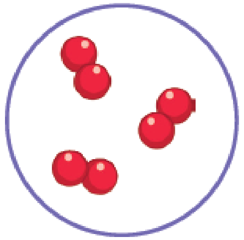
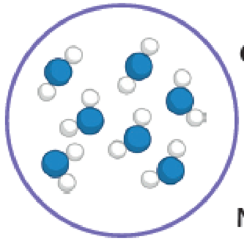
Pure Substances

Pure substances, in chemistry, only contain **one type of element** or **one type of compound**. For example, pure water will just contain water (a compound).

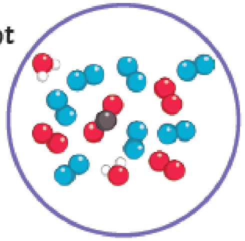
In our everyday language, we use the word 'pure' differently to how it is used in chemistry. Pure can mean a **substance** that has had **nothing else added to it** and is in its natural state. An example of this is pure orange juice. This means that the bottle will just contain orange juice and no other substances.



Elements are made up of **one type of atom**. For example, oxygen is made up of oxygen atoms. Carbon is made up of carbon atoms.



Compounds are **two or more elements** that are **chemically joined** together. For example, NaCl which is sodium chloride.



Mixtures are **two or more elements or compounds** that are **not chemically joined** together. An example of this is a standard cup of coffee. Coffee contains water, milk, coffee and possibly sugar. The components of the cup of coffee are not bonded together.

Pure Substances have a **sharp melting point** compared to **impure** substances which **melt over a range** of temperatures.

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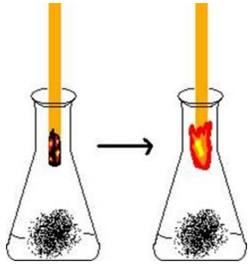
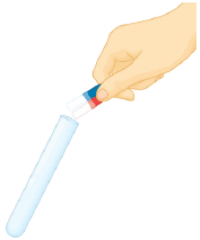
Test for gases

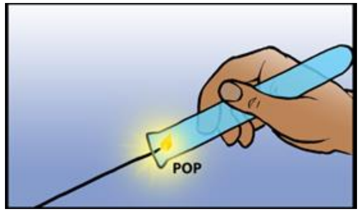
Test	Observation	Inference
Glowing splint held in a test tube	Splint relights	Oxygen is present
Lighted splint held in a test tube	Pop sound heard	Hydrogen is present
Gas bubbled through limewater	Limewater turns milky or cloudy white	Carbon dioxide is present
Damp litmus paper held in a test tube	Paper turns white	Chlorine is present



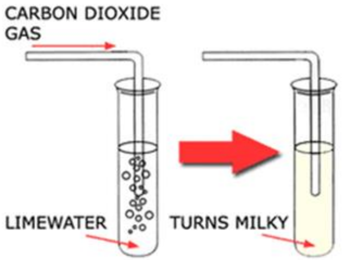
Testing for Oxygen



Testing for Chlorine



Testing for Hydrogen



Testing for Carbon Dioxide

Formulations

Formulations are **mixtures of compounds or substances** that **do not react together**. They do **produce a useful product** with desirable characteristics or properties to suit a particular function.

There are examples of formulations all around us such as medicines, cleaning products, deodorants, hair colouring, cosmetics and sun cream.

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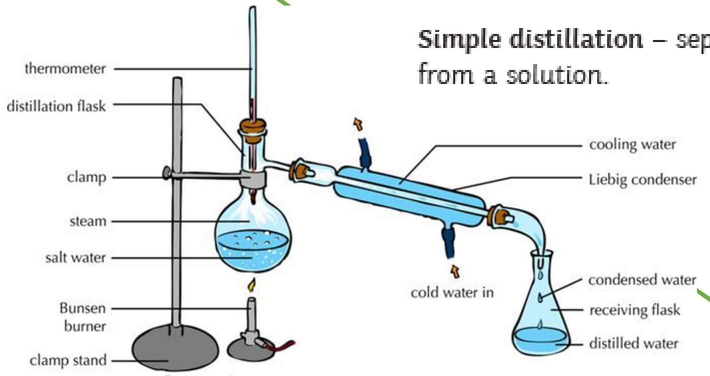
Separating mixtures

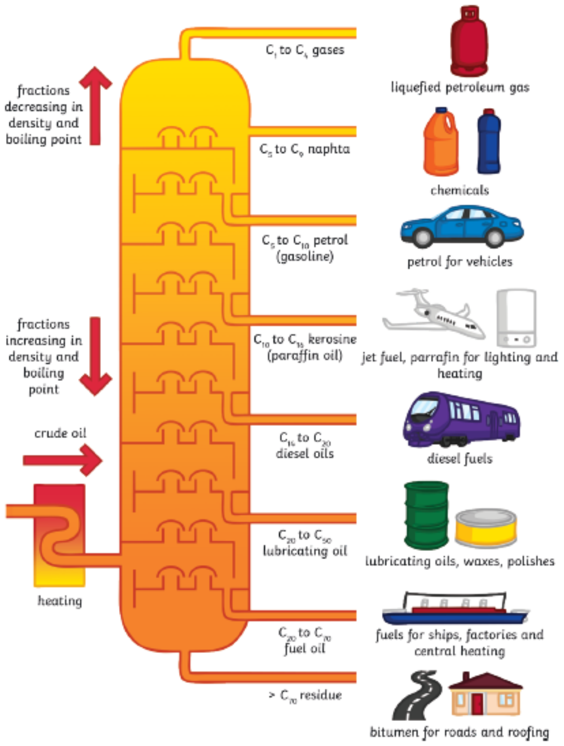
Mixtures – in a mixture there are no chemical bonds, so the elements are easy to separate. Examples of mixtures are air and salt water.

Distillation

Simple distillation – separating a liquid from a solution.



Fractional Distillation

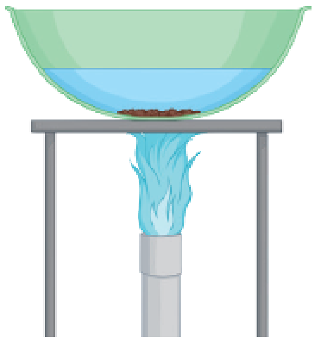


Fractional distillation is used to separate a mixture of long-chain hydrocarbons in crude oil into smaller, more useful fractions.

Crude oil is heated and enters at all column called a **fractioning column**. The column is **hot at the bottom** and decreases in temperature toward the top. As the crude oil is heated, it begins to evaporate and its vapours begin to rise up through the column. These vapours condense at the different fractions.

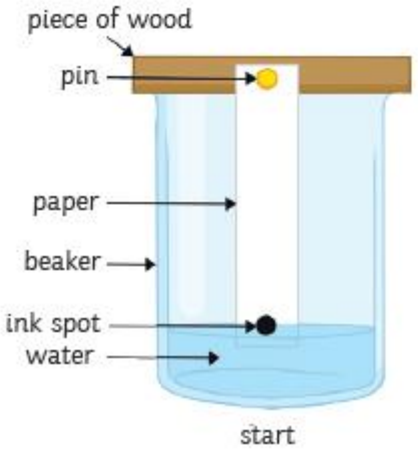
Evaporation

Evaporation – to separate a soluble salt from a solution; a quick way of separating out the salt.



Chromatography

Chromatography – to separate out mixtures.



Crystallisation

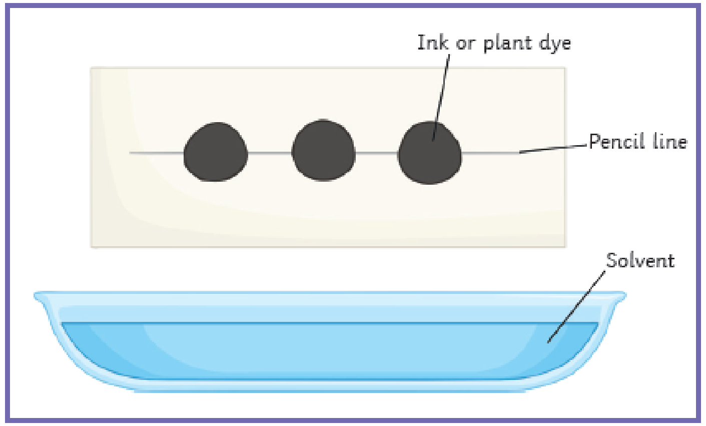
Crystallisation - to separate a soluble salt from a solution; a slower method of separating out salt.

Filtration

Filtration – to separate solids from liquids.

Chromatography Required Practical

In chromatography, there are two **phases**: the mobile and **stationary** phase.

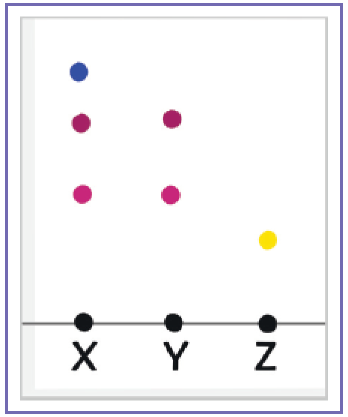


The **mobile phase moves** through the stationary phase. The **solvent** is the **mobile phase**. It moves through the paper carrying the different substances with it.

The **stationary phase** in paper chromatography is the **absorbent paper**.

Separation of the dissolved substances produces what is called **chromatogram**. In paper chromatography, this can be used to **distinguish** between those substances that are **pure** and those that are **impure**. **Pure substances** have **one spot** on a chromatogram as they are made from a single substance. **Impure substances** produce **two or more spots** as they contain multiple substances.

By calculating the **R_f values** for each of the spots, it is possible to identify the unknown substances. Similarly, if an unknown substance produces the **same number** and **colour of spots**, it is possible to match it to a known substance.



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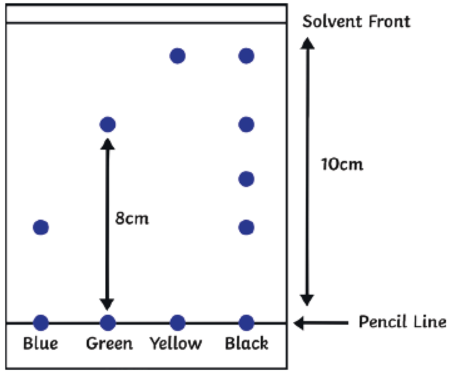
Rf Value

$$R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$$

Different compounds have different R_f values in different solvents. The R_f values of known compounds can be used to help identify unknown compounds.



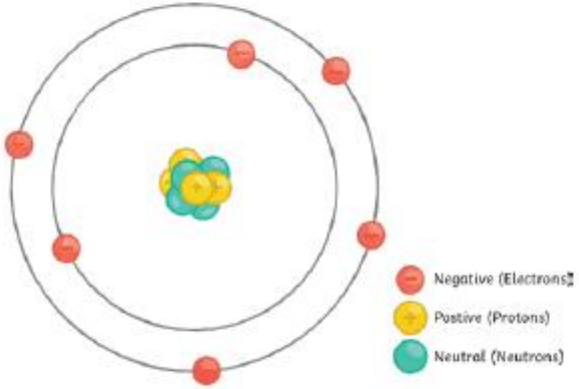
Atomic Structure

Contained in the nucleus are the **protons** and **neutrons**. Moving around the nucleus are the **electron** shells. They are negatively charged.

Particle	Relative Mass	Charge
proton	1	+1
neutron	1	0
electron	Very small	-1

Electronic Structure

Electrons are found in shells. A maximum of two in the most inner shell, then eight in the 2nd and 3rd shell. The inner shell is filled first, then the 2nd then the 3rd shell.



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Ions

An **ion** is an **atom** or group of atoms with a positive or negative **charge**. Ions form when atoms lose or gain **electrons** to obtain a full outer shell:

- **metal** atoms lose electrons to form positively charged ions
- **non-metal** atoms gain electrons to form negatively charged ions

Example of ion charges and groups

Group	Element	Ion charge	Ion symbol
1	Na	+	Na^{+}
2	Mg	2+	Mg^{2+}
6	O	2-	O^{2-}
7	Cl	-	Cl^{-}

Positive Ions

Metal atoms lose electrons from their outer shell when they form ions:

- the ions are positive, because they have more **protons** than electrons
- the ions formed have full outer shells
- the ions have the electronic structure of a noble gas (group 0 element), with a full outer shell

Negative Ions

The outer shells of non-metal atoms gain electrons when they form ions:

- the ions formed are negative, because they have more electrons than protons
- the ions have the electronic structure of a noble gas (group 0 element), with a full outer shell

Group 7

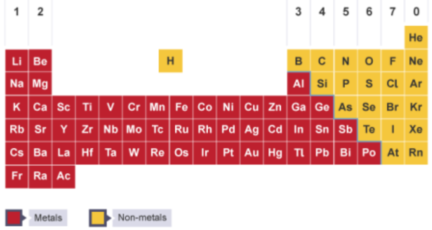
The halogens are **non-metals**: fluorine, chlorine, bromine, iodine. As you go down the group they become less reactive. It is harder to gain an extra electron because its outer shell is further away from the nucleus. The melting and boiling points also become higher.

Group 0

The **noble gases** (**group 0** elements) include: **helium**, **neon** and **argon**. They are un-reactive as they have full outer shells, which makes them very stable. They are all colourless gases at room temperature.

The boiling points all increase as they go down the group – they have greater intermolecular forces because of the increase in the number of electrons.

- the elements are arranged in order of increasing **atomic number**
- the horizontal rows are called **periods**
- the vertical columns are called **groups**
- elements in the same group are similar to each other



Periodic Table

In the early 1800s, elements were arranged by atomic mass. The periodic table was not complete because some of the elements had not been found. Some elements were put in the wrong group.

Dimitri Mendeleev (1869) left gaps in the periodic table. He put them in order of **atomic mass**. The gaps show that he believed there was some undiscovered elements. He was right! Once found, they fitted in the pattern.

The Modern Periodic Table

Elements are in order of **atomic mass/proton number**. It shows where the metals and non-metals are. **Metals** are on the **left** and **non-metals** on the **right**. The **columns** show the **groups**. The **group number** shows the number of **electrons** in the **outer shell**. The rows are **periods** – each period shows another full shell of electrons.

The periodic table can be used to predict the reactivity of elements.

Group 1

The alkali metals (**group 1 elements**) are soft, very reactive metals. They all have **one electron** in their **outer shell**, making them **very reactive**. They are **low density**. As you go down the group, they become more reactive. They get bigger and it is easier to lose an electron that is further away from the nucleus.

They form ionic compounds with non-metals.

They react with water and produce hydrogen.

E.g. $2Li + 2H_2O \rightarrow 2LiOH + H_2$

lithium + water → lithium hydroxide + hydrogen

They react with chlorine and produce a metal salt.

E.g. $2Li + Cl_2 \rightarrow 2LiCl$

lithium + chlorine → lithium chloride

They react with oxygen to form metal oxides.