GCSE C3 – Quantitative Chemistry

science chemistry

1) Conservation of mass – No atoms are lost or made during a chemical reaction so the mass of the products is equal to the mass of the reactants.
If an element is heated in the air, the mass appears to increase due to it reacting with oxygen.
In thermal decomposition reactions of metal carbonates the mass appears to decrease as one of the products is a gas and escapes.
e.g.
calcium carbonate → calcium oxide + carbon dioxide

2) Relative Atomic Mass (Ar)
The relative atomic mass of an element (Ar) is the average mass of the isotopes of that element.

3) Relative Formula Mass (Mr)
The relative formula mass (Mr) of a compound is the sum of the relative atomic masses of the atoms in the chemical formula.
(e.g. Mr of NaOH = 23 + 16 + 1 = 40)

4) Isotopes – Elements **with the same number of protons but different number of neutrons** (so they will have different relative masses).

5) Percentage by mass of an element

$$\% \text{ Mass} = \frac{Total\ relative\ mass\ of\ the\ element}{Relative\ mass\ of\ whole\ compound}\ x\ 100$$

6) The mole (HT only)
A mole is an amount of substance. 1mol of any substance will contain the same number of particles (6.02×10^{23}).
This is known as the Avogadro constant.
e.g. 1 mol of H_2O will contain 6.02×10^{23} molecules.

The relative mass of any substance, in grams, is equivalent to 1mol of that substance.

7) Calculating moles (HT only)

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

n = no. of moles (mols)

m = mass (grams)

Mr = Relative atomic mass

8) Reacting Masses

Mg + 2HCl → $MgCl_2$ + H_2

If you have a 60g of Mg, what mass of HCl do you need to convert it to $MgCl_2$?

A_r : Mg =24 so mass of 1 mole of Mg = 24g
M_r : HCl (1 + 35.5) so mass of 1 mole of HCl = 36.5g

So 60g of Mg is 60/24 = 2.5 moles

Balanced symbol equation tells us that for every one mole of Mg, you need two moles of HCl to react with it.

So you need 2.5x2 = 5 moles of HCl

You will need 5 x 36.5g of HCl= 182.5g

Alternatively can be set out in a table like this

Ratio	Mg 1	+ 2HCl 2
Mass	60	182.5
Mr	24	36.5
Moles	2.5	5

9) Limiting reactants
The reactant that is used up first is called the limiting reactant. The other reactant is in excess.

This limits the amount of product that is made and ensures that one of the reactants is completely used up.

10) Concentration of solutions
Worked out by knowing the mass of solid dissolved and the volume of liquid it's dissolved in.

$$\text{conc} = \frac{mass\ (g)}{volume\ (cm^3)} x1000 \quad \text{or} \quad \text{conc} = \frac{mass\ (g)}{volume\ (dm^3)}$$

$1dm^3 = 1000cm^3$

11) Using moles to balance equations (HT only)
Convert the masses in grams to amounts in moles and convert the number of moles to simple whole number ratios.
e.g. 8.5g of sodium nitrate is heated in a test tube, it forms 6.9g of sodium nitrite and the remainder is oxygen. Balance the equation

	$NaNO_3$ →	$NaNO_2$ +	O_2
Work out mols	8.5/85 =0.1	6.9/69 = 0.1	1.6/32 = 0.05

then divide each number by smallest

Equation is **2**$NaNO_3$ → **2**$NaNO_2$ + O_2

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12) Yield

The amount of a product obtained in a reaction

13) Percentage yield

$$\% \text{ Yield} = \frac{actual\ mass\ of\ product}{\text{maximum}\ theoretical\ mass} \times 100$$

14) Factors affecting percentage yield

- Reaction may be reversible
- Unwanted / competing reactions
- Loss of product in handling / separation
- Reactants may not be pure.

15) Atom economy

A measure of the amount of starting materials that end up as useful products:

$$\% \text{ atom economy} = \frac{Mr\ of\ useful\ products}{\text{Mr of all the reactants}} \times 100$$

16) Calculating moles for solutions (HT only)

$$n = \frac{CV}{1000}$$

n= no. of moles (mols)

C = concentration (mol/dm^3)

V = Volume **(cm^3)**

17) Volumes of gases (HT only)

- 1mol of any gas at room temperature & pressure has a volume of $24dm^3$ ($24000cm^3$)

So if you have 0.5mol of O_2 gas then it would have a volume of $12dm^3$

18) Titrations

- The volumes of acid and alkali solutions that react with each other can be measured by titration using a suitable indicator.
- If the concentration of one of the reactants is known, the results of a titration can be used to find the concentration of the other reactant.

- Fill the burette with acid (bottom of meniscus level with mark).
- Measure out known volume of alkali using a pipette.
- The pipette is filled with a pipette filler and then emptied under gravity into a conical flask.
- 2-3 drops of a suitable indicator (e.g. phenolphthalein) is added which will go pink in alkali and then colourless in acid.
- Place conical flask on a white tile so the colour change is clearer to see.
- Add acid slowly from the burette to the alkali until the last drop of pink disappears. This is called the end-point.
- The reading on the burette is taken at eye level (to reduce any errors).
- Repeat the experiment until you obtain **concordant** results (within ± $0.1cm^3$ of each other)

- Looking at the results in the table below, you would use your two concordant results which would be from experiments 2 & 3. The average would be $21.33cm^3$.

Titration	1	2	3
Initial burette reading (cm^3)	0.00	0.00	0.30
Final burette reading (cm^3)	22.50	21.30	21.65
Vol of acid added (cm^3)	22.50	21.30	21.35

19) Titration calculations (HT only)

What is the concentration of hydrochloric acid if $21.33cm^3$ of acid were needed to neutralise $25cm^3$ of $0.5mol/dm^3$ solution of sodium hydroxide?

e.g.

$HCl + NaOH \rightarrow NaCl + H_2O$

From the equation 1mol HCl needs 1mol of HCl

Using $n = \frac{CV}{1000}$ work out moles of NaOH

Moles NaOH = $\frac{0.5 \times 25}{1000}$ = 0.0125

So from the equation the same amount of HCl would be needed so we have 0.0125mols of HCl.

Rearrange the equation to get the concentration:

Conc = $\frac{1000 \times n}{V\ (acid)} = \frac{1000 \times 0.0125}{21.33}$ = $0.59mol/dm^3$

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