Chemistry

National 5

Learning Outcomes & Summary Notes
Unit 1 – Chemical Changes and Structure

1. Rates of Reaction
2. Atomic Structure and Bonding
3. Formula and Reaction Quantities
4. Acids and Bases

Unit 2 – Nature’s Chemistry

1. Energy from Fuels
2. Hydrocarbons / Homologous Series
3. Everyday Consumer Products

Unit 3 – Chemistry in Society

1. Metals
2. Properties of Plastics
3. Fertilisers
4. Nuclear Chemistry
5. Chemical Analysis
**Unit 1 – Chemical Changes and Structure**  
**Reaction Rates & Atomic Structure**

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate the average rates of reactions from graph.</td>
<td></td>
</tr>
<tr>
<td>I can show a change in reaction rate as the reaction progresses from a graph.</td>
<td></td>
</tr>
<tr>
<td>I can describe an ion as a charged particle.</td>
<td></td>
</tr>
<tr>
<td>I can write the symbols for atoms and ions using nuclide notation.</td>
<td></td>
</tr>
<tr>
<td>I can explain the term isotope and calculate the relative atomic mass for elements.</td>
<td></td>
</tr>
<tr>
<td>I understand the structure and physical properties of covalent molecular, covalent network and ionic substances and can distinguish between them.</td>
<td></td>
</tr>
<tr>
<td>I can draw electron cloud diagrams for covalent elements and compounds including double and triple bonds.</td>
<td></td>
</tr>
<tr>
<td>I can write the chemical formulae for ionic compounds including group ions.</td>
<td></td>
</tr>
<tr>
<td>I can use these formulae to write equations.</td>
<td></td>
</tr>
<tr>
<td>I can write balanced chemical equations using molecular formulae.</td>
<td></td>
</tr>
<tr>
<td>I can carry out calculations based on balanced equations.</td>
<td></td>
</tr>
<tr>
<td>I know how to calculate the gram formula mass and use this information in mass and mole calculations.</td>
<td></td>
</tr>
<tr>
<td>I am able to calculate volume of solutions and concentration using mole calculations.</td>
<td></td>
</tr>
</tbody>
</table>
### Formula and Reaction Quantities

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can write balanced equations using molecular formulae.</td>
<td></td>
</tr>
<tr>
<td>I can carry out calculations based on balanced equations.</td>
<td></td>
</tr>
<tr>
<td>I know how to calculate the gram formula mass and use this information in mass and mole calculations.</td>
<td></td>
</tr>
</tbody>
</table>

### Acids & Bases

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can state that water dissociates into hydrogen and hydroxide ions.</td>
<td></td>
</tr>
<tr>
<td>I know that pH is related to the concentration of hydrogen and hydroxide ions and that these are equal in a neutral solution.</td>
<td></td>
</tr>
<tr>
<td>I can write neutralisation equations using ionic formula with the omission of spectator ions.</td>
<td></td>
</tr>
<tr>
<td>I can carry out neutralisation titration experiments.</td>
<td></td>
</tr>
<tr>
<td>I am able to calculate volume of solutions and concentration using mole calculations.</td>
<td></td>
</tr>
</tbody>
</table>
# Unit 1: Section A – Reaction Rates

## Learning Statement

<table>
<thead>
<tr>
<th>Learning Statement</th>
<th>Red</th>
<th>Amber</th>
<th>Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>A chemical reaction can be recognised by one of the following:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• A colour change e.g. blue → red (always give start and end colour)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• An energy change e.g. a rise or fall in temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• A gas being given off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• A solid being formed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In all chemical reactions a new substance is formed. This is called the product. The substances you started with are called the reactants.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactants → Products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g. magnesium + oxygen → magnesium oxide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>An EXOTHERMIC reaction is one in which energy EXits, which means the temperature of the surroundings increases.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>An ENDOThERMIC reaction is one in which energy ENters, which means the temperature of the surroundings decreases.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The rate of a reaction is a measure of the speed of the reaction.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There are 4 ways we can change the rate of a chemical reaction:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Changing Particle Size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Changing Concentration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Changing the Temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Using a Catalyst</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing Particle Size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you decrease particle size, the rate of reaction will increase. This is because more surfaces are available for reactions to take place on.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="Diagram of changing particle size" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you increase particle size, the rate of reaction will decrease.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing Concentration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you increase concentration, the rate of reaction will increase. This is because there are more reactant particles present to react.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image.png" alt="Diagram of changing concentration" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you decrease concentration, the rate of reaction will decrease. This is because there are fewer reactant particles present to react.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Changing Temperature

If you increase temperature, the rate of reaction will increase. This is because particles have gained more energy and are more likely to collide and react.

If you decrease temperature, the rate of reaction will decrease. This is because particles have less energy and as a result are less likely to collide and react.

Using a Catalyst

In some reactions another chemical can be added to the reaction which will speed up the reaction. This chemical is called a catalyst.

Catalysts do not get used up in the reaction so can be used again. For example if you put 273 g of catalyst into the reaction, you would be able to get 273 g of the catalyst back at the end of the reaction.

e.g. Platinum is used as a catalyst in catalytic converters in car exhausts.

Enzymes are biological catalysts. They catalyse reactions in living things.

The rate of a reaction can be measured by monitoring the mass loss of reactants or the volume of gas produced in a reaction.

Measuring Mass Loss of Reactants

You could use the following apparatus to carry out this experiment.

![Diagram of apparatus for measuring mass loss of reactants]

The reading on the balance decreases with time as a gas is being produced.

Measuring Volume of Gas Produced

You could use the following apparatus to carry out this experiment.

![Diagram of apparatus for measuring volume of gas produced]
Graphs can be plotted showing the change in mass or volume against time. This gives you curves with the following shapes. The steeper the line is, the faster the reaction is. The graphs level off eventually as the reactants are used up.

1. Mass of reactants or products against time

![Graph 1: Mass of Reactants with Time](image1)

![Graph 2: Mass of Products with Time](image2)

2. Volume of gas produced against time

![Volume of Gas Produced with Time](image3)

The results from a mass loss or volume of gas produced experiment can be used to calculate the average rate of reaction.

**Calculating Average Rate**

\[
\text{Average Rate} = \frac{\text{Change in Mass or Volume}}{\text{Change in Time}}
\]

**Units of Average Rate**

1. **Mass and Time**
   In this case rate is a measure of the mass loss over time therefore the unit of rate is \( \text{g s}^{-1} \) (grams per second).
   
   \[
   \frac{\text{g}}{\text{s}} \rightarrow \text{g s}^{-1}
   \]

2. **Volume and Time**
   In this case rate is a measure of the change in volume of gas over time therefore the unit of rate is \( \text{cm}^3 \text{ s}^{-1} \) (cubic centimetres per second).
   
   \[
   \frac{\text{cm}^3}{\text{s}} \rightarrow \text{cm}^3 \text{ s}^{-1}
   \]
Unit 1: Section B1 – The Periodic Table & Atomic Structure

Learning Statement

<table>
<thead>
<tr>
<th>Classification Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>naturally occurring/made by scientists</td>
<td>All elements with atomic number above 92 are made by scientists and are not found naturally on Earth.</td>
</tr>
<tr>
<td>solid/liquid/gas</td>
<td>The majority of elements are solid. There are 11 gases (mainly found on the right of the Periodic Table). Two elements exist as liquids, they are bromine and mercury.</td>
</tr>
<tr>
<td>metal/non-metal</td>
<td>Metals are found on the left of the zig-zag line. Non-metals are found on the right of the zig-zag line.</td>
</tr>
</tbody>
</table>

Some groups have specific names:

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alkali Metals</td>
<td>lithium, sodium, potassium</td>
</tr>
<tr>
<td>2</td>
<td>Alkaline Earth Metals</td>
<td>calcium, magnesium, strontium</td>
</tr>
<tr>
<td>Between 2 and 3</td>
<td>Transition Metals</td>
<td>gold, iron, copper</td>
</tr>
<tr>
<td>7</td>
<td>Halogens</td>
<td>fluorine, chlorine, bromine</td>
</tr>
<tr>
<td>0</td>
<td>Noble Gases</td>
<td>helium, neon, argon</td>
</tr>
</tbody>
</table>

Elements in the same group in the Periodic Table have similar chemical properties.

Group 1 - The Alkali Metals

The alkali metals are soft metals which are shiny when freshly cut but lose their shininess when exposed to air as a layer of metal oxide forms.

\[
\text{metal} + \text{oxygen} \rightarrow \text{metal oxide}
\]

For this reason alkali metals are stored under oil to prevent contact with the air or water.

Alkali metals react violently with water. When they react with water they form alkaline solutions, this is why they are called the Alkali Metals.

\[
\text{e.g. sodium} + \text{water} \rightarrow \text{sodium hydroxide} + \text{hydrogen}
\]

(an alkali)

Group 7 - The Halogens

The halogens and their compounds have many uses. Fluorine compounds are used in toothpaste to help avoid tooth decay. Chlorine is used in drinking water and swimming pools as it can kill harmful bacteria. Bromine is used in dyes and medicines. Iodine can be used as an antiseptic.

Astatine is a radioactive element that does not occur naturally on Earth.

Like hydrogen, nitrogen and oxygen, the halogens are diatomic molecules. This means they exist in a molecule of two atoms. This means that we can write a chemical formula for them: F₂, Cl₂, Br₂, I₂, At₂.
Group 0: The Noble Gases

The gases in this group are all colourless. They are unreactive and so exist as single atoms, they are described as monatomic. These gases can be used in lasers and lighting.

Every element is made up of small particles called atoms.

Each element contains one type of atom only, e.g. sulfur contains only sulfur atoms and copper contains only copper atoms.

Atoms have the following structure:

![Atomic Structure Diagram]

Atoms are made up of 3 different particles.

<table>
<thead>
<tr>
<th>Particle</th>
<th>Location</th>
<th>Charge</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>proton</td>
<td>nucleus</td>
<td>+1</td>
<td>1 amu</td>
</tr>
<tr>
<td>neutron</td>
<td>nucleus</td>
<td>0</td>
<td>1 amu</td>
</tr>
<tr>
<td>electron</td>
<td>outside nucleus</td>
<td>-1</td>
<td>approximately zero</td>
</tr>
</tbody>
</table>

Atoms are neutral because they have the same number of protons and electrons. The positive charge of the nucleus is equal to the sum of the negative charges of the electrons.

Electrons are held in electron shells which are sometimes called energy levels.

<table>
<thead>
<tr>
<th>Energy Level</th>
<th>Protons</th>
<th>Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st energy level holds</td>
<td>2</td>
<td>2 electrons</td>
</tr>
<tr>
<td>2nd energy level holds</td>
<td>8</td>
<td>8 electrons</td>
</tr>
<tr>
<td>3rd energy level holds</td>
<td>8</td>
<td>8 electrons initially</td>
</tr>
<tr>
<td>4th energy level holds</td>
<td>8</td>
<td>8 electrons initially</td>
</tr>
</tbody>
</table>

**Electron arrangements can be found on page 6 of the data booklet**

Elements in the same group have the same number of outer electrons e.g. Group 1 - The Alkali Metals.

<table>
<thead>
<tr>
<th>Lithium</th>
<th>Sodium</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,1</td>
<td>2,8,1</td>
<td>2,8,8,1</td>
</tr>
</tbody>
</table>

Elements with the same number of electrons in their outer shell have similar chemical properties.

Each element in the Periodic Table has its own atomic number.

atomic number = number of protons

The mass of atom is due to the particles found in the nucleus, the protons and the neutrons.

mass number = no. of protons + no. of neutrons

The symbol of an element can be written showing the mass number and atomic number. This is called nuclide notation.

mass number → \( ^{23} \text{Na} \) \( \text{atomic number} \)

The number of protons, neutrons and electrons in neutral atoms can be calculated by doing the following:

mass number → \( ^{23} \text{Na} \) \( \text{atomic number} \)

Number of protons = atomic number = 11
Number of neutrons = mass number - atomic number = 23 - 11 = 12
Number of electrons = number of protons (for neutral atoms only) = 11
An ion is a charged particle, e.g., \( \text{Ca}^{2+} \), \( \text{Cl}^- \), \( \text{Na}^- \) or \( \text{O}^{2-} \).

An ion is formed when a neutral atom loses or gains electrons.
- Metals always lose electrons to form positive ions e.g., \( \text{Na}^+ \), \( \text{Mg}^{2+} \)
- Non-metals gain electrons to form negative ions e.g., \( \text{F}^- \), \( \text{O}^{2-} \)

Nuclide notation can also be drawn for ions. The charge is written at the top right of the symbol.

<table>
<thead>
<tr>
<th>Mass number</th>
<th>Atomic number</th>
<th>Charge</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>11</td>
<td>( +1 )</td>
<td>( \text{Na}^+ )</td>
</tr>
<tr>
<td>18</td>
<td>8</td>
<td>( -2 )</td>
<td>( \text{O}^{2-} )</td>
</tr>
</tbody>
</table>

The number of protons, neutrons and electrons in charged ions can be calculated by doing the following:

\[
\begin{align*}
\text{Number of protons} &= \text{atomic number} = 11 \\
\text{Number of neutrons} &= \text{mass number} - \text{atomic number} = 23 - 11 = 12 \\
\text{Number of electrons} &= \text{number of protons} - \text{charge} = 11 - (+1) = 10 \\
\text{Number of protons} &= \text{atomic number} = 8 \\
\text{Number of neutrons} &= \text{mass number} - \text{atomic number} = 18 - 8 = 10 \\
\text{Number of electrons} &= \text{number of protons} - \text{charge} = 8 - (-2) = 10
\end{align*}
\]

Isotopes are atoms of the same element which have:
- the same atomic number but a different mass number
- the same number of protons but a different number of neutrons.

\[ \begin{align*} \text{Cl}^{35} & \quad \text{Cl}^{37} \\
17 & \quad 17 \end{align*} \]

The relative atomic mass (RAM) is the average mass of all the isotopes of an element.
- RAM is rarely a whole number because it is an average.

E.g. The RAM of chlorine is 35.5
- The two isotopes of chlorine are \( \text{Cl}^{35} \) and \( \text{Cl}^{37} \)
- As the RAM is closer to 35 than 37, there must be more \( \text{Cl}^{35} \) atoms in the sample than \( \text{Cl}^{37} \).
### Learning Statement

<table>
<thead>
<tr>
<th>There are 3 types of bonding:</th>
<th>Red</th>
<th>Amber</th>
<th>Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Metallic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Ionic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Covalent</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Metallic Bonding**

- Occurs in metals.
- Results from an electrostatic attraction between positively charged metal ions and a sea of delocalised (free) electrons.
- Metallic bonds are strong.
- Most metals are solids. Mercury is the only liquid metal.
- As electrons can move from metal ion to metal ion, metals conduct electricity.

**Ionic Bonding**

- Ionic bonds are the electrostatic forces of attraction between positive ions and negative ions.
- Ionic bonds are strong.
- Ionic compounds have a lattice structure.
- Ionic compounds dissolve in water. When they dissolve in water the lattice breaks up.
- Ionic compounds conduct electricity as a melt or a solution as the ions are free to move. As solids they do not conduct as the ions are not free to move.
- Ionic compounds have high melting and boiling points. This means they are solids at room temperature.
- The colour of an ionic compound comes from the ions present. A list of ions colours can be found on page 6 of the data booklet.

When an ionic compound is dissolved in water a solution called an **electrolyte** is formed. Electrolytes conduct electricity as the ions are free to move.

Solutions of ionic compounds can be broken down using a process called **electrolysis**.

**Electrolysis** is the breaking down of compound using electricity.
Covalent Bonding
- A covalent bond is a shared pair of electrons between atoms.
- Atoms share electrons to gain a full, stable outer shell of electrons.
- The atoms are held together in a covalent bond by the electrostatic attraction between the positively charged nuclei of each atom and the negatively charged electrons.
- Covalent substances do not conduct electricity.
- Most covalent substances do not dissolve in water. However, there are solvents they do dissolve in e.g. acetone (nail varnish remover).
- Covalent molecules tend to be liquids or gases at room temperature as they have low melting and boiling points.

A molecule is a group of atoms held together by covalent bonds.

A diatomic molecule is one which is made up of two atoms.

\[
\text{di atomic molecule} = \begin{array}{c}
\text{atomic} \\
2 \text{ atoms}
\end{array} \quad \text{atoms joined by covalent bond}
\]

Several elements exist as diatomic molecules.

<table>
<thead>
<tr>
<th>Hydrogen</th>
<th>Nitrogen</th>
<th>Oxygen</th>
<th>Fluorine</th>
<th>Chlorine</th>
<th>Bromine</th>
<th>Iodine</th>
<th>Astatine</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂</td>
<td>N₂</td>
<td>O₂</td>
<td>F₂</td>
<td>Cl₂</td>
<td>Br₂</td>
<td>I₂</td>
<td>At₂</td>
</tr>
</tbody>
</table>

Diagrams can be drawn to show how the outer electrons in atoms are shared to form a covalent bond.

- Hydrogen H₂ molecule
- Oxygen O₂ molecule
- Chlorine Cl₂ molecule
- Nitrogen N₂ molecule
- Hydrogen chloride HCl
- Water H₂O
- Ammonia NH₃
- Methane CH₄
Shapes of Molecules

<table>
<thead>
<tr>
<th>Linear</th>
<th>Bent</th>
<th>Pyramidal</th>
<th>Tetrahedral</th>
</tr>
</thead>
<tbody>
<tr>
<td>H—Cl</td>
<td>O—H</td>
<td>N—H</td>
<td>C—H</td>
</tr>
</tbody>
</table>

Also with same shape:
- HCl
- HBr
- HI
- H₂S
- H₂Se
- PH₃
- NCl₃
- PCl₃
- CCl₄
- CF₄
- SiH₄

Covalent substances can also exist as giant networks. We call these covalent networks.

Examples of covalent networks are: diamond (carbon) and sand (silicon dioxide).

They only contain strong covalent bonds and therefore are solids and have extremely high melting and boiling points.

<table>
<thead>
<tr>
<th>Name</th>
<th>Diamond</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements present</td>
<td>Carbon</td>
<td>Silicon and oxygen</td>
</tr>
<tr>
<td>Structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melting point (°C)</td>
<td>3550</td>
<td>1610</td>
</tr>
<tr>
<td>Boiling point (°C)</td>
<td>4827</td>
<td>2230</td>
</tr>
</tbody>
</table>

Bonding Summary

<table>
<thead>
<tr>
<th>State at Room Temp</th>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Bonding</td>
<td>Ionic or Covalent</td>
<td>Covalent</td>
<td>Covalent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Bonding</th>
<th>Conduction as a Solid</th>
<th>Conduction as a Liquid</th>
<th>Conduction as a Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallic (Metals only)</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Covalent (Non-metals only)</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Ionic (Metals + Non-metals)</td>
<td>✗</td>
<td>✔</td>
<td>✗</td>
</tr>
</tbody>
</table>

metals do not dissolve in water
Unit 1: Section C – Formulae and Equations

Learning Statement

The chemical formula of a substance tells us which elements are present and how many of each element we have, e.g. CH₄, HBr.

The valency method can be used to work out a chemical formula. The valency of an element is how many bonds it can form. Valency is the number of unpaired electrons in the outermost shell.

<table>
<thead>
<tr>
<th>Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valency</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

The valency method involves doing the following:

- Write down element symbols
- Write down valency below each element’s symbol
- Follow arrows and cancel down if necessary to get formula

Some chemical names contain a prefix in them, e.g. mono, di, tri, tetra, which tells us how many of each element we have. This means we can write the formula for these without having to use the valency method.

<table>
<thead>
<tr>
<th>Compound</th>
<th>carbon monoxide</th>
<th>carbon dioxide</th>
<th>sulfur trioxide</th>
<th>carbon tetrachloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
<td>CO</td>
<td>CO₂</td>
<td>SO₃</td>
<td>CCl₄</td>
</tr>
<tr>
<td>Meaning</td>
<td>mono = 1</td>
<td>di = 2</td>
<td>tri = 3</td>
<td>tetra = 4</td>
</tr>
</tbody>
</table>

Some formulae involve group ions. Group ions are ions that contain more than one element. A list of group ions can be found on page 8 of the data booklet.

<table>
<thead>
<tr>
<th>Ion</th>
<th>Formula</th>
<th>Ion</th>
<th>Formula</th>
<th>Ion</th>
<th>Formula</th>
<th>Ion</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>ammonium</td>
<td>NH₄⁺</td>
<td>ethanoate</td>
<td>CH₃COO⁻</td>
<td>carbonate</td>
<td>CO₃²⁻</td>
<td>phosphate</td>
<td>PO₄³⁻</td>
</tr>
<tr>
<td>hydrogen carbonate</td>
<td>HCO⁻</td>
<td>dichromate</td>
<td>CrO₂⁻</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hydrogen sulfite</td>
<td>HSO₃⁻</td>
<td>sulfate</td>
<td>SO₄²⁻</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hydrogen oxide</td>
<td>H₂O</td>
<td>sulfite</td>
<td>SO₃⁻</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nitrate</td>
<td>NO₃⁻</td>
<td>thiosulfate</td>
<td>S₂O₃⁻</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>permanganate</td>
<td>MnO₄⁻</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The valency of a group ion is the number value of its charge, e.g. sulfate SO₄²⁻ has a valency of 2 as the charge is 2⁻.

The ionic formula of an ionic compound is a formula that contains ions, therefore has charges in it, e.g. Na⁺Cl⁻ is the ionic formula for sodium chloride.

Reactions can be described using word and formula (or chemical) equations.

- Word Equations
  - Describe chemical reactions using words. For example:
  
  calcium + nitric acid \(\rightarrow\) calcium nitrate + hydrogen
Formula (or chemical) Equations

Describe chemical reactions using the chemical formulae for the substances involved. For example:

\[
Ca + HNO_3 \rightarrow Ca(NO_3)_2 + H_2
\]

Formula (or chemical) equations can be balanced using the following method.

Write down correct chemical formula of all reactants before the arrow and all products after the arrow.

\[
\begin{align*}
Na & \quad + \quad O_2 \quad \rightarrow \quad Na_2O \\
\text{There are 2 oxygen atoms on left hand side but only 1 oxygen atom on right hand side. As the formula of Na}_2 O \text{ cannot be changed, double the number of Na}_2 O \text{ molecules by adding the number 2 in front of the formula} \\
Na & \quad + \quad 2O_2 \quad \rightarrow \quad 2Na_2O \\
\text{There is 1 sodium atom on the LHS but 4 sodium atoms on the RHS. As the formulae of Na and Na}_2 O \text{ are set and cannot be changed, we must add the number 4 in front of the Na on the LHS to balance the number of Na atoms} \\
4Na & \quad + \quad O_2 \quad \rightarrow \quad 2Na_2O
\end{align*}
\]

Formula Mass

The formula mass of a substance is the relative atomic masses of all the elements present added together. A list of relative atomic masses can be found on page 7 of the data booklet.

\[
C_3H_8
\]

\[
\begin{align*}
3 \times C & = 3 \times 12 = 36 \\
8 \times H & = 8 \times 1 = 8 \\
\text{Formula mass has no units.}
\end{align*}
\]

Gram Formula Mass (GFM)

The gram formula mass of a substance is the relative atomic masses of all the elements present added together. A list of relative atomic masses can be found on page 7 of the data booklet.

\[
Ca(OH)_2
\]

\[
\begin{align*}
1 \times Ca & = 1 \times 40 = 40 \\
2 \times O & = 2 \times 16 = 32 \\
2 \times H & = 2 \times 1 = 2 \\
\text{The unit of gram formula mass is grams, g.}
\end{align*}
\]

The gram formula mass (GFM) of a substance is also known as 1 mole of a substance.

\[
1 \text{ GFM} = 1 \text{ mole}
\]
Calculations Involving No. of Moles, Mass and GFM

The number of moles, mass and GFM have the following relationship.

\[
\begin{array}{|c|c|c|}
\hline
\text{g} & \text{mol} & \text{gfm} \\
\hline
\text{g = no. of grams} & \text{mol = no. of moles} & \text{GFM = gram formula mass} \\
\hline
\text{g = mol x gfm} & \text{mol = } \frac{\text{g}}{\text{gfm}} & \text{gfm = } \frac{\text{g}}{\text{mol}} \\
\hline
\end{array}
\]

Calculations Involving No. of Moles, Volume and Concentration

The number of moles, volume and concentration have the following relationship.

\[
\begin{array}{|c|c|c|}
\hline
\text{mol} & \text{c = concentration (mol/l)} & \text{v = volume (litres)} \\
\hline
\text{mol = v x c} & \text{c = } \frac{\text{mol}}{\text{v}} & \text{v = } \frac{\text{mol}}{\text{c}} \\
\hline
\end{array}
\]

N.B. Concentration has the unit mol l\(^{-1}\) (moles per litre) this means the volume in this equation must be in litres as well.

To convert from cm\(^3\) to litres, divide by 1000.

\[\text{e.g. } 45 \text{ cm}^3 = \frac{45}{1000} = 0.045 \text{ litres}\]

Worked Example

Calculations involving concentration and number of grams of solid:

\[\text{e.g. Calculate the concentration of a solution when 5.85g of NaCl is dissolved in 50cm}^3\text{ water.}\]

\[
\begin{align*}
\text{Calculate the gfm of NaCl} & \quad \text{no. of mol} = \frac{\text{no. of grams}}{\text{gfm}} \\
\text{Na} & \quad 1 \times 23 = 23 \\
\text{Cl} & \quad 1 \times 35.5 = 35.5 \\
\text{gfm} & \quad \underline{58.5g} \\
\text{no. of mol} & \quad = \frac{5.85}{58.5} = 0.1 \text{mol} \\
\text{concentration} & \quad = \frac{\text{no. of moles}}{\text{volume}} \\
& \quad = \frac{0.1 \text{mol}}{50 \text{ cm}^3} = 0.05 \text{ mol/l} \\
\text{NB Volume must be in litres!}\end{align*}
\]
Unit 1: Section D – Acids and Bases

Learning Statement

The pH scale is a continuous range of numbers.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acids</td>
<td>Neutral</td>
<td>Bases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH below 7</td>
<td>pH equal to 7</td>
<td>pH above 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid</td>
<td>Neutral (including pure water)</td>
<td>Base</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An alkali is a soluble base.

Examples of common household and laboratory acids and alkalis.

<table>
<thead>
<tr>
<th>Acids</th>
<th>Alkalts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household</td>
<td>Laboratory</td>
</tr>
<tr>
<td>Vinegar</td>
<td>Sulfuric acid</td>
</tr>
<tr>
<td>Lemon juice</td>
<td>Hydrochloric acid</td>
</tr>
<tr>
<td>Fizzy drinks</td>
<td>Nitric acid</td>
</tr>
<tr>
<td>Baking soda</td>
<td>Caustic soda</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>Ammonia solution</td>
</tr>
<tr>
<td>Oven cleaner</td>
<td>Potassium hydroxide</td>
</tr>
</tbody>
</table>

Examples of bases include metal oxides, metal carbonates or metal hydroxides.

Making Acids

- Non-metal oxides dissolve in water to produce acidic solutions.
  - Carbon dioxide + water → carbonic acid
  - Sulfur dioxide + water → sulfurous acid
  - Nitrogen dioxide + water → nitrous acid

Problems with Acids

Sulfur dioxide reacts with water in the atmosphere to produce acid rain.

The damaging effects of acid rain include:

- Damage to building rocks
- Damage to structures like metal bridges
- Acidifying soil which reduces crop growth
- Damage to the habitat of plant and animal life.

Making Alkalts

Alkalts are soluble bases that are made by dissolving metal oxides or metal hydroxides in water.

E.g. lithium oxide, sodium oxide, potassium oxide or magnesium oxide.

E.g. potassium hydroxide, sodium hydroxide or calcium hydroxide.

Acids and alkalts contain ions.

- Acids contain the hydrogen ion, H⁺(aq)
- Alkalts contain the hydroxide ion, OH⁻(aq)

This means that solutions of acids and alkalts can conduct electricity.
Solutions are classified as acidic, alkaline or neutral based on the proportion of $H^+$ and $OH^-$ ions present in the solution.

<table>
<thead>
<tr>
<th>Type</th>
<th>Proportion of Ions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid</td>
<td>$H^+(aq) &gt; OH^-(aq)$</td>
</tr>
<tr>
<td>Neutral</td>
<td>$H^+(aq) = OH^-(aq)$</td>
</tr>
<tr>
<td>Alkali</td>
<td>$H^+(aq) &lt; OH^-(aq)$</td>
</tr>
</tbody>
</table>

Diluting solutions of acids or alkalis has the following effects.

<table>
<thead>
<tr>
<th>Type of Solution</th>
<th>Effect of Dilution on pH</th>
<th>Effect of Dilution on Solution</th>
<th>Effect of Dilution on Ions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid</td>
<td>increases to 7</td>
<td>Acidity decreases</td>
<td>Decrease in the concentration of $H^+(aq)$ ions</td>
</tr>
<tr>
<td>Neutral</td>
<td>stays 7</td>
<td>No change</td>
<td>No change in the concentration of $H^+(aq)$ or $OH^-(aq)$ ions. $H^+(aq) = OH^-(aq)$</td>
</tr>
<tr>
<td>Alkali</td>
<td>decreases to 7</td>
<td>Alkalinity decreases</td>
<td>Decrease in the concentration of $OH^-(aq)$ ions</td>
</tr>
</tbody>
</table>

When an acid reacts with a base a reaction called neutralisation occurs.

Neutralisation changes the pH of acids and bases.

<table>
<thead>
<tr>
<th>Type of Substance</th>
<th>Effect on pH</th>
<th>Example of pH Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid</td>
<td>Increases to 7</td>
<td>pH = 0 → pH = 7</td>
</tr>
<tr>
<td>Base</td>
<td>Decreases to 7</td>
<td>pH = 14 → pH = 7</td>
</tr>
</tbody>
</table>

There are many everyday examples of neutralisation reactions.

- Reducing soil acidity by adding lime.
- The use of lime to reduce acidity in lakes caused by acid rain.
- Treatment of indigestion.
- Treating wasp or bee stings.

In neutralisation the hydrogen ions in acids react with the hydroxide ions found in alkalis to form water.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

hydrogen ion + hydroxide ion $\rightarrow$ water

In reactions involving metal carbonates, carbon dioxide gas is also formed.

$$2H^+(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$$

hydrogen ions + carbonate ion $\rightarrow$ carbon dioxide + water

Acids react with bases and metals to form salts.

<table>
<thead>
<tr>
<th>acid + alkali (metal hydroxide)</th>
<th>salt + water</th>
</tr>
</thead>
<tbody>
<tr>
<td>acid + metal oxide</td>
<td>salt + water</td>
</tr>
<tr>
<td>acid + metal carbonate</td>
<td>salt + water + carbon dioxide</td>
</tr>
<tr>
<td>acid + metal</td>
<td>salt + hydrogen</td>
</tr>
</tbody>
</table>

The chemical test for hydrogen gas is that it ignites with a squeaky pop.

The chemical test for carbon dioxide is that it turns lime water chalky.

A salt is a substance in which the hydrogen ion of an acid has been replaced by a metal ion.

- Ammonium ions ($NH_4^+$) can also replace hydrogen ions ($H^+$) to make salts.
- Most ionic substances are salts (except oxides and hydroxides).
To name the salt formed in reactions, we have to use the name of the acid and base.

- The neutraliser provides the first name of the salt formed.
  
  | Neutralising Name | Sodium hydroxide | Potassium oxide | Calcium carbonate |
  | First Name of Salt | Sodium           | Potassium      | Calcium           |

- The acid provides the second name of the salt formed.

  | Acid Name | Hydrochloric acid | Sulfuric acid | Nitric acid |
  | Second Name of Salt | ...chloride | ...sulfate | ...nitrate |

There are 2 types of salt: soluble and insoluble.

Making Soluble Salts

Soluble salts are made by (1) Neutralisation, (2) Filtration and (3) Evaporation.

1. Neutralisation
   - Insoluble metal carbonate (or metal oxide) is used to neutralise the acid.
   - When all acid has been neutralised, some excess carbonate or oxide will lie on the bottom of the beaker.

2. Filtration
   - Excess metal carbonate (or metal oxide) is removed from the solution by filtration.
   - The residue in the filter paper is attached metal carbonates.

3. Evaporation
   - The salt solution can be returned to the solid salt by evaporating the water.

Making Insoluble Salts

Insoluble salts are made by a precipitation reaction. This involves mixing two solutions and forming a powdery solid called a precipitate.

**The precipitate is the insoluble salt**

When 2 solutions are mixed, there can be a chemical reaction where one of the products is insoluble in water.

- Insoluble solid product of chemical reaction is called a precipitate.
- Insoluble  solid can be formed by precipitation and collected by filtration.

The insoluble solid formed in a precipitation reaction can be identified by:

<table>
<thead>
<tr>
<th>Writing down the names of the reactants</th>
<th>Sweep the names over</th>
<th>Check if of data book for solubility of products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium nitrate</td>
<td>Lead nitrate</td>
<td>Potassium nitrate (dissolved in solution)</td>
</tr>
<tr>
<td>Insoluble solid</td>
<td></td>
<td>Lead nitrate (insoluble)</td>
</tr>
</tbody>
</table>

When 2 solutions are mixed, there can be a chemical reaction where one of the products is insoluble in water.

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- Insoluble  solid can be formed by precipitation and collected by filtration.

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<td>Lead nitrate</td>
<td>Potassium nitrate (dissolved in solution)</td>
</tr>
<tr>
<td>Insoluble solid</td>
<td></td>
<td>Lead nitrate (insoluble)</td>
</tr>
</tbody>
</table>

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</tr>
<tr>
<td>Insoluble solid</td>
<td></td>
<td>Lead nitrate (insoluble)</td>
</tr>
</tbody>
</table>
A special technique can be carried out to accurately work out how much base is needed to neutralise an acid. This technique is called a titration.

Titration experiments involve using the following apparatus:

1. A Pipette

   A pipette is used to accurately measure out a volume of solution into a conical flask.

2. A Burette

   A burette is a graduated piece of glassware with a tap at the bottom of it. It can be used to release small volumes of a solution into a conical flask. Using small volumes of solution, sometimes drop by drop, allows a high degree of precision in this technique.

   An indicator is also added to the titration flask, which will change colour when the neutralisation has taken place. In this technique you should always swirl the titration flask as you are running solution from the burette into it, this ensures thorough mixing of the chemicals. A white tile should also be placed under the titration flask to allow the colour change to be clearly seen.

   In a titration experiment results must be concordant. This means that volume readings from the burette should be within 0.2 cm³ of each other.

   Results should be recorded in a table like the following.

<table>
<thead>
<tr>
<th></th>
<th>Rough</th>
<th>Run 1</th>
<th>Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Volume (cm³)</td>
<td>0</td>
<td>16.2</td>
<td>32.3</td>
</tr>
<tr>
<td>End Volume (cm³)</td>
<td>16.2</td>
<td>32.3</td>
<td>48.5</td>
</tr>
<tr>
<td>Titre (cm³)</td>
<td>16.2</td>
<td>16.1</td>
<td>16.2</td>
</tr>
</tbody>
</table>

\[ \text{Average Titre} = \frac{\text{Run 1} + \text{Run 2}}{2} \]

**Only use the average of concordant results in any calculation**
<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can define the term isomer and can draw the structural formula for isomers of</td>
<td></td>
</tr>
<tr>
<td>alkanes and alkenes up to $C_8$.</td>
<td></td>
</tr>
<tr>
<td>I know the general formula for cycloalkanes.</td>
<td></td>
</tr>
<tr>
<td>I can work out the names, molecular, shortened and structural formulae for</td>
<td></td>
</tr>
<tr>
<td>cycloalkanes up to $C_8$.</td>
<td></td>
</tr>
<tr>
<td>I can work out the systematic names for branched alkanes and alkenes.</td>
<td></td>
</tr>
<tr>
<td>I can state that alkenes take part in addition reactions and I can write</td>
<td></td>
</tr>
<tr>
<td>chemical equations for these reactions.</td>
<td></td>
</tr>
<tr>
<td>I can write a balanced chemical equation for the combustion of a given</td>
<td></td>
</tr>
<tr>
<td>hydrocarbon.</td>
<td></td>
</tr>
<tr>
<td>I can state the general formula and functional groups for the homologous series</td>
<td></td>
</tr>
<tr>
<td>of alkanols and alkanoic acids.</td>
<td></td>
</tr>
<tr>
<td>I can draw the structural formulae for alkanols and alkanoic acids up $C_8$.</td>
<td></td>
</tr>
<tr>
<td>I can give the systematic name for alkanols and alkanoic acids up $C_8$.</td>
<td></td>
</tr>
<tr>
<td>I can explain the production of an ester from an alkanol and alkanoic acid.</td>
<td></td>
</tr>
<tr>
<td>I can investigate the use of esters.</td>
<td></td>
</tr>
<tr>
<td>I know that different fuels provide different quantities of energy when burned.</td>
<td></td>
</tr>
<tr>
<td>I can carry out experiments to investigate the amount of energy released by</td>
<td></td>
</tr>
<tr>
<td>fuels.</td>
<td></td>
</tr>
<tr>
<td>I can carry out calculations using $E=cm\Delta T$.</td>
<td></td>
</tr>
</tbody>
</table>
### Everyday Consumer Products

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can state the general formula and functional groups for the homologous series of alkanols and alkanoic acids.</td>
<td>✔</td>
</tr>
<tr>
<td>I can draw the structural formulae for alkanols and alkanoic acids up C₈.</td>
<td></td>
</tr>
<tr>
<td>I can give the systematic name for alkanols and alkanoic acids up C₈.</td>
<td></td>
</tr>
<tr>
<td>I can explain the production of an ester from an alkanol and alkanoic acid.</td>
<td></td>
</tr>
<tr>
<td>I can investigate the use of esters.</td>
<td></td>
</tr>
</tbody>
</table>
### Learning Statement

A fuel is a substance that can be burned to release energy.

The burning of a fuel is called **combustion**. Combustion is the reaction of a substance with oxygen, giving out energy.

The burning of a fuel releases energy to the surroundings, so the burning of a fuel is an example of an **exothermic reaction**.

When a fuel burns oxygen is used up.
- The chemical test for oxygen is that it relights a glowing splint.

A fossil fuel is a fuel which is formed over millions of years from the remains of living things.

<table>
<thead>
<tr>
<th>Fossil Fuels</th>
<th>Coal</th>
<th>Oil</th>
<th>Gas</th>
</tr>
</thead>
</table>

### How Coal is Made

- Tree and plant materials die, fall to the bottom of a swamp and get covered in mud.
- Dead materials get compressed by heavier and heavier layers of rock.
- Over millions of years, dead materials turn into coal, oil or gas (depending on the starting material)
- Coal is then mined out of the ground.

### How Oil & Gas are Made

- Sea organisms die and fall to the bottom of the sea and get covered in sand.
- Fuel companies drill for oil and gas.

### Pollution problems which are associated with the burning of coal, oil and gas are:

<table>
<thead>
<tr>
<th>Pollutant Gas</th>
<th>Reason for Formation</th>
<th>Environmental Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>sulfur dioxide</td>
<td>Formed from the burning of sulfur impurities in coal.</td>
<td>Dissolves in atmospheric moisture to form acid rain.</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>Formed from burning any carbon-based fossil fuel.</td>
<td>Contributes to Global Warming (The Greenhouse Effect).</td>
</tr>
<tr>
<td>carbon monoxide</td>
<td>Formed by incomplete combustion (where the supply of oxygen is limited).</td>
<td>Carbon monoxide is a poisonous gas.</td>
</tr>
<tr>
<td>nitrogen dioxide</td>
<td>Produced by the spark in a car engine reacting with nitrogen and oxygen in the air.</td>
<td>Dissolves in atmospheric moisture to form acid rain.</td>
</tr>
</tbody>
</table>

Crude oil is a mixture of compounds called **hydrocarbons**.

Fractional distillation is used to separate crude oil into **fractions** according to their boiling point.
- A fraction is a group of compounds with a similar boiling point.
- Each fraction separated by fractional distillation has a different boiling point range.
Fractions obtained from the fractional distillation of crude oil have a variety of uses.

<table>
<thead>
<tr>
<th>Petroleum Gas</th>
<th>Naptha</th>
<th>Kerosene</th>
<th>Light Gas Oil</th>
<th>Heavy Gas Oil</th>
<th>Residue</th>
</tr>
</thead>
<tbody>
<tr>
<td>bottled gases, color gas</td>
<td>petrol, making plastics</td>
<td>aircraft fuel, paraffin</td>
<td>diesel</td>
<td>ship fuel, lubrication oil</td>
<td>bitumen, tar</td>
</tr>
</tbody>
</table>

Viscosity is the measure of the thickness of a liquid.
- The more viscous a substance is, the thicker it is and the less easily it flows.

Flammability means how easily a substance catches fire.
- The bigger a molecule is, the less flammable it is.

<table>
<thead>
<tr>
<th>CH₄</th>
<th>C₂₀H₄₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions with Smaller Molecules</td>
<td>Fractions with larger Molecules</td>
</tr>
<tr>
<td>As the molecular size increases:</td>
<td></td>
</tr>
<tr>
<td>Evaporation becomes more difficult</td>
<td></td>
</tr>
<tr>
<td>The flammability decreases</td>
<td></td>
</tr>
<tr>
<td>The viscosity (thickness) increases</td>
<td></td>
</tr>
<tr>
<td>The boiling point increases</td>
<td></td>
</tr>
</tbody>
</table>

Complete combustion of a fuel is when it is burned in a plentiful supply of oxygen.

Incomplete combustion of a fuel is when it is burned in a limited supply of oxygen.
- In carbon based fuels this can lead to the formation of poisonous carbon monoxide.

A hydrocarbon is a compound which contains only carbon and hydrogen.

Complete combustion of a hydrocarbon results in the formation of carbon dioxide and water.
- Hydrogen burns in oxygen to form hydrogen oxide (water)
- Carbon burns in oxygen to form carbon dioxide.

Hydrocarbon + Oxygen → Carbon dioxide + Water

The following apparatus could be used to examine the products of combustion of a hydrocarbon.

Air pollution from the burning of hydrocarbons can be reduced by adding catalytic converters to car exhausts which contain platinum catalysts. Catalytic converters convert harmful gases into harmless gases.

The energy produced by a fuel can be calculated using the following formula:

\[ E_h = cm\Delta T \]

where:
- \( E_h \) = the energy given out in the reaction, measured in kilojoules (kJ)
- \( c \) = the specific heat capacity of water, 4.18 kJ kg\(^{-1}\) °C\(^{-1}\) (in data booklet)
- \( m \) = mass of water being heated, which must be in kg (e.g. 75 cm\(^3\) water = 75/1000 kg)
- \( \Delta T \) = the change in temperature of the water (°C)
Unit 2: Section B – Homologous Series

Learning Statement

A homologous series is a group of compounds with:
- the same general formula
- similar chemical properties
- a gradual change in physical properties such as melting and boiling point.

Examples of homologous series include groups of compounds called the alkanes, cycloalkanes and alkenes.

The Alkanes
The alkanes are the simplest homologous series of hydrocarbons.
- The names of the first eight alkanes are:

<table>
<thead>
<tr>
<th>No. C’s</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>methane</td>
<td>ethane</td>
<td>propane</td>
<td>butane</td>
<td>pentane</td>
<td>hexane</td>
<td>heptane</td>
<td>octane</td>
</tr>
</tbody>
</table>

- You need to be able to name and draw the first eight alkanes.

\[
\text{butane}
\]

- The names of the alkanes always end in _ANE.
- The alkanes contain C-C single bonds.
- The general formula for the alkanes is \( \text{C}_n\text{H}_{2n+2} \).

Alkanes can be straight chained like the above, or branched.

- Branched alkanes can be named systematically according to rules set down by the International Union of Pure and Applied Chemistry (IUPAC).
  - Find the longest continuous chain of carbons
  - Identify any branches off the longest chain, e.g., methyl or ethyl
  - Put the name together with the branches first and the name of the long chain last. The longest chain should be numbered to give branches the lowest possible number.

\[4\text{-methyl}  \]
\[3\text{-ethyl}  \]

Here the longest chain is 6 carbons.
There is an ethyl branch on carbon 3 and a methyl branch on carbon 4.
So this is:
3-ethyl-4-methylhexane
The Cycloalkanes

The cycloalkanes are a homologous series of hydrocarbons with cyclic shapes.

- The names of the first five cycloalkanes are:

<table>
<thead>
<tr>
<th>No. Cs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Doesn't exist</td>
<td>Doesn't exist</td>
<td>cyclopropane</td>
<td>cyclobutane</td>
<td>cyclopentane</td>
<td>cyclohexane</td>
<td>cycloheptane</td>
</tr>
</tbody>
</table>

- You need to be able to draw and name the cycloalkanes.

- The names of the cycloalkanes start with CYCLO- and end with ...ANE.
- The cycloalkanes contain C-C single bonds.
- The general formula for the cycloalkanes is \( C_nH_{2n} \).

The Alkenes

The alkenes are another homologous series of hydrocarbons.

- The names of the first seven alkenes are:

<table>
<thead>
<tr>
<th>No. Cs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Doesn't exist</td>
<td>ethene</td>
<td>propene</td>
<td>butene*</td>
<td>pentene*</td>
<td>hexene*</td>
<td>heptene*</td>
<td>octene*</td>
</tr>
</tbody>
</table>

*Names should have numbers to show the position of C=C

- You need to be able to name and draw the alkenes.

- The names of the alkenes always end in ...ENE.
- The name of alkenes sometimes has a number in it, e.g., pent-1-ene. The number tells us where the C=C is.

This would be:

pent-2-ene

- Alkenes contain at least one C=C double bond. This is called the functional group, which means it is the part of the molecule that reacts.
- The general formula for the alkenes is \( C_nH_{2n} \).

Alkenes can also be straight chain or branched. Branched alkenes are named in the same way we named branched alkanes. The position of the C=C double bond is numbered first and then the branches are numbered in this case however. For example:

\[
\text{5-methylhex-2-ene}
\]

An isomer is when you have compounds that have the same molecular formula but a different structural formula.

- \( C_4H_{10} \)
- \( C_4H_{10} \)
- \( C_4H_{10} \)
- \( C_4H_{10} \)
- \( C_4H_{10} \)
Saturated hydrocarbons contain only C-C single bonds.
- The alkanes are saturated hydrocarbons.
- The cycloalkanes are saturated hydrocarbons.

Unsaturated hydrocarbons contain C=C double bonds.
- The alkenes are unsaturated hydrocarbons.

The bromine solution test can be used to distinguish between saturated and unsaturated hydrocarbons.
- Unsaturated hydrocarbons immediately decolourise bromine solution.
- Saturated hydrocarbons do not immediately decolourise bromine solution.

When an unsaturated hydrocarbon, such as an alkene, reacts with bromine solution a reaction called ADDITION has occurred.

\[
\text{C}_2\text{H}_4 + \text{Br}_2 \rightarrow \text{C}_2\text{H}_4\text{Br}_2
\]

The addition of hydrogen to an alkene is called HYDROGENATION. Adding hydrogen to an alkene forms an alkane.

\[
\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6
\]

The addition of water to an alkene is called HYDRATION.

\[
\text{C}_2\text{H}_4 + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_5\text{OH}
\]

Cracking is when you take a large alkane and break it down into a smaller alkane and a smaller alkene.

The following apparatus can be used to carry out cracking in a laboratory.

The aluminium oxide is a catalyst in this reaction.

When carrying out the experiment, the delivery tube must be removed from the bromine before you stop heating to prevent suckback.
## Unit 2: Section C – Consumer Products

### Learning Statement

**Alcohols are a homologous series containing the hydroxyl functional group, -OH.**

**Alcohols can be made by the hydration of alkenes.**

$$
\text{Ethene} + \text{Water} \rightarrow \text{Ethanol}
$$

$$
\text{C}_2\text{H}_4 + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_5\text{OH}
$$

Alcohol can also be made by the fermentation of glucose which is catalysed by the enzymes found in yeast.

- **glucose** \(\rightarrow\) **Yeast** \(\rightarrow\) **ethanol (alcohol) + carbon dioxide**

**Alcohols**

- Are a homologous series of compounds containing the hydroxyl functional group, -OH.
- The names of the first eight members are:

<table>
<thead>
<tr>
<th>No. C(s)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>methanol</td>
<td>ethanol</td>
<td>propanol*</td>
<td>butanol*</td>
<td>pentanol*</td>
<td>hexanol*</td>
<td>heptanol*</td>
<td>octanol*</td>
</tr>
</tbody>
</table>

*names will also have a number in them telling you the position of the -OH group.

- You need to be able to name and draw the above alcohols.

**Ethanol**

- The name of an alcohol ends in **-OL**.
- The general formula for the alcohols is \(\text{C}_n\text{H}_{2n+1}\text{OH}\)

In alcohols with more than 3 carbons in their chain, the -OH group can be in different positions on the chain. To show where the -OH group is, we can place a number in the name of the alcohol. For example:

**Propan-1-ol**

**Propan-2-ol**

Propan-1-ol and propan-2-ol are isomers, as they have the same molecular formula but a different structural formula.

Small alcohols such as methanol, ethanol and propanol are soluble in water. Longer carbon chained alcohols are not soluble in water.

Alcohols are useful as solvents. They are found in a variety of skincare products as some alcohols are able to dissolve the oils present in skin.

Alcohols are highly flammable, which means they make good fuels.

Alcohols make good fuels as they burn with a much cleaner flame than hydrocarbon fuels.
Ethanol, which can be made by fermentation, is becoming more widely used as a fuel for vehicles.

Alcohols can be converted into another type of chemical, called a carboxylic acid.

**Carboxylic acids** are a homologous series of compounds which contain the carboxyl functional group.

![carboxyl functional group]

**Carboxylic Acids**
- Are a homologous series of compounds contain the carboxyl functional group (COOH)
- The names of the first five members are:

<table>
<thead>
<tr>
<th>No. C's</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>methanoic acid</td>
<td>ethanoic acid</td>
<td>propanoic acid</td>
<td>butanoic acid</td>
<td>pentanoic acid</td>
</tr>
</tbody>
</table>

- You need to be able to name and draw carboxylic acids

![propanoic acid]

- Their names all end in **ANOIC ACID**.
- They have the general formula \( C_nH_{2n+1}COOH \).

Ethanoic acid is more commonly known as vinegar.

Carboxylic acids can have a variety of uses:
- as preservatives
- as cleaning products as they are weak acids
- in the food industry.

Carboxylic acids tend to have an unpleasant smell, e.g. butanoic acid. This acid is formed when butter becomes rancid.

Carboxylic acids can react with alcohols to form a compound called an **ester**.

\[
\text{Alcohol} + \text{Carboxylic Acid} \rightleftharpoons \text{Ester} + \text{Water}
\]

When an ester is made, water is also formed. This type of reaction is called a condensation reaction.

**Esters** are compounds which contain an ester functional group. An ester functional group has the following structure.

![ester functional group]

You need to be able to identify this functional group if you are given the structural formula of a substance.

Esters have sweet smells. They are found in many everyday products.

Esters have a variety of uses:
- as fragrance compounds
- as flavourings in foods
- as cleaning agents
- as solvents, e.g. nail varnish remover.

Esters are found in fats and oils.
Unit 2: Section D – Calculations from Equations

## Learning Statement

Balanced chemical (or formula) equations can be used to find the mass of reactants used, or products formed.

Here is an example question involving a calculation from a balanced equation and the steps you could use to perform the calculation.

**Question:** Calculate the mass of water formed on burning 5 g of methane.

\[
2O_2(g) + CH_4(g) \rightarrow CO_2(g) + 2H_2O(l)
\]

### Step 1: Write the balanced equation

\[
2O_2(g) + CH_4(g) \rightarrow CO_2(g) + 2H_2O(l)
\]

### Step 2: Cross out irrelevant info.

\[
2O_2(g) + CH_4(g) \rightarrow CO(g) + 2H_2O(l)
\]

### Step 3: Write mol relationship.

\[
1 \text{ mol CH}_4(g) \rightarrow 2 \text{ mol H}_2O(l)
\]

\[
\text{Mass of CH}_4 = 16 \quad \text{Mass of H}_2O = (2 \times 18) = 36
\]

### Step 4: Write the masses.

\[
16 \text{ g} \quad \rightarrow \quad 36 \text{ g}
\]

### Step 5: Use proportion to get answer.

\[
1 \text{ g} \quad \rightarrow \quad \frac{36}{16} \text{ g}
\]

\[
5 \text{ g} \quad \rightarrow \quad \left(\frac{36}{16}\right) \times 5 \text{ g} = 4.5 \text{ g}
\]

In step 5, it is possible to convert the unit of mass to whatever is stated in the question as this is just a ratio.

### Step 5: Use proportion to get answer

\[
1 \text{ g} \quad \rightarrow \quad \frac{36}{16} \text{ g}
\]

\[
1 \text{ kg} \quad \rightarrow \quad \frac{36}{16} \text{ kg}
\]

\[
1 \text{ tonne} \quad \rightarrow \quad \frac{36}{16} \text{ tonnes}
\]
## Unit 3 - Chemistry in Society

### Metals

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can explain what is meant by a metallic bond and how it conducts electricity.</td>
<td>✓</td>
</tr>
<tr>
<td>I can write balanced chemical equations for the reactions of metals.</td>
<td></td>
</tr>
<tr>
<td>I can write ion-electron equations for the reactions in an electrochemical cell.</td>
<td></td>
</tr>
<tr>
<td>I understand and can identify oxidation and reduction reactions.</td>
<td></td>
</tr>
<tr>
<td>I can combine ion-electron equations to form a redox reaction.</td>
<td></td>
</tr>
<tr>
<td>I can carry out % composition calculations.</td>
<td></td>
</tr>
</tbody>
</table>

### Plastics

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can explain how polymers are made by addition and condensation reactions including polyesters.</td>
<td></td>
</tr>
<tr>
<td>I can identify the type of polymer from its structural formula.</td>
<td></td>
</tr>
<tr>
<td>I can draw the structural formula for a polymer from a given monomer and vice versa.</td>
<td></td>
</tr>
<tr>
<td>I can identify the repeating unit for a polymer.</td>
<td></td>
</tr>
<tr>
<td>I can give examples of natural polymers and their uses.</td>
<td></td>
</tr>
</tbody>
</table>
## Fertilisers

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can explain the Haber process and the optimum conditions for the production of ammonia.</td>
<td></td>
</tr>
<tr>
<td>I can describe the use of ammonia as a raw material in the Ostwald Process.</td>
<td></td>
</tr>
<tr>
<td>I can name the catalysts involved in the Haber and Ostwald Processes.</td>
<td></td>
</tr>
<tr>
<td>I can calculate the % mass of elements in fertilisers.</td>
<td></td>
</tr>
</tbody>
</table>

## Nuclear Chemistry

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can name the 3 main types of radiation.</td>
<td></td>
</tr>
<tr>
<td>I can describe the properties of these particles in particular mass, charge and ability to penetrate different materials.</td>
<td></td>
</tr>
<tr>
<td>I can write nuclear equations for the loss and gain of alpha and beta particles.</td>
<td></td>
</tr>
<tr>
<td>I know the definition of half life and can carry out half life calculations.</td>
<td></td>
</tr>
<tr>
<td>I can describe the use of different radioisotopes in medicine and industry.</td>
<td></td>
</tr>
<tr>
<td>I can explain the use of carbon dating.</td>
<td></td>
</tr>
</tbody>
</table>

## Chemical Analysis

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can carry out the following techniques used for monitoring environmental issues:</td>
<td></td>
</tr>
<tr>
<td>Titration / Precipitation / Soil Analysis</td>
<td></td>
</tr>
<tr>
<td>I can explain the importance of monitoring the environment and reducing pollution.</td>
<td></td>
</tr>
</tbody>
</table>
Key Area: Properties of Plastics

<table>
<thead>
<tr>
<th>Learning Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most plastics and synthetic fibres are made from crude oil.</td>
</tr>
<tr>
<td>Synthetic means that the fibre has been made by scientists and is not naturally occurring.</td>
</tr>
<tr>
<td>Both natural and synthetic fibres are examples of polymers.</td>
</tr>
<tr>
<td>There are advantages and disadvantages of using natural or synthetic materials.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advantages of Plastics over Natural Materials</th>
<th>Disadvantages of Plastics over natural materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lightweight and cheap</td>
<td>Plastics made from finite resources (crude oil)</td>
</tr>
<tr>
<td>Good thermal and electrical insulating properties</td>
<td>Plastics burn to release toxic gases</td>
</tr>
<tr>
<td>Plastics are non-biodegradable and can last a long time compared to natural alternatives</td>
<td>Plastics are non-biodegradable and can be difficult to dispose of</td>
</tr>
</tbody>
</table>

Some plastics release toxic gases when they are burned.

<table>
<thead>
<tr>
<th>Toxic Gas</th>
<th>Carbon Monoxide</th>
<th>Hydrogen Chloride</th>
<th>Hydrogen Cyanide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>All plastics</td>
<td>PVC / Poly(chloroethene)</td>
<td>Polyurethane</td>
</tr>
</tbody>
</table>

A biodegradable plastic is one that can be broken down by organisms such as bacteria.

There are 2 types of plastic: thermoplastic and thermosetting.
- Thermoplastics melt on heating, as their polymer chains are not cross-linked.
- Thermosetting plastics keep their shape on heating, as their chains are cross-linked.

Polymers are large molecules made from smaller molecules called monomers.

<table>
<thead>
<tr>
<th>Name</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>monomer</td>
<td>Small molecules which join together to form polymers</td>
</tr>
<tr>
<td>polymer</td>
<td>The long chain molecule made by the joining up of monomers</td>
</tr>
<tr>
<td>polymerisation</td>
<td>The process where monomers join together to form polymers</td>
</tr>
</tbody>
</table>

There are 2 types of polymerisation:
- Addition
- Condensation

Addition Polymerisation

In addition polymerisation small unsaturated monomers containing a C=C undergo addition reactions to form a saturated polymer.

\[
\text{example: } \quad \begin{align*}
\text{chloroethene} & \quad \begin{array}{ccc}
\text{H} & \text{Cl} & \text{H} \\
\text{H} & \text{H} & \text{H}
\end{array} \\
\text{poly(chloroethene)} & \quad \begin{array}{cccccc}
\text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} \\
\text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H}
\end{array}
\end{align*}
\]
The polymer name starts with poly and then has the name of the monomer in brackets, for example ethene monomers polymerise to make poly(ethene).

**Condensation Polymerisation**
In condensation polymerisation monomers with functional groups at each end of the molecule undergo condensation reactions to form a polymer and water.

**Making Polyester**
Polyesters are chains of polymers that contain an ester functional group. They are made from a carboxylic acid monomer and an alcohol monomer.

![Chemical structure of polyester](image)

**Creative and Smart Materials Made from Polymers**
- **Kevlar** is made by condensation polymerisation and is used in bullet proof vests. It is a very strong fibre but is lighter than any other material with the same strength.
- **Polyvinyl Alcohol (PVA)** is a soluble plastic that can be used to make laundry bags.
- **Poly(acrylate)** is a hydrogel that has special water absorbing properties which allows hydrogels to be used in a variety of applications such as nappies, contact lenses and as medical bandages.
- **Colour changing plastics** can be used in food packaging to let consumers know the condition of food inside.
- **Conductive plastics** are currently being researched which allow the development of flexible touch screens and e-paper in the near future.
Key Area: Fertilisers

Learning Statement

The increasing population of Earth has led to a need for more efficient food production to grow enough food to feed the increasing number of people on Earth.

Growing plants require nutrients including compounds of:

<table>
<thead>
<tr>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
<th>Potassium (K)</th>
</tr>
</thead>
</table>

- Different types of crops need fertilisers containing different proportions of N, P and K.

Decomposition of protein in plants and animal remains recycles nitrogen in the nitrogen cycle.

Fertilisers are substances that restore the essential element for plant growth.
- Fertilisers need to be soluble to be absorbed through plant roots.

<table>
<thead>
<tr>
<th>Soluble compounds of</th>
<th>Ammonium salts</th>
<th>Potassium salts</th>
<th>Nitrates</th>
<th>Phosphates</th>
</tr>
</thead>
</table>

- Overuse of fertilisers can result in unused fertiliser being washed into rivers and lochs causing damage to wildlife.

Nitrifying bacteria in plant root nodules can convert (fix) nitrogen from the air into compounds containing nitrogen.
- Plants with such root nodules include clover, peas and beans.
- The nitrogen compounds formed are nitrates (NO₃).
- These bacterial methods for fixing nitrogen are cheaper than chemical methods.

Synthetic methods can be made from nitrogen compounds such as ammonia (NH₃) and nitric acid (HNO₃).

Ammonia (NH₃) is made by the Haber Process.

\[
\text{Nitrogen} + \text{Hydrogen} \quad \Rightarrow \quad \text{Ammonia}
\]

\[
\text{N}_2(g) + 3\text{H}_2(g) \quad \Rightarrow \quad 2\text{NH}_3(g)
\]

- The Haber Process is carried out at moderate temperature as high temperature leads to the breakdown of ammonia into nitrogen and hydrogen.
- Not all the reactants turn into ammonia as eventually the ammonia breaks down as quickly as it is formed.
- The catalyst used in the Haber Process is iron.

** The ⇄ sign means that the reaction is reversible.**

Ammonia can be converted into ammonium compounds by reacting ammonia with a strong alkali.
**Ammonia has the following properties.**

|----------------|----------------|-------------------|-----------------------------|

Ammonia is \( \text{NH}_3 \)  
Ammonium is \( \text{NH}_4^+ \)

**Nitric acid is made by the Ostwald Process.**

- The Ostwald Process involves the catalytic oxidation of ammonia to form nitric acid.
  
  **Stage 1:** Ammonia + Oxygen \( \rightarrow \) Nitrogen monoxide + Water

  **Stage 2:** Nitrogen monoxide + Oxygen \( \rightarrow \) Nitrogen dioxide

  **Stage 3:** Nitrogen dioxide + Oxygen + Water \( \rightarrow \) Nitric Acid

- The Ostwald Process is carried out at moderate temperature \( (900^\circ C) \).
- The reaction is exothermic so once started, the reaction does not require further heating.
- A platinum catalyst is used in this process.
- When nitrogen dioxide is dissolved in water, nitric acid is formed.

The percentage mass of elements in fertilisers can be calculated.

e.g. Calculate the percentage mass of nitrogen in ammonium nitrate, \( \text{NH}_4\text{NO}_3 \).

- **Find the GFM**
  - \( 2 \times \text{N} = 2 \times 14 = 28 \)
  - \( 4 \times \text{H} = 4 \times 1 = 4 \)
  - \( 3 \times \text{O} = 3 \times 16 = 48 \)
  - Total = 80 g

- **Find the mass of N in the formula**
  - \( 2 \times \text{N} = 2 \times 14 = 28 \text{ g} \)

- **Divide:** \( \text{mass in formula by GFM} \)
  - % Mass = \( \frac{28}{80} \times 100\% \)
  - %Mass = 35%
Nuclear Chemistry
Summary and Revision Guide

- Isotopes are atoms of the same element with different numbers of neutrons.
- The abundance of an isotope means how much of a certain isotope there is in a sample.
- The relative atomic mass (RAM) of an element is an average of the masses of all the isotopes taking abundance into account.
- To calculate RAM
  \[ \text{RAM} = \left(\% \text{ abundance of isotope 1} \times \text{mass}\right) + \left(\% \text{ abundance of isotope 2} \times \text{mass}\right) \]
  \[ \frac{\text{mass}}{100} \]
- The RAM must be a number somewhere between the lowest and highest masses.
- The radiation all around us that we receive every day from rocks and cosmic rays is called background radiation.
- The three types of radiation are called alpha, beta and gamma.

<table>
<thead>
<tr>
<th>Type</th>
<th>Symbol</th>
<th>Charge</th>
<th>Mass</th>
<th>Stopped by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>𝛛</td>
<td>1+</td>
<td>4</td>
<td>paper</td>
</tr>
<tr>
<td>Beta</td>
<td>𝛽</td>
<td>1-</td>
<td>0</td>
<td>metal foil</td>
</tr>
<tr>
<td>Gamma</td>
<td>𝜈</td>
<td>0</td>
<td>0</td>
<td>lead</td>
</tr>
</tbody>
</table>
What happens during nuclear and the new elements formed during decay can be shown using Nuclear Decay Equations. Write decay equations for
  o a decay of polonium-218
  
  o β decay of protactinium-234

The amount of radiation can be measured using a Geiger counter aka Geiger-Muller Tube.

The half-life of radioisotope is the amount of time it takes for the radiation to decrease by half.

Anything that was once living on the earth can be dated using carbon dating techniques. All living things absorb a naturally occurring radioactive form of carbon which then decays after death.

There are many other uses of radioactivity:
  o Generating electricity in nuclear power stations
  o Quality control in industry - testing the thickness or fullness of products.
  o In medicine diagnosing and treating illnesses such as cancers.
# Key Area: Chemical Analysis

## Learning Statement

<table>
<thead>
<tr>
<th>Learning Statement</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>There are two types of chemical analysis:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Qualitative analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Quantitative analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative analysis allows the presence of a substance to be detected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantitative analysis allows the presence of a substance to be detected and allows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>us to work how much of the substance there is.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Qualitative Analytical Methods

1. **Flame Testing**
   - When metal compounds are placed in a flame, characteristic colours are produced.
   - Different metals give different colours, therefore the presence of a metal in a compound can be detected using flame colour.
   - Flame colours can be found in the data booklet on page 6.

2. **Precipitation**
   - Metal ions can also be detected using precipitation reactions.
   - The colour of the precipitate formed (insoluble solid) allows us to determine which metal ion was present.
   - Non-metal ions can also be detected using precipitation.

3. **Chromatography**
   - Chromatography can be used to separate mixtures of substances.
   - Chromatography involves spotting small quantities of a substance on a piece of chromatography paper, then placing this chromatography paper vertically in a solvent. The solvent flows up the paper and separates the single spot for the substance into a spot for each component of the mixture.
   - Advanced forms of chromatography are available that allow better separation of mixtures. High Performance Liquid Chromatography (HPLC) and Gas Phase Chromatography (GPC) and Liquid Chromatography Mass Spectrometry (LCMS) are all example of such techniques.
Quantitative

1. Titration

A titration can be used to determine the concentration of acid or base used in a neutralisation reaction.

In a titration a pipette is used to transfer a known volume of acid or base into a conical flask. An indicator is then added to the conical flask. The indicator allows the end point of the titration to be easily observed.

A burette is filled with acid or base of a known concentration.

The burette is then used to accurately add known volumes of acid or base into the conical flask. When a colour change is observed, the reaction has reached its end point.

The measurements in a titration are often recorded in a table such as the following:

<table>
<thead>
<tr>
<th></th>
<th>1st (Rough)</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Volume (cm³)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End Volume (cm³)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Titre (cm³)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The average titre can be worked out using concordant values. Concordant values are values that are with 0.2 cm³ of each other.

Using the values obtained from the titration experiment, the formula:

\[
\frac{ACID}{V_1C_1} = \frac{BASE}{V_2C_2}\]

Where:

<table>
<thead>
<tr>
<th>V₁ = Volume of acid</th>
<th>V₂ = Volume of base</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁ = Concentration of acid</td>
<td>C₂ = Concentration of base</td>
</tr>
<tr>
<td>n₁ = Number of moles of acid from reaction equation.</td>
<td>n₂ = Number of moles of base from reaction equation.</td>
</tr>
</tbody>
</table>
National 5 Revision

Additional websites:

www.evans2chemweb.co.uk

login: stmungos    password: atom

www.new.chemistry-teaching-resources.com

www.bbc.co.uk/education/subjects/zmnp34j

http://chemistryatstabs.wikispaces.com/home