The content on this sheet is assessed on paper 1 only.

Mass Calculations and Quantitative Analysis (Separate)

* Indicates that these are some examples only: you could be asked about any substance / reaction.

5.8—Concentration in mol dm^{-3} and g dm^{-3} (HT only)

Concentration is a measure of the quantity of solute which is dissolved in a solvent. It can be measured either in g dm^{-3} or mol dm^{-3}.

Mass concentration = $\frac{mass\ (g)}{volume\ (dm^3)}$

Molar concentration = $\frac{number\ of\ moles\ (mol)}{volume\ (dm^3)}$

You may be expected to convert between mass and moles. To do this, use the equation:

number of moles = $\frac{mass\ (g)}{relative\ mass\ (g\ mol^{-1})}$

You are also likely to need to convert between cm^3 and dm^3. To convert from cm^3 to dm^3, you simply divide by 1000.

5.9—CP5—Titration

Method:

1) Measure out a set volume of alkali using a pipette.
2) Add this to a conical flask.
3) Add a couple of drops of indicator (for example phenolphthalein or methyl orange).
4) Fill a burette with acid. Record the start volume.
5) Place the conical flask on a white tile.
6) Add acid to the alkali. Towards the end, add it dropwise.
7) When the indicator has changed colour permanently, stop adding acid. Record the final volume.
8) Repeat until you have concordant titres (results).
9) Repeat steps 1-8, using the same volume of acid, and no indicator.

Suggest a safety precaution that should be taken when carrying out a titration:

Ensure you wear safety glasses to protect the eyes.

Ensure any spillages on the skin are rinsed with plenty of water.

5.11—Calculating percentage yield

Percentage yield is a measure of how much product is made compared to the amount that should theoretically have been made.

The calculation is:

Percentage yield = $\frac{actual\ yield}{theoretical\ yield} \times 100$

The value for a percentage yield can **never** be more than 100 %.

5.10—Calculating unknown concentration/volume from a titration (HT only)*

The key formula here is:

number of moles = concentration (mol dm^{-3}) x volume (dm^3).

e.g. calculate the concentration of hydrochloric acid, when 25.20 cm^3 reacts with 20 cm^3 of 0.800 mol dm^{-3} sodium hydroxide solution

1) Set out a table (shown right)
2) Populate the table with the data you are given (there will be three data given, concentrations or volumes). Remember to convert volumes to dm^3.

	Acid	Alkali
n	4) 0.016	3) 0.016
C	5) 0.635	2) 0.800
V	2) 0.0252	2) 0.020

3) Calculate the number of moles of the substance you have a C and V for.
4) Use the balanced equation to identify the number of moles of substance you are finding the value for.
5) Calculate the missing value by rearranging n = CV:

C = n / V = 0.635 mol dm^{-3}.

5.12—Reasons why percentage yield will not be 100%

a) There may be incomplete reactions, so not all of the reactants are converted to products (especially in a reversible reaction).

B) There may be loss of substance during a reaction, for example when transferring a solid between containers.

C) There may be unwanted side reactions, meaning some of the expected product actually becomes a different chemical.

5.13—Atom economy

The atom economy is a measure of how much of the relative mass of the reactants is converted into a useful product.

By definition, the atom economy of a reaction with only one product is always 100%, as all of the reactants become the useful product.

5.14—Calculating atom economy

Atom economy = $\frac{Relative\ mass\ of\ useful\ products}{Relative\ mass\ of\ all\ products} \times 100$

The value for atom economy can **never** be more than 100%.

5.11 & 5.14—Practice calculations*

Calculate the atom economy & percentage yield for the following reaction to make hydrogen gas: $CH_4 + H_2O \longrightarrow 3\ H_2 + CO$. M_r: CH_4=16, H_2O=18, H_2=2, CO=28. The actual yield was 254 g and the theoretical yield was 320 g.

Percentage yield = $\frac{254}{320} \times 100 = 79.4$ %

Atom economy = $\frac{3 \times 2}{(3 \times 2) + 28} \times 100 = 17.6$ %

5.15—Explaining choice of reaction pathway (HT only)*

Methods of making ethanol

Method	% yield	Atom economy	Rate
Hydration of ethene	Very high	100	Quick
Fermentation of glucose	Low	51	Very slow

When selecting a reaction pathway, many factors need to be considered. As well as the above, the usefulness of side products should be considered, as well as position of equilibrium (for a reversible reaction).

•Briefly explain which method is best for making ethanol.

Either hydration of ethene, as it has a higher atom economy, yield and rate. (Although ethene is a product of crude oil, and is non-renewable).

Or fermentation of glucose as it has lower energy costs and the raw materials are from plants, which are renewable. (Although low rate, yield & atom economy)

5.16—Molar volume of a gas, a.k.a. Avogadro's law (HT only)

One mole of **any** gas, at room temperature and pressure, will have a volume of 24 dm^3 (which is 24 000 cm^3).

5.17—Using molar volume of a gas (HT only)*

These calculations involve using molar volume, reacting masses and balanced equations to find a volume of gas produced in a reaction. e.g. 1.95 g of potassium reacts completely with water according to the equation:

$2\ K + H_2O \longrightarrow 2\ KOH + H_2$. Calculate the volume of H_2 formed in dm^3.

A_r: K = 39, H = 1, O = 16.

1) Calculate number of moles of potassium:

number of moles = $\frac{mass\ (g)}{relative\ mass\ (g\ mol^{-1})} = \frac{1.95}{39} = 0.05$ moles

2) From the balanced equation, 2 moles of potassium react to form 1 mole of hydrogen, therefore the number of moles of H_2 = answer from step 1 divided by 2 = 0.025 moles.

3) Multiply the number of moles calculated in step 2 by the molar volume of a gas (24 dm^3): 0.025 x 24 dm^3 = 0.6 dm^3.

5.18—Calculating volumes of gases involved in reactions (HT only)*

In these questions, you will need to use balanced equations, and the molar gas volume, to identify the volume of gases involved in reactions.

E.g. calculate the volume of ammonia that could (theoretically) be formed from 1250 cm^3 of nitrogen and an **excess** of hydrogen.

$N_2 + 3\ H_2 \longrightarrow 2\ NH_3$

1) Balance the equation (in an exam, this may be done for you).
2) Identify the ratio of the gases in the question. In this example, the ratio of nitrogen:ammonia is 1:2.
3) Convert the known volume to the unknown volume by multiplying or dividing by the appropriate value. In this case, multiply by 2.
4) Write your final answer. In this case, it is 2 500 cm^3.