Subject: Science (Chemistry)	Topic: Quantitative Chemistry	Year Group: 11

Calculation Types I

1	Relative atomic mass (A_r)	$A_r = \frac{\text{sum of (isotope abundance x isotope mass no.)}}{\text{sum of abundances of all the isotopes}}$ Example: ^{35}Cl 75% abundance & ^{37}Cl 25% abundance (35 x 75) + (37 x 25) ÷ 100 = **35.5 A_r of Chlorine**
2	Relative formula or molecular mass (M_r)	Sum of the relative atomic masses of all the atoms shown in the formula Example $MgSO_4$ contains: 1 x Mg: 1 x 24 = 24 1 x S: 1 x 32 = 32 4 x O: 4 x 16 = 64 So the relative formula mass = 24 + 32 + 64 = **120**
3	% mass of an element in a compound	$A_r \times \frac{\text{No. of atoms of that element}}{M_r \text{ of the compound}} \times 100$ Example: Find the % mass of O in Na_2O A_r of Na is 23; A_r of O is 16 1 x O atom so 1 x16 = 16 M_r of Na_2O so (2 x 23) + (1 x 16) = 62 % mass = A_r ÷ M_r x 100 so 16 ÷ 62 x 100 = **26%**
4	The mole & A_r / M_r	The mass of one mole of a substance in grams is equal to its relative atomic mass or relative formula mass. So 32 g of sulphur is one mole of Sulphur $\text{Number of moles} = \frac{\text{mass in g (of an element or compound)}}{M_r \text{ (of the element or compound)}}$ Example: how many moles is 48 g of sulfur? A_r of S is 32 So mass in g divided by A_r is 48 ÷ 32 = **1.5 moles**

Calculations Types II

5	**HT Only**: The mole & Avogadro's Constant	A mole of a substance **ALWAYS** contains the same number of molecules/ions/particles/atoms – this is called Avogadro's Constant: 1 mole = 6.02×10^{23} $\text{number of moles} = \frac{\text{number of particles}}{6.02 \times 10^{23}}$ Example: How many atoms are in 11.5 g of sodium? • Calculate number of moles first = 11.5 ÷ 23 = 0.5 moles • No. of moles (0.5) x 6.02×10^{23} = **3.01×10^{23} atoms**
6	Concentration	Concentration is the amount of substance in a specific volume of a solvent. It can be expressed as mass (in g) per unit volume, g/dm^3 or $g\ dm^{-3}$ ***or*** moles in a specific volume of solvent, mol/dm^3 or $mol\ dm^{-3}$ (**Chemistry only**) Concentration (g/dm^3) = $\frac{\text{mass (g)}}{\text{volume } (dm^3)}$ Examples: What volume of water do I need to add to 25 g of common salt to get a concentration 0.65 g / dm^3? Volume = mass ÷ concentration so 25 ÷ 0.65 = **38.5 dm^3** **Chemistry Only**: Concentration (mol/dm^3) = $\frac{\text{number of moles}}{\text{volume } (dm^3)}$ Calculate the number of moles in a 0.55 dm^3 solution with a concentration of 0.35 mol/dm^3 No. of moles = concentration x volume 0.35 x 0.55 = **0.19 moles**

Key Vocabulary

1	Law of Conservation of Mass	No atoms can be created or destroyed in a chemical reaction so the total mass of reactants must equal the total mass of the products
2	Relative atomic mass (A_r)	Average mass of an element taking into account the mass & amount of each isotope it contains on a scale where the mass of a ^{12}C atom is 12
3	Relative formula (or molecular) mass (M_r)	The sum of the relative atomic masses of all the atoms shown in the formula
4	**HT only:** Mole	Measurement of the amount of substance
5	**HT only:** Avogadro's constant	The number of atoms, molecules or ions in one mole of a given substance (6.02×10^{23}). *One mole of any substance contains the same number of particles as the number of atoms in one mole of carbon 12.*
6	Uncertainty	The range of values within which the true value is expected to lie. So for example a volume of gas collected would be 10cm^3 plus or minus 1cm^3 so expressed as 10cm^3 +/- 1cm^3 so true value is anywhere between 9-11cm^3

Beckfoot

Subject: Science (Chemistry)	Topic: Quantitative Chemistry	Year Group: 11

enjoy learn succeed

Calculations Types III

5	**Chemistry Only** Percentage yield (%)	The amount of product formed in a reaction compared to the maximum theoretical mass that could be produced as a percentage $\text{percentage yield} = \frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100$ Example: 25g of salt was produced in a reaction but the expected mass was 80g. What is the % yield? 25 ÷ 80 x 100 = **31.3%**
6	**Chemistry Only** Atom economy	A way of measuring what percentage of the mass of all the atoms in the reactants ends up in the desired product $\text{atom economy} = \frac{\text{relative formula mass of desired product}}{\text{relative formula mass of all reactants}} \times 100$ Example: The reaction below is used to produce calcium oxide (CaO). Calculate the atom economy of the reaction: $CaCO_3 \rightarrow CaO + CO_2$ M_r of CaO = 40 + 16 = 56 (desired product) M_r of $CaCO_3$ = 100 (Formula mass of all reactants) Therefore, 56 ÷ 100 x 100 = **56%**
	Chemistry Only Gas volumes	1 mole of a gas at room temperature (20^{o}C) and pressure (1 atm) occupies a volume of 24dm^3 $\underbrace{\text{Volume of gas}}_{\text{in dm}^3} = \frac{\overbrace{\text{Mass of gas}}^{\text{in g}}}{M_r \text{ of gas}} \times 24$ Example: What volume will 88g of CO_2 gas occupy at room temperature & pressure? Volume = mass ÷ M_r x 24 so 88 ÷ 44 = 2 x 24 = **48 dm^3**

Mass Conservation in Chemical Reactions

1	The law of mass conservation in terms of a chemical reaction…	The total number of each type of atom in a chemical reaction is the same before and after the reaction
2	How can we show conservation of mass in a chemical equation?	The total M_r of all the reactants will be equal to the total M_r of all the products
3	Why might mass appear to go up in a reaction?	Due to one or more reactants being a gas found in air, that 'adds on' to the substance
4	Why might mass appear to go down?	One of the products is a gas that escapes

HT only: Reacting Mass Calculations: the steps

1	Example question	*What mass of calcium chloride ($CaCl_2$) is produced when 3.7g of calcium hydroxide ($Ca(OH)_2$) reacts with an excess of hydrochloric acid (HCl)?*
2	Write out the balanced equation & identify what we know & don't know	$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$ 3.7g ?
3	Work out the moles of what you know	$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$ Remember moles = mass ÷ Mr 3.7 ÷ 74 Mr of $Ca(OH)_2$ is 74 = 0.05 mol
4	Check ratio in the balanced equation	1 unit of $CaCl_2$ is formed from 1 unit of $Ca(OH)_2$ So whatever moles of what you have worked out ($Ca(OH)_2$) will make the same moles of what you need to work out (calcium chloride)
5	Calculate the number of moles of what you don't know	We will make 0.05 moles of $Ca(OH)_2$ as the ratio of both compounds in the equation is 1:1
6	Calculate the mass of what you don't know	So in the last step we are converting moles to a mass in grams Mass = M_r x Moles M_r of $CaCl_2$ is 111 111 x 0.05 = **5.6g**

Key Vocabulary

7	Thermal decomposition	Reaction where heat causes a substance to break down into simpler substances
8	**HT only**: Limiting reactant / reagent	The reactant in a reaction that determines the amount of products formed. Any other reagents are in excess & some of them will be left over, unreacted
9	**HT only**: Excess	When the amount of a reactant is greater than the amount that can react
10	**Chemistry Only:** Yield	The amount of product formed in a reaction
11	**Chemistry Only:** Titration	A technique used to find the concentration of a solution using a solution of known concentration
12	**Chemistry only:** Concordant	Two or more results from titration where the values are very close together (within 0.10cm^3)
13	**Chemistry only:** End point	The moment when the indicator changes colour in a titration showing that the moles of acid & alkali are equal