Chapter 2 Amount of substance – GCSE Assumed Knowledge

Learning Objectives	Keypoints
Use names and chemical symbols to write the formulae of elements and simple covalent compounds	Elements – the symbol is found in the periodic table. For most elements the formula is just the chemical symbol. Some elements are diatomic which means they are found as molecules containing two atoms of the same element. This means that the formula contains a subscript 2 e.g. N_2, O_2, H_2, Br_2, Cl_2, I_2, F_2. Simple covalent compounds show the number and type of each atom e.g. CH_4 contains one carbon and 4 hydrogens.
Use the formula of common ions to deduce the formulae of ionic compounds	Common ions are: Hydrogen H^+ , ammonium NH_4^+ , hydroxide OH^- , nitrate NO_3^- , carbonate CO_3^{2-} , sulfate SO_4^{2-}. Metals from groups 1,2 and 3 form positive ions with the same charge as the group number. Non-metals from groups 5,6 and 7 form negative ions with the same charge as 8 - the group number. Transition metals can have different charges - shown in their name by(I)=+1,(II)= +2,(III) = +3,(IV)=+4 and(V)=+5. Ionic compounds are neutral (have no overall charge). This means that there needs to be an equal number of positive and negative charges e.g. calcium is Ca^{2+}, hydroxide is OH^-. To be neutral we need to have $2OH^-$ ions i.e. $Ca(OH)_2$.
Recall and use the law of conservation of mass	Atoms cannot be created or destroyed in a chemical reaction. This means that the total mass of the reactants must equal the total mass of the products
Write and balance chemical equations	Since mass is always conserved in a chemical reaction, the number of each type of atom needs to be the same on both the left hand side and the right hand side of the equation
Use state symbols	(s) means solid, (l) means liquid, (g) means gas and (aq) means aqueous / dissolved in water
Explain the meanings of the terms 'mole' and 'avagadro constant'	A mole is a unit for the amount of a substance. A mole contains 6.02×10^{23} entities (either atoms, molecules or formula units). One mole of an element will have the same mass in g as its relative atomic mass. One mole of a compound will have the same mass in g as its relative formula mass
Calculate the mass of a mole of a substance	For a monoatomic element: Number of moles = (mass in g) ÷ relative atomic mass For a compound or molecule: Number of moles = (mass in g) ÷ relative formula mass
Use a balanced equation to calculate masses of reactants and products	The masses of all the reactants must add up to same as the masses of all the products.
Explain the effect of a limiting reactant	A limiting reactant is a reactant present in an amount less than that needed to react completely with the other reactant in a chemical reaction. This means that it is used up first. When all of the limiting reactant has been used up the reaction will stop. A reactant which is in excess is one that is present in an amount greater than that needed to react with the other reactant. Once the reaction has finished there will still be some of the reactant that was in excess left over.
Calculate the stoichiometry of an equation	The stoichiometry is the relative amounts of each substance involved in a chemical reaction. If you know the number of moles of the reactants and products that take part in the reaction then you can work out the stoichiometry of the balanced equation.
Calculate the theoretical yield of a product from a given mass of reactant.	The **limiting reactant** is the one that gets used up and stops the reaction from proceeding further. The other reactant is **in excess.** The **yield** of a product is the mass of that product made in a chemical reaction. The **theoretical yield** is the maximum amount you *could* make if everything went perfectly. The **theoretical yield** is calculated from the amount of **limiting reactant** used. The reactant in **excess** has no effect on the **theoretical yield**.
Calculate the percentage yield of a product	**Percentage yield** = (actual yield / theoretical yield) x 100 The **percentage yield** may be reduced if by-products are made, if the reaction is reversible or if mass is lost during the experiment for example on filter paper or if the reaction mixture is transferred from one container to another, some might remain in the original container. A high percentage yield is important because it reduces cost and doesn't waste starting materials.

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Define the atom economy of a reaction	The **atom economy** is a measure of how many atoms in the reactant are turned into useful products. A high **atom economy** is desirable as it reduces the production of unwanted products, it makes the process more sustainable and it maximises profit.
Calculate the atom economy of a reaction	**Atom economy** = (sum of the Mr of the desired product/sum of the Mr of all products) x 100
Explain why a particular reaction pathway is chosen to produce a specified product, using appropriate data	The factors that need to be considered when choosing the reaction pathway for making a particular substance are: Percentage yield Atom economy Whether the by-product is useful, or difficult to dispose of Rate of reaction Equilibrium position if the reaction is a reversible one
Calculate concentration of solution in mol/dm^3	Concentration in mol/dm^3 = amount of solute in moles / volume of solution in dm^3 To convert cm^3 to dm^3 divide by 1000 To convert dm^3 to cm^3 multiply by 1000
Explain the relationship between concentration of solution, mass of solute and volume of solution	Concentration in g/dm^3 = amount of solute in g / volume of solution in dm^3 To convert concentration from mol/dm^3 to g/dm^3 multiply the concentration by the Mr To convert concentration from g/dm^3 to mol/dm^3 divide the concentration by the Mr
Describe how to carry out an acid-alkali titration	A known volume of alkali is added to a conical flask using a pipette and pipette filler. A few drops of indicator such as phenolphthalein is added. Acid is then added from a burette. When the indicator changes colour (called the end-point) the alkali has been neutralised and the volume added is recorded. A conical flask is used rather than a beaker as it is easier to swirl without losing liquid via splashing. The acid is normally added to the burette as strong alkalis can react with the glass burette. A mixed indicator such as universal indicator is not used in a titration as it would give a gradual colour change, whereas a single indicator gives a sudden colour change. A pipette is used to add the alkali rather than a measuring cylinder as a pipette is more accurate. Results should be repeated until they are concordant (within 0.1ml of each other). To ensure titrations are repeatable, the flask should be swirled whilst the acid is added to ensure the reactants are mixed together. A rough titre should also be done first – this gives a rough idea of how much needs to be added so that the next titrations can be done more slowly near the end-point.
Carry out titration calculations involving concentrations and volumes	A titration will involve an acid solution and an alkali solution. You will normally know the volumes of both solutions but only the concentration of one of them. This will allow you to calculate the missing concentration. If the ratio of acid to alkali in the balanced equation is 1:1 then you can use $c_{acid} \times V_{acid} = c_{alkali} \times V_{alkali}$
Describe the relationship between molar amounts of gases and their volumes	One mole of gas occupies $24dm^3$ at room temperature and pressure
Calculate the volumes of gases involved in reactions using the molar gas volume	Amount in moles = volume in dm^3 / 24