OCR B GCSE Chemistry

Topic 5: Chemical analysis

How are the amounts of substances in reactions calculated?

Notes

1. Recall and use the law of conservation of mass

- Law of conservation of mass: no atoms are lost or made during a chemical reaction so the mass of the products = mass of the reactants

2. Explain any observed changes in mass in non-enclosed systems during a chemical reaction and explain them using the particle model

- If a reaction appears to involve a change in mass – check to see if this is due to a reactant or a product as a gas and its mass has not been taken into account
    - if a reactant is a gas e.g. oxygen reacting with metals to form a metal oxide, the mass of the product would be greater
    - if a product is a gas e.g. hydrogen is given off, the mass of the products would be less than that of the reactants

3. Calculate relative formula masses of species separately and in a balanced chemical equation

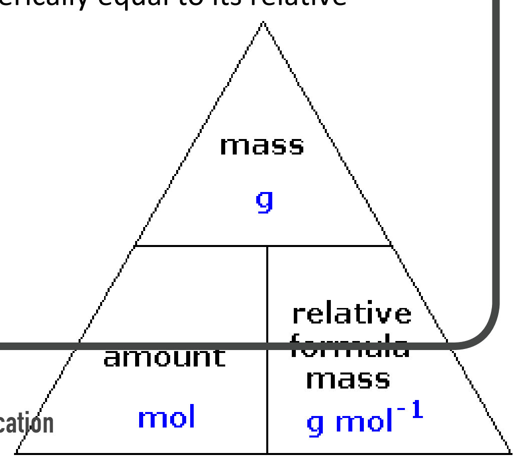
- Relative formula mass (Mr) of a compound: sum of the relative atomic masses of the atoms in the numbers shown in the formula (remember you could have more than 1 atom of a certain element in a compound e.g. in $CaCl_2$,there are 2 atoms of chlorine so you need to add on 35.5 x2)
- In a balanced chemical equation:
  sum of Mr of reactants in quantities shown = sum of Mr of products in quantities shown

4. (HT only) recall and use the definitions of the Avogadro constant (in standard form) and of the mole

- Chemical amounts are measured in moles. The symbol for the unit mole is mol. / Mole = amount of substance
- The number of atoms, molecules or ions in a mole of a given substance is the Avogadro constant: 6.02×10^{23} per mole.

5. (HT only) explain how the mass of a given substance is related to the amount of that substance in moles and vice versa and use the relationship: number of moles = mass of substance (g) ÷ relative formula mass (g)

- The mass of one mole of a substance in grams is numerically equal to its relative formula mass.
- For example, the Ar of Iron is 56, so one mole of iron weighs 56g.
- The Mr of nitrogen gas (N_2) is 28 (2 x 14), so one mole is 28g.



- One mole of a substance contains the same number of the stated particles, atoms, molecules or ions as one mole of any other substance
- You can convert between moles and grams by using this triangle:
  - E.g how many moles are there in 42g of carbon?
    - Moles = Mass / Mr = 42/12 = 3.5 moles

6. (HT only) deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant

- Deduce the stoichiometry of an equation from the masses of reactants and products
  - Find moles of each reactant and product using moles = mass / molar mass
  - Compare ratios of moles to find the stoichiometry (e.g. the big number in front of a compound in a chemical equation)
    - For example, $Mg + 2HCl \rightarrow MgCl_2 + H_2$ (results of finding moles would show a ratio of 1 mole Mg : 2 moles HCl : 1 mole $MgCl_2$: 1 mole H_2)
- Explain the effect of a limiting quantity of a reactant
  - In a chemical reaction with 2 reactants you will often use one in excess to ensure that all of the other reactant is used
    - The reactant that is used up / not in excess is called the limiting reactant since it limits the amount of products
  - If a limiting reactant is used, there will be less product since there are less reactants, this means a smaller mass of product or a decrease in moles of product – think about balancing the moles: less moles on left means less moles on right
  - in calculations, you must use the mass/moles of the limiting reagent

7. (HT only) use a balanced equation to calculate masses of reactants or products

if you are given the mass of a reactant/product and are asked to find the mass of another reactant/product:

- Find moles of that one substance: moles = mass / molar mass
- Use balancing numbers to find the moles of desired reactant or product (e.g. if you had the equation: $2NaOH + Mg \rightarrow Mg(OH)_2 + 2Na$, if you had 2 moles of Mg, you would form 2x2=4 moles of Na)
- Mass = moles x molar mass(of the reactant/product) to find mass

8. Use arithmetic computation, ratio, percentage and multistep calculations throughout quantitative chemistry

9. (HT only) carry out calculations with number written in standard form when using the Avogadro constant

- standard form: e.g. 5.62×10^3
- the number (without the 10^x) should always only have a single digit number to the left of the decimal place
- if 10 is to the power of a large positive number, it means the actual number is very large e.g. 10^7 means 7 zeroes after the 1 so 10,000,000
- if 10 is to the power of a large negative number, the number is very small e.g. $10^{-4} = 0.0001$

10. Change the subject of a mathematical equation

- moles = mass ÷ formula mass
- can be rearranged to…
  - mass = moles x formula mass
  - formula mass = mass ÷ moles

11. Calculate the theoretical amount of a product from a given amount of reactant (separate science only)

- same method to calculate this as in point 7

12. Calculate the percentage yield of a reaction product from the actual yield of a reaction (separate science only)

$$\text{Percentage yield} = \frac{\text{Amount of product produced}}{\text{Maximum amount of product possible}} \times 100$$

maximum amount of product possible = theoretical yield

13. Suggest reasons for low yields for a given procedure (separate science only)

- Product lost by…
  - Filtering
  - Evaporating
  - Transferring liquids
- Also not all reactants react to make product

14. (HT only) describe the relationship between molar amounts of gases and their volumes and vice versa, and calculate the volumes of gases involved in reactions, using the molar gas volume at room temperature and pressure (assumed to be 24dm^3) (separate science only)

- Equal amounts in mol. of gases occupy the same volume under the same conditions of temperature and pressure (e.g. RTP)
- Volume of 1 mol. of any gas at RTP (room temperature and pressure: 20 degrees C and 1 atmosphere pressure) is 24 dm^3
- This sets up the equation:

$$\text{Volume } (dm^3) \text{ of gas at RTP} = \text{Mol.} \times 24$$

- Use this equation to calculate the volumes of gaseous reactants and products at RTP