WJEC England GCSE Chemistry

Topic 3: Chemical formulae, equations and amount of substance

Notes

(Content in bold is for Higher Tier only)

charges on ions

- an ion is formed when an atom loses or gains electrons
- since electrons have a negative charge, when electrons are lost, an ion with a positive charge is formed. When electrons are gained, ions with a negative charge are formed
- atoms form ions in order to gain a full outer shell of 8 electrons, since this is the most stable arrangement
- group 1 atoms lose one electron to form a +1 ion
- group 2 atoms lose two electrons to form a +2 ion
- group 3 atoms lose three electrons to form a +3 ion
- group 6 atoms gain two electrons to form a -2 ion
- group 7 atoms gain one electron to form a -1 ion
- other common ions:
    - from HCl (hydrochloric acid): Cl^-
    - from HNO_3 (nitric acid): NO_3^-
    - from H_2SO_4 (sulfuric acid): SO_4^{2-}

formulae of elements and simple covalent and ionic compounds

- In a compound, the charges of ions have to balance out, e.g. HCl exists, because of the formation of an H^+ ion and a Cl^- ion, also H_2SO_4 exists, because of the formation of $2H^+$ ions and a SO_4^{2-} ion (therefore, 2 hydrogen ions are needed here, due to the SO_4 ion having a 2- charge)

empirical formula

- empirical formula: simplest whole number ratio of atoms of different elements in a compound

from diagrams:

- observe the ratio of different elements e.g. if there are 2 hydrogen atoms for every 1 oxygen then the formula of the compound would be H_2O

from reacting mass data:

- **for each element, calculate mass ÷ relative mass**
- **form a ratio from these values**
- **use these ratios to write the formula for the compound**
- **e.g. 4g of hydrogen reacts with 32g of oxygen**
  4 ÷ 1=4 and 32 ÷ 16=2 , therefore ratio hydrogen to oxygen= 4:2 = 2:1
  therefore chemical formula= H_2O

Conservation of mass and balanced chemical equations

- 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

- o Therefore, chemical reactions can be represented by symbol equations, which are balanced in terms of the numbers of atoms of each element involved on both sides of the equation.
- Use this law to write chemical equations

writing half equations

- **This is an example of a half equation; the small number is always the same as the 2 larger numbers within the equation. & electrons are represented by the symbol 'e-'**

$$2Cl^- \longrightarrow Cl_2 + 2e^-$$

or

$$2Cl^- - 2e^- \longrightarrow Cl_2$$

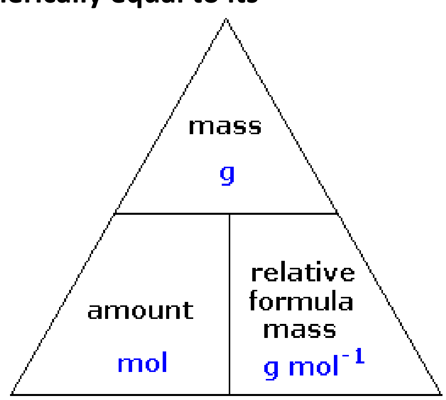
- **writing half equations:**
    - **positive ion to neutral charge: X^+ -> X, so ionic equation must be: $X^+ + e^-$ -> X**
    - **negative ion to neutral charge: X^- -> X, so ionic equation must be: X^- -> e^- + X**

writing ionic equations

- **Split up every compound that is aqueous into its ions and write as a separate equation**
- **Cancel out the similar ions on either side of the equation (known as spectator ions)**
- **Left with the ionic equation – ions that react, i.e. do not stay the same and therefore are not the same on the other side of the equation**

Moles

- **Chemical amounts are measured in moles (therefore it is the amount of substance). The symbol for the unit mole is mol.**
- **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 (N2) 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:**



    - o **E.g how many moles are there in 42g of carbon?**
        - **Moles = Mass / Mr = 42/12 = 3.5 moles**

Amounts of substances in equations

- Masses of reactants & products can be calculated from balanced symbol equations
- Chemical equations can be interpreted in terms of moles
  - E.g. $Mg + 2HCl \rightarrow MgCl_2 + H_2$ shows that 1 mol. Mg reacts with 2 mol. HCl to produce 1 mol. $MgCl_2$ and 1 mol. H_2

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

stoichiometry of an equation

- Stoichiometry refers to the balancing numbers in front of compounds/elements in reaction equations
- Balancing numbers in a symbol equation can be calculated from the masses of reactants and products:
  - convert the masses in grams to amounts in moles (moles = mass/Mr)
  - convert the numbers of moles to simple whole number ratios
- e.g. for the reaction: $Cu + O_2 \rightarrow CuO$ (not balanced), 127 g Cu react, 32g of oxygen react and 159g of CuO are formed. Work out the balanced equation using the masses given:
  - moles: (moles = mass/Mr)
    Cu: moles = 127 / 63.5 = 2
    O_2: moles= 32 / (16 x 2) = 32/32 = 1
    CuO moles = 159 / (16 + 63.5) = 2
  - therefore you have a ratio of 2:1:2 for Cu:O_2:CuO, making the overall balanced equation $2Cu + O_2 \rightarrow 2CuO$

limiting reagents:

- In a chemical reaction with 2 or more 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 reagent is used, the amount reactant in excess that actually reacts is limited to the exact amount that reacts with the amount of limiting reagent you have, so you need to use the moles/mass of the limiting reagent for any calculations

avogadro's constant:

- **The number of atoms, molecules or ions in a mole of a given substance is the Avogadro constant: 6.02×10^{23} per mole.**
- **e.g if you had 10 moles of H_2, you would have $6.02 \times 10^{23} \times 10 = 6.02 \times 10^{22}$ atoms**

Gases

- **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:**

Volume (dm^3) of gas at RTP = Mol. x 24

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