Chemical Analysis

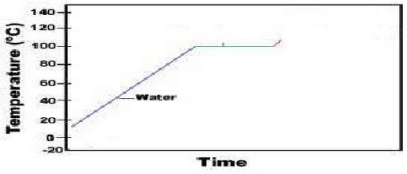
Pure Substances

In chemistry a pure substance is a single element or compound, not mixed with any other substance.

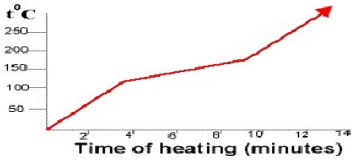
Pure elements and compounds melt and boil at specific temperatures.

Melting point and boiling point data can be used to distinguish pure substances from mixtures.

In advertising a pure substance can mean a substance that has had nothing added to it (in its natural state).



Pure substance:
Fixed boiling point



Mixture:
Unclear boiling point

Formulations

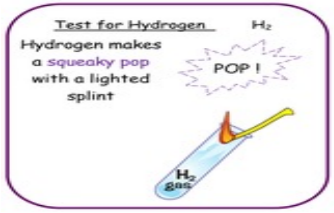
A formulation is a mixture that has been designed as a useful product.

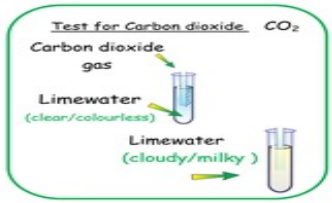
Many products are complex mixtures in which each chemical has a particular purpose.

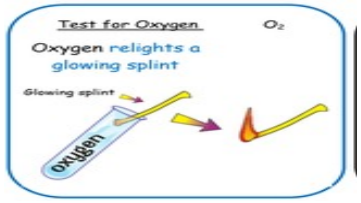
Formulations are made by mixing the components in carefully measured quantities to make sure the product has the required properties.

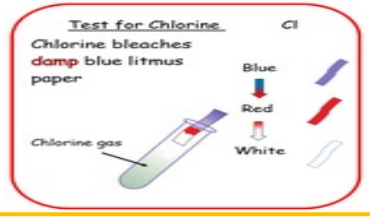
Fuels **Cleaning agents** **Paints** **Medicines** **Alloys** **Fertilisers** **Foods**

Testing Gases







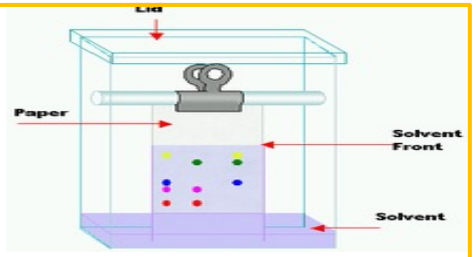


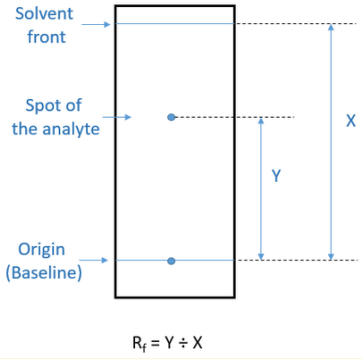
Chromatography

Chromatography can be used to separate mixtures and can give information to help identify substances.

Chromatography involves a stationary phase (where the molecules can't move – the paper) and a mobile phase (where the molecules can move – the liquid called the solvent)

Separation depends on the distribution of substances between the phases. The chemicals in a mixture spend different amounts of time dissolved in the mobile phase and stuck to the stationary phase.





The R_f value of a chemical is the ratio between the distance travelled by the dissolved substance (the solute) and the distance travelled by the solvent

$$R_f = \frac{distance\ moved\ by\ substance}{distance\ moved\ by\ solvent}$$

Different compounds have different R_f values in different solvents which can be used to help identify the compounds.

The compounds in a mixture may separate into different spots depending on the solvent but a pure substance will produce a single spot in all solvents.

Required practical: Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Place spot of mixture on chromatography paper and place in solvent. When the solvent moves up the paper the mixture will separate into spots. Calculate the R_f value of each spot.

Chemical Analysis *(separate Chemistry only)*

REQUIRED PRACTICAL: Use chemical tests to identify the ions in unknown single ionic compounds (the cation and the anion).

Testing Cations (positive ions)

Flame tests

Flame tests can be used to identify some metal ions (cations)
If a sample contains a mixture of ions then some flame colours can be masked.

Metal Ion	Flame Colour
Lithium	Crimson
Sodium	Yellow
Potassium	Lilac
Calcium	Orange-red
Copper	Green

Metal Hydroxides

Sodium hydroxide can be used to identify some metal ions (cations).
They form metal hydroxide precipitates.

Metal Ion	Colour of Precipitate	Ionic equation for precipitate
Calcium Ca^{2+}	White	$Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Ca(OH)_{2\,(s)}$
Copper (II) Cu^{2+}	Blue	$Cu^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Cu(OH)_{2\,(s)}$
Iron (II) Fe^{2+}	Green	$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Fe(OH)_{2\,(s)}$
Iron (III) Fe^{3+}	Brown	$Fe^{3+}_{(aq)} + 3OH^-_{(aq)} \rightarrow Fe(OH)_{3\,(s)}$
Aluminium Al^{3+}	White but then re dissolves to form a colourless solution	$Al^{3+}_{(aq)} + 3OH^-_{(aq)} \rightarrow Al(OH)_{3\,(s)}$
Magnesium Mg^{2+}	White	$Mg^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Mg(OH)_{2\,(s)}$

Testing Anions (negative ions)

Carbonates

Carbonates react with dilute acids to form carbon dioxide gas.
Carbon dioxide can then be tested for using limewater.

$$Na_2CO_{3\,(aq)} + 2HCl_{(aq)} \rightarrow CO_{2\,(g)} + 2NaCl_{(aq)} + H_2O_{(l)}$$

Sulphates

Sulphate ions in solution produce a white precipitate with barium chloride solution (in the presence of dilute HCl).
The precipitate is **barium sulphate**.

$$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4\,(s)}$$

Halides

Adding halides to silver nitrate solution (with nitric acid).
produce precipitates of silver halides.

Halide	Colour of Precipitate in acidified silver nitrate	Ionic equation for precipitate
Chloride Cl^-	White	$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$
Bromide Br^-	Cream	$Ag^+_{(aq)} + Br^-_{(aq)} \rightarrow AgBr_{(s)}$
Iodide I^-	Yellow	$Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$

Instrumental Analysis

Advantages over chemical testing: They produce **fast**, **sensitive** and **accurate** means of analysing chemicals and are particularly useful when the amount of chemical being **analysed is small**.

Flame emission spectroscopy

- Used to analyse **metal ions** in solution.
- The sample is put into a flame and the light given out is passed through a spectroscope.
- The output is a line spectrum that can be analysed to identify the metal ions in the solution and measure their concentrations.
- The line spectrum is unique for every ion – so you compare the pattern you get with known samples to identify the correct ion.