Calculations

MEASUREMENT OF MOLAR QUANTITIES

In the laboratory moles can conveniently be measured using either mass or volume depending on the substances involved.

SOLIDS

Normally measured by weighing to obtain the mass.

1.000 kg = 1000 g

When weighing a substance the mass should be recorded to show the accuracy of the balance. For example, exactly 16 g of a substance would be recorded as 16.00 g on a balance weighing to + or – 0.01 g but as 16.000 g on a balance weighing to + or – 0.001 g.

SOLUTIONS

Volume is usually used for solutions.

1.000 litre = 1.000 dm^3 = 1000 cm^3

Concentration is the amount of solute (dissolved substance) in a known volume of solution (solute plus solvent). It is expressed either in g dm^{-3} or more usually in mol dm^{-3}. A 1.00 mol dm^{-3} solution of sodium hydroxide contains 40.00 g of sodium hydroxide in one litre of solution. A 25.0 cm^3 sample of this solution contains

$1.00 \times \frac{25.0}{1000} = 2.50 \times 10^{-2}$ mol of NaOH

LIQUIDS

Pure liquids may be weighed or the volume recorded.

The density of the liquid = $\frac{\text{mass}}{\text{volume}}$ and is usually expressed in g cm^{-3}.

GASES

Mass or volume may be used for gases. Avogadro's Law states that equal volumes of different gases at the same temperature and pressure contain the same number of moles. From this it follows that if the temperature and pressure are specified one mole of any gas will occupy the same volume. This is known as the **molar volume of a gas** and is equal to 22.4 dm^3 at 273 K and 1 atmosphere pressure. This is sometimes quoted as 24.0 dm^3 under standard conditions of temperature and pressure (298 K, 1atm).

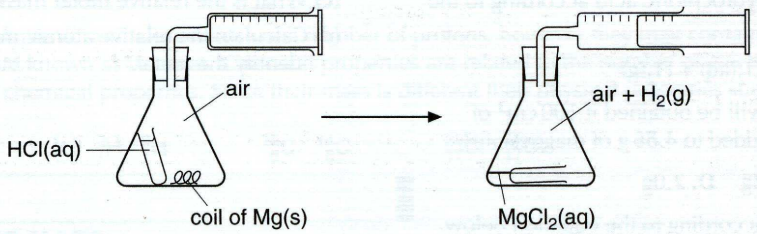
CALCULATIONS FROM EQUATIONS

Work methodically.

Step 1. Write down the correct formulas for all the reactants and products.
Step 2. Balance the equation to obtain the correct stoichiometry of the reaction.
Step 3. If the amounts of all reactants are known work out which are in **excess** and which one is the limiting reagent. By knowing the **limiting reagent** the maximum **yield** of any of the products can be determined.
Step 4. Work out the number of moles of the substance required.
Step 5. Convert the number of moles into the mass or volume.
Step 6. Express the answer to the correct number of significant figures and include the appropriate units.

WORKED EXAMPLE

Calculate the volume of hydrogen gas evolved at 273 K and 1 atm pressure when 0.623 g of magnesium reacts with 27.3 cm^3 of 1.25 mol dm^{-3} hydrochloric acid.



Equation: $Mg(s) + 2HCl(aq) \rightarrow H_2(g) + MgCl_2(aq)$

A_r for Mg = 24.31. Amount of Mg present = $\frac{0.623}{24.31} = 2.56 \times 10^{-2}$ mol

Amount of HCl present = $1.25 \times \frac{27.3}{1000} = 3.41 \times 10^{-2}$ mol

From the equation $2 \times 2.56 \times 10^{-2} = 5.12 \times 10^{-2}$ mol of HCl would be required to react with all of the magnesium.

Therefore the magnesium is in excess and the limiting reagent is the hydrochloric acid.

The maximum amount of hydrogen produced = $\frac{3.41 \times 10^{-2}}{2} = 1.705 \times 10^{-2}$ mol

Volume of hydrogen at 273 K, 1 atm = $1.705 \times 10^{-2} \times 22.4 = 0.382$ dm^3 (or 382 cm^3)