium nitrate = 14 + 4 x 1+ 14 + 3 x 16 = 80

Percentage of nitrogen = $\frac{2\times14}{80} \times 100 = 35\%$

## Empirical Formulae

- This is the formula which shows the lowest whole number ratio of the atoms
- e.g. Molecular formula = $C_2H_4$, Empirical Formula = $CH_2$
- To calculate an empirical formula
- Find the mass (or %) of each element present
- Divide each of these masses by the relative mass of that element
- Divide each number obtained in stage 2 by the smallest of those numbers.
- This should give whole numbers which can be used in the empirical formula.

# Masses and Moles

20g of a compound of Silicon with hydrogen contains 17.5g of silicon. Find the empirical formula.

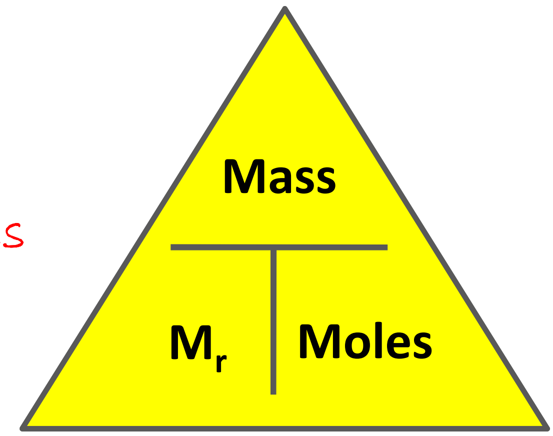
| Element | Si | H |
|---|---|---|
| Mass of element present | 17.5 | 20-17.5 = 2.5 |
| Relative Mass (Ar) | 28 | 1 |
| Mass ÷ Ar | 17.5÷28 = **0.625** | 2.5÷1 = **2.5** |
| Divide through by smallest. | 0.625 ÷ 0,625 = **1** | 2.5 ÷ 0.625 = **4** |
| Whole Number Ratio | **1** | **4** |
| Empirical Formula | $\mathbf{SiH_4}$ | |

## Equation Calculations

In these, you will always be given the mass of one substance and be asked to find the mass of another substance

MOLES; MOLES; MASS !!

Moles of the one you know
Moles of the one you don't
Now work out the unknown mass

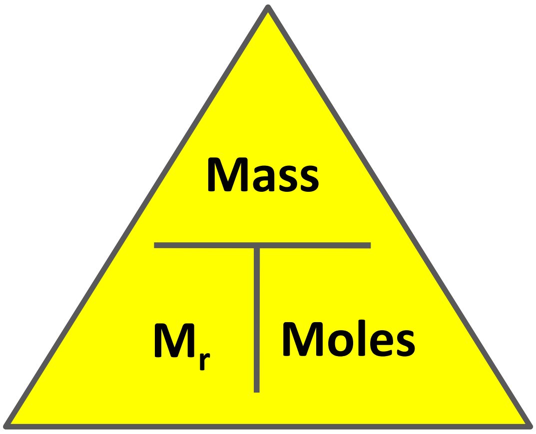


# Masses and Moles

What mass of carbon dioxide is obtained by burning 3g of $C_2H_6$?

$2C_2H_6 + 7O_2 = 4CO_2 + 6H_2O$

$M_r$: $C_2H_6 = 30$, $CO_2 = 44$




Moles of $C_2H_6 = \frac{\text{Mass}}{M_r} = \frac{3}{30} =$ **0.1**

Moles of $CO_2$ = Moles of $C_2H_6 \times 2 =$ **0.2**

Mass of $CO_2 = M_r \times$ Moles $= 44 \times 0.2 =$ **<u>8.8g</u>**

## <u>Atom Economy</u>

This is given as $\frac{\text{Formula Mass of all molecules of Useful Product}}{\text{Formula Mass of all molecules of Reactants}} \times 100$

Eg.
Atom economy for making iron from the equation

$Fe_2O_3 + 3CO = 2Fe + 3CO_2$

(Mr : $Fe_2O_3$ =160, CO = 28, Fe = 56, $CO_2$ =44)

Mass of useful product (iron atoms) = 2x56 =112
Mass of all reactants = 160 + (3x28) = 244

Atom economy $= \frac{112}{244} \times 100 =$ **<u>45.9%</u>**

# Chromatography and GC-MS

Paper chromatography is a form of separation that allows analysis of food additives or dyes in pens.

Instrumental methods:

- Great for analysis of small amounts
- Rapid
- Sensitive
- Accurate

**G**as **C**hromatography linked to **M**ass **S**pectroscopy (GC-MS) is an example of an instrumental method

Gas chromatography allows the separation of a mixture of compounds

The time taken for a substance to travel through the column helps to identify the substance

The mass spectrometer attached to the gas chromatography column allows the mass of the substance to be observed as it leaves the column, which also helps to identify the substance

The mass spectrometer can also give the relative molecular mass (Mr) of each substance separated – this is seen at the molecular ion peak.