WJEC Chemistry A-level

1.1: Formulae and Equations

Detailed Notes

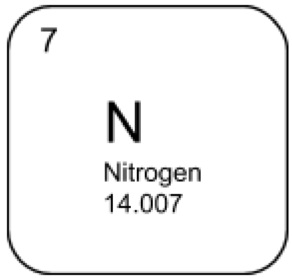
Welsh Specification

Elements and Compounds

Elements

An element is a substance consisting of **one single type** of atom. It cannot be broken down into simpler substances in any chemical reaction, making them the building blocks of all substances. Elements are represented using **chemical symbols**.

Example:



Simple Compounds

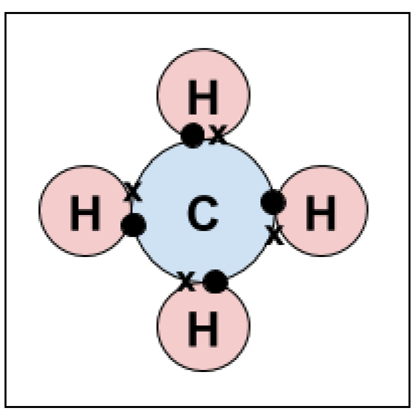
A compound is a substance that is made up of **two or more types** of atom. They are **chemically bound** together meaning the chemical properties of the component elements are changed and the compound will react differently. Simple compounds are expressed using **formulae**.

Example:

Water	=	H_2O
Sodium Chloride	=	NaCl
Calcium Carbonate	=	$CaCO_3$

These simple compounds can also be represented using a **diagram and key**, showing how the electrons are distributed and shared between the different atoms.

Example:



Ionic Compounds

Ionic compounds are also expressed using **formulae** that contain the **ions** that make up the compound. Overall, the compound will have a **neutral charge** (zero) meaning the charges of the separate ions must be **balanced** when writing the formula.

Example:

> Sodium Chloride consists of:
> **Sodium ions** (Na^+) and **Chloride ions** (Cl^-)
>
> When writing an ionic formula, the overall charge on the compound must be zero.
> Each ion only has a single charge, therefore they will cancel each other out giving the overall neutral charge required.
>
> **1 + -1 = 0**
>
> **=> NaCl is the ionic formula**

Oxidation Numbers

Oxidation number gives the **oxidation state** of an element or ionic substance. Allocation of oxidation number to a species follows a number of rules:

- Oxidation number of an element is **zero**.
- Oxidation numbers in a **neutral** compound add up to **zero**.
- Oxidation numbers in a **charged** compound add up to **the total charge**.
- Hydrogen has an oxidation number of **+1** (except in metal hydrides where it is -1).
- Oxygen has an oxidation number of **-2** (except in peroxides and F_2O where it is -1).
- All halogens have an oxidation number of **-1**.
- Group I metals have an oxidation number of **+1**.

These rules can be used to work out the oxidation number of species or elements in a reaction.
Example:

This compound's oxidation state must total zero, therefore using the rules above, the oxidation number of sulfur can be found:

$$2 - 8 + x = 0$$
$$-6 + x = 0$$
$$X = 6$$

> 2 x (+1) = 2
>
> Na_2SO_4
>
> 2 x (-2) = -8

Chemical Reactions

Writing Equations

Reactions can be seen as a re-arrangement of the reactant atoms to produce various different products. The number of atoms ***must* remain the same** throughout, as physical matter cannot be created in the chemical reaction. This also means the number of **each type of atom** must **stay the same**. These reactions can be represented using **word equations** or as **balanced chemical equations**.

Example:

Sodium Hydroxide + Sulfuric Acid -------> Sodium Sulfate + Water

These can be converted to chemical formulae:

$$NaOH + H_2SO_4 \text{ -------> } Na_2SO_4 + H_2O$$

Now the formula needs to be balanced:

$$2\ NaOH + H_2SO_4 \text{ -------> } Na_2SO_4 + 2\ H_2O$$

All chemical equations **must be balanced** to be complete. It can also be useful to include **state symbols** to help predict what observations might be able to be made from a reaction.

Writing Ionic Equations

Ionic equations show chemical species as **dissociated ions** with **individual charges**. They are very similar to regular chemical equations in that the number of species must **balance** throughout. The **total charge** must also **remain the same** during the reaction, so the total charge of the reactants equals the total charge of the products. **State symbols** should be used, because all reactants need to be in an **aqueous state** to be able to dissociate to ions.

The best method for writing an ionic equation is to start with the full chemical equation for the reaction taking place, then separate it into the dissociated ions before cancelling the **'spectator ions'** and re-writing it as an ionic equation.

Example:

$$Na_2CO_{3(aq)} + 2HCl_{(aq)} \text{ -------> } 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Rewrite the equation as individual ions:

$$2Na^+_{(aq)} + CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} + 2Cl^-_{(aq)} \text{ -------> } 2Na^+_{(aq)} + 2Cl^-_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Remove the spectator ions and rewrite the simplified ionic equation:

$$CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} \text{ -------> } H_2O_{(l)} + CO_{2(g)}$$