C3 Knowledge Organiser – Quantitative Chemistry COMBINED

Conservation of Mass (1)

- ***No atoms are lost or made during a chemical reaction:*** **Mass of the products equals the mass of the reactants.**
- **Mass changes when a reactant or product is a gas:**

Mass appears to increase during a reaction	*One of the reactants is a gas*	Magnesium + oxygen → magnesium oxide
Mass appears to decrease during a reaction	*One of the products is a gas and has escaped*	Calcium carbonate → carbon dioxide + calcium oxide

Relative Formula Mass, M_r (2)

The sum of the relative atomic masses of the atoms in the numbers shown in the formula

$2Mg + O2 \rightarrow 2MgO$
48g + 32g = 80g
80g = 80g

Balancing symbol equations: *Represent chemical reactions and have the same number of atoms of each element on both sides of the equation*

$H_2 + Cl_2 \rightarrow 2HCl$

Subscript — Normal script

Subscript numbers show the number of atoms of the element to its left.

Normal script numbers show the number of molecules.

Uncertainty (3)

Whenever a measurement is taken, there is always some uncertainty about the result obtained.

1.Calculate the mean
2.Calculate the range of the results
3.Estimate of uncertainty in mean would be half the range.

Does the mean value fall within the range of uncertainty of the result?

Moles HT (4)

Chemical amounts are measured in moles (mol).

Mass of one mole of a substance in grams = relative formula mass.
e.g. One mole of H_2O = 18g (1 + 1+ 16), One mole of Mg = 24g

Avogadro's Constant: 6.02 x 10^{23}

'One mole of any substance will contain the same number of particles, atoms, molecules or ions.'

6.02 x 10^{23} per mole:
One mole of H_2O will contain 6.02 x 10^{23} molecules of water
One mole of NaCl will contain 6.02 x 10^{23} Na^+ ions.

Calculating number of moles: *Number of moles =* $\frac{\text{mass (g)}}{A_r}$ *or* $\frac{\text{mass (g)}}{M_r}$

Amounts of substances in equations HT (5)

Chemical reactions show the number of moles reacting and the number of moles made.
e.g.
$Mg + 2HCl \rightarrow MgCl_2 + H_2$
One mole of magnesium reacts with two moles of hydrochloric acid to make one mole of magnesium chloride and one mole of hydrogen

Calculating amounts of substances in equations HT (6)

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

Limiting Reactants HT (7)

In a reaction with 2 reactants, it is common to use an **excess** of one reactant to make sure that **all** of the other reactant is used up. This reactant that is completely used up is called the **limiting reactant**, as it **limits the amount of the products** that can be made.
You can **calculate the moles or mass of the products formed**.

Concentration HT (8)

- The concentration of a solution (aq) can be measured in **g/dm³** (mass/volume)
Concentration = mass ÷ volume
- The concentration of the **solution** depends on the mass of the **solute** and the volume of the **solvent**. Increasing mass increases concentration, increasing volume decreases concentration.

Using Moles to balance equations HT (9)

Remember: moles = mass ÷ M_r
- If you calculate the number of moles of each reactant and product in a reaction it will give you the **ratio of reactants and products**, so you can write the **balanced equation**.
e.g 48g of Mg reacts with 32g of O_2 to produce 80g of MgO
so: 48÷24 = **2mol of Mg**; 32÷(2x16)= **1mol of O_2**; 80÷(24+16)= **2mol of MgO**
this is a **ratio** of **2:1:2** (Mg: O_2: MgO):
2Mg + O_2 —> **2**MgO (**Balanced**)

C3 Knowledge Organiser – Quantitative Chemistry CHEM ONLY

Atom Economy 1

A measure of the amount of starting materials that end up as useful product.

$$\text{Atom economy} = \frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula mass of all reactants from equation}} \times 100$$

High atom economy is important for sustainable development and economic reasons.

Calculate the atom economy for making hydrogen by reacting zinc with hydrochloric acid:

$Zn + 2HCl \rightarrow ZnCl2 + H2$

Mr of H2 = 1 + 1 = 2

Mr of Zn+ 2HCl= 65 + 1 + 1 + 35.5 + 35.5 =138

Atom economy =2/138 ×100

=2/138×100 = 1.45%

This method is unlikely to be chosen as it has a low atom economy.

Percentage Yield 2

$$\text{\% Yield} = \frac{\text{Mass of product made}}{\text{Max. theoretical mass}} \times 100$$

Percentage yield is comparing the amount of product obtained as a percentage of the maximum theoretical amount.

It is not always possible to obtain the calculated amount of a product because:

-The reaction may not go to completion because it is reversible.

-Some of the product may be lost when it is separated from the reaction mixture.

-Some of the reactants may react in ways different to the expected reaction.

HT ONLY:

200g of calcium carbonate is heated. It decomposes to make calcium oxide and carbon dioxide. *Calculate the theoretical mass of calcium oxide made:*

$CaCO_3 \rightarrow CaO + CO_2$

M_r of $CaCO_3$ = 40 + 12 + (16x3) = 100

M_r of CaO = 40 + 16 = 56

100g of $CaCO_3$ would make 56 g of CaO

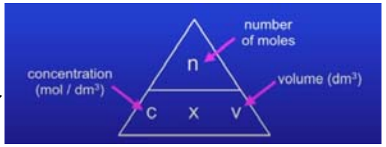
So 200g would make 112g

Using Concentration of solutions HT 3

Concentration of a solution is the amount of solute per volume of solution.

$$\text{Concentration (mol/dm}^3\text{)} = \frac{\text{amount (mol)}}{\text{volume (dm}^3\text{)}}$$

If the volumes of two solutions that react completely are known and the concentrations of one solution is known, the concentration of the other solution can be calculated. E.g.



A solution of sodium nitrate has a concentration of 0.8 mol/dm³. Calculate the mass of sodium nitrate in 0.5dm³. Mr $NaNO_3$ = 85.

1. Calculate the moles using the equation:
number of moles = concentration (mol/dm³) x volume (dm³).
2. Calculate mass using the equation:
mass (g) = number of moles x M_r

1) Number of moles = 0.8 x 0.5 = **0.4 moles**
2) Mass = 0.4 x 85 = **<u>34g of sodium nitrate in the solution</u>**

Use of amount of substance in relation to volumes of gases HT 4

Equal amounts of moles or gases occupy the same volume under the same conditions of temperature and pressure.

Molar volume of gas:

'The volume of one mole of any gas at room temperature and pressure (20°C and 1 atmospheric pressure) is 24 dm³'

$$\text{No. of moles of gas} = \frac{\text{vol of gas (dm}^3\text{)}}{24\text{dm}^3}$$

What is the volume of 11.6 g of butane (C_4H_{10}) gas at RTP?	6g of a hydrocarbon gas had a volume of 4.8 dm³. Calculate its molecular mass.
M_r : (4 x 12) + (10 x 1) = 58	1 mole = 24 dm³, so 4.8/24 = 0.2 mol
11.6/58 = 0.20 mol	M_r = 6 / 0.2 = 30
Volume = 0.20 x 24 = 4.8 dm³	If 6g = 0.2 mol, 1 mol equals 30 g