

# FACTFILE: GCSE DAS CHEMISTRY: UNIT 1.9



## Chemical Analysis

### Learning outcomes

Student should be able to:

- 1.9.1 demonstrate knowledge and understanding that a pure substance is a single element or compound not mixed with any other substance;
- 1.9.2 demonstrate knowledge and understanding that pure elements and compounds melt and boil at specific temperatures and melting point and boiling point can be used to distinguish pure substances from mixtures;
- 1.9.3 demonstrate knowledge and understanding that a formulation is a mixture that has been designed as a useful product and is formed by mixing together several different substances in carefully measured quantities to ensure the product has the required properties, for example alloys, medicines and fertilisers;
- 1.9.4 demonstrate knowledge and understanding of the terms soluble, insoluble, solute, solvent, solution, residue, filtrate, distillate, miscible, immiscible, evaporation and condensation;
- 1.9.5 investigate practically how mixtures can be separated using filtration, crystallisation, paper chromatography, simple distillation or fractional distillation (including the use of fractional distillation in the laboratory to separate miscible liquids, for example ethanol and water);
- 1.9.6 describe paper chromatography as the separation of mixtures of soluble substances by running a solvent (mobile phase) through the mixture on the paper (stationary phase) which causes the substances to move at different rates over the paper;
- 1.9.7 interpret a paper chromatogram **including calculating  $R_f$  values**;
- 1.9.8 analyse given data on mixtures to make judgements on the most effective methods of separation, and plan experiments to carry out this separation;
- 1.9.9 use anhydrous copper(II) sulfate to test for water;
- 1.9.10 describe how to carry out a flame test using nichrome wire and concentrated hydrochloric acid to identify metal ions;
- 1.9.11 demonstrate knowledge of the flame colours of different metal ions:
  - lithium (crimson);
  - sodium (yellow/orange);
  - potassium (lilac);

- calcium (brick red); and
- copper (blue-green/green-blue).

## Pure substances

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

For example 'pure' orange juice is not a single element or compound but contains water, citric acid, vitamin C and other ingredients – it is not a pure substance. It is a mixture.

## Melting and boiling point of pure substances and mixtures

**Melting point is the temperature at which a solid changes into a liquid.**

**Boiling point is the temperature at which a liquid changes into gas.**

Pure elements and compounds have specific melting points and boiling points. For example the compound water has a boiling point of 100 °C and a melting point of 0 °C. Substances can be identified by their melting points and boiling points.

Impure substances do not have sharp melting or boiling points, but melt or boil over a range of temperatures.

## Formulations

**A formulation is a mixture that has been designed as a useful product and is formed by mixing together several different substances in carefully measured quantities to ensure the product has the required properties.**

Example of formulation	Description
alloys	An alloy is a <b>mixture of two or more elements, at least one of which is a metal</b> – it is a formulation made by mixing measured quantities to ensure the alloy has the specific properties required for its use.
medicines	Medicines are formulations of the active drug and flavourings.
fertilisers	Fertilisers are mixtures of different nitrogen, phosphorus and potassium compounds, in measured quantities suitable for different plants.

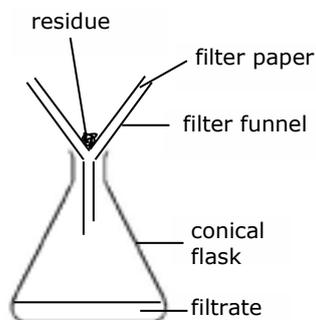
## Separating Mixtures

- **A mixture is defined as two or more substances mixed together**
- **A solute is the substance that dissolves in a solvent**
- **A solvent is the liquid in which a solute dissolves**
- **A solution is a solute dissolved in a solvent**
- **A soluble substance is one which will dissolve in a solvent**
- **An insoluble substance is one which does not dissolve in a solvent**

Different methods are used to separate different types of mixtures.

## 1. Filtration

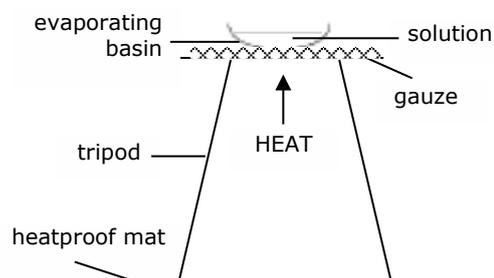
Filtration is used to separate an *insoluble solid from a liquid*. **The liquid which passes through the filter paper during filtration is called the filtrate. The solid that remains on the filter paper during filtration is called the residue.**



**Separation of an insoluble solid from a liquid**

## 2. Crystallisation

This involves heating a solution to boil off some of the solvent and create a saturated solution. The saturated solution is then cooled and the dissolved solid (solute) becomes less soluble and so cannot remain dissolved and crystallises out of solution. The crystals are often then separated from the saturated solution by filtration.



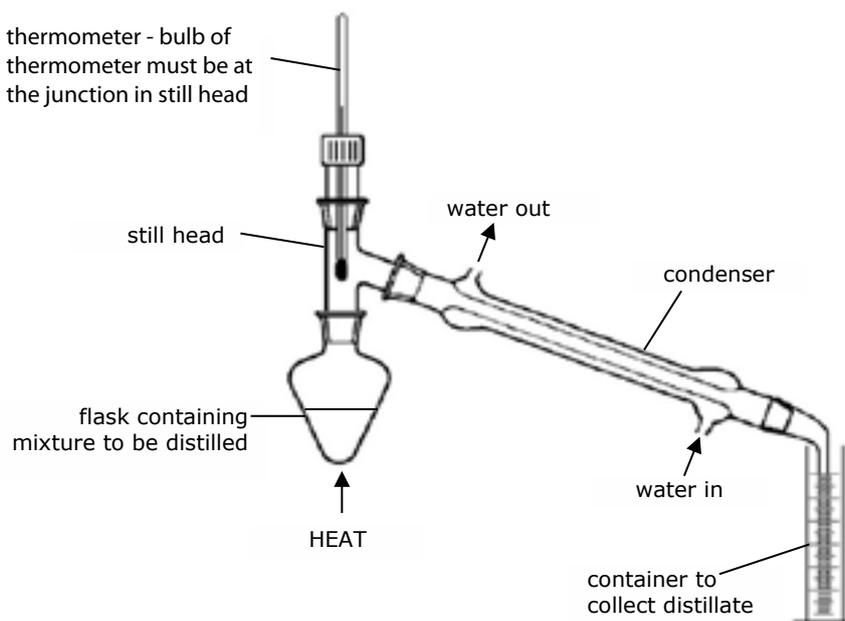
**Obtaining salt from a salt solution**

### 3. Simple Distillation

To separate a *solvent from a solution*, simple distillation is used. Distillation is evaporation followed by condensation.

Anti-bumping granules are added to the mixture in the flask to promote smooth boiling.

The solution is heated and the vaporised solvent passes into the condenser where it cools and condenses and then runs into the collection flask. **The distillate is the liquid which is cooled from the vapour and collected during distillation.**



**Separating water from a salt solution using simple distillation**

#### 4. Fractional distillation

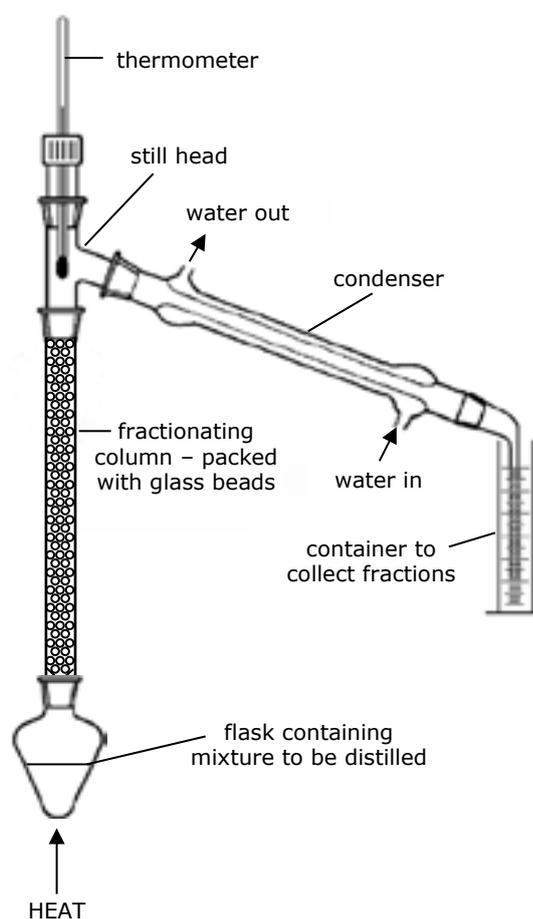
Fractional distillation is used to *separate miscible liquids* which have different boiling points, for example alcohol and water.

**Miscible liquids are liquids that mix together**, for example alcohol and water.

**Immiscible liquids are liquids which do not mix together but form two layers**, for example oil and water.

The mixture is heated and the liquids in it boil one by one as the temperature rises. Each vapour rises up, is condensed and collected. The distillate collected at each different temperature is called a *fraction*, and a different receiver is used for each fraction. Ethanol boils at 79 °C and is condensed and collected first. The temperature then rises to 100 °C and water boils and is collected.

A *fractionating column* packed with glass beads is used - any evaporated liquids below their boiling point condense on the glass beads and run back to the flask.



**Fractional distillation of a water/ethanol mixture**

## 5. Paper chromatography

Chromatography can be used to separate *mixtures of soluble substances* in a solution, e.g. inks.

### Method

- 1 Draw a pencil base line 1–2cm from bottom of chromatography paper. Pencil is used as it will not dissolve in the solvent.
- 2 Place a spot of substance on the base line using a capillary tube, dry and add another spot on top, to make a concentrated spot.
- 3 Hang the paper in a beaker with the bottom touching the solvent.
- 4 The solvent soaks up the paper. It is removed and the level that the solvent reached is marked. (solvent front).

If the tested substance is a mixture it should have separated into different components, which are seen as spots on the paper. If the spots are colourless and not visible, they can be sprayed with a chemical developing agent.

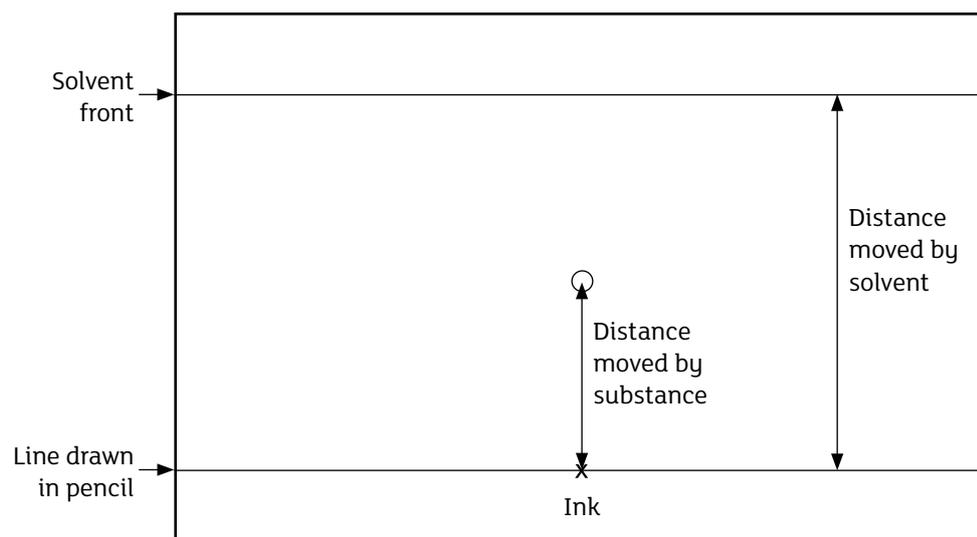
**Solvent front is the furthest distance travelled by the solvent**

### How chromatography works

In paper chromatography the *stationary phase* is the sample mixture on the paper, and the solvent is the *mobile phase*, which runs through the stationary phase and causes the substances in the mixture to move at different rates over the paper. To identify the separated components the  $R_f$  value can be calculated

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

The distances can be measured from the chromatogram using a ruler.



## Test for water

Test	Observation
Add a few drops of the liquid to white anhydrous copper(II) sulfate	White anhydrous copper(II) sulfate turns blue

## Cation tests

Cations can be identified in two different ways.

### Flame tests

#### Method

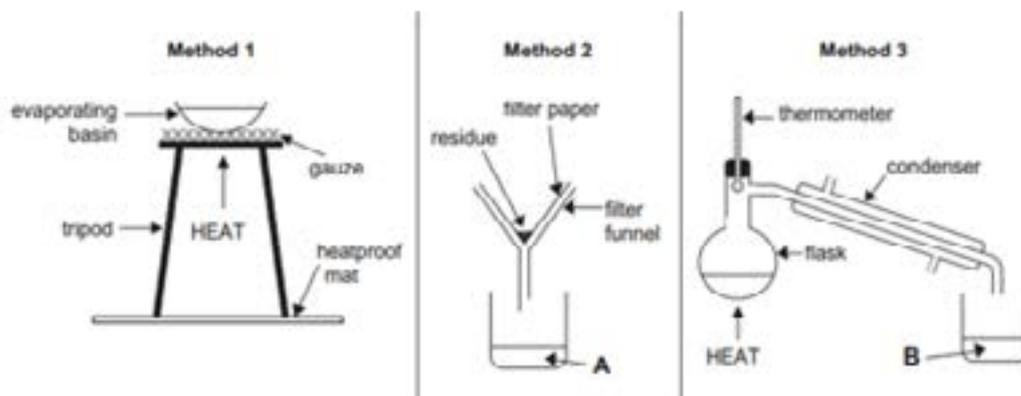
- Make a loop on the end of a piece of nichrome wire.
- Dip the loop into concentrated hydrochloric acid and then into the salt to be tested.
- Place the loop into a blue Bunsen burner flame and record the first colour observed.

Metal ion present	Flame colour
Lithium (Li <sup>+</sup> )	Crimson
Sodium (Na <sup>+</sup> )	Yellow/orange
Potassium (K <sup>+</sup> )	Lilac
Calcium (Ca <sup>2+</sup> )	Brick red
Copper(Cu <sup>2+</sup> )	Blue-green/green-blue

## Questions

1 Mixtures may be separated in the laboratory in many different ways.

(a) Three different methods of separating mixtures are shown below.



(i) Which method (1, 2 or 3) would be most suitable for obtaining water from salt solution?

\_\_\_\_\_ [1]

(ii) Which method would be most suitable for removing sand from a mixture of sand and water?

\_\_\_\_\_ [1]

(iii) Explain fully why Method 2 would **not** be suitable to separate copper(II) sulfate from copper(II) sulfate solution.

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 \_\_\_\_\_ [1]

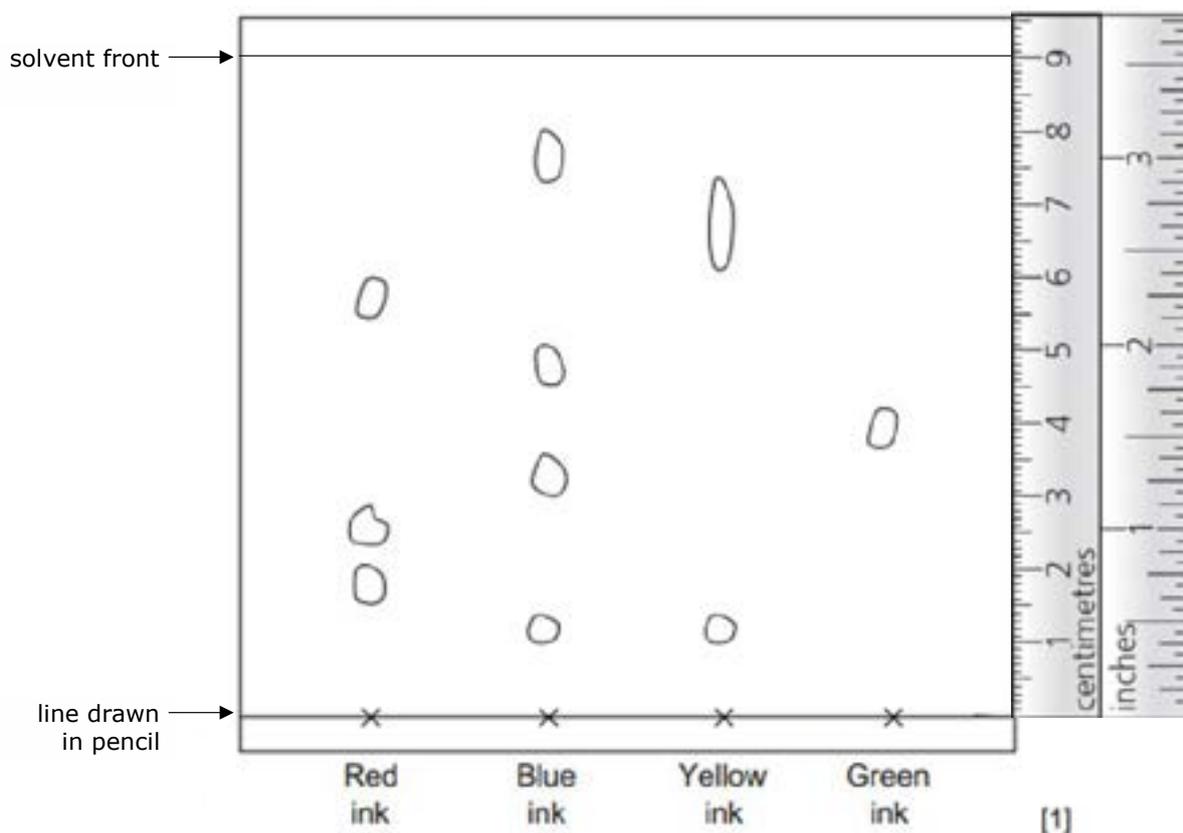
(iv) What general term is used for liquid **A** collected in Method 2 and liquid **B** collected in Method 3?

**A** \_\_\_\_\_  
**B** \_\_\_\_\_ [2]

(v) Liquid B was found to have a boiling point range of 79 and 82 °C. Is liquid B pure? Explain your answer.

\_\_\_\_\_  
 \_\_\_\_\_ [2]

- (b) A student analyses four different inks using paper chromatography. The inks are spotted along a pencil line. The chromatography paper is placed in a solvent and the coloured components in the inks separate out. The resulting chromatogram is shown below.



- (ii) Which ink contains the most soluble component?

\_\_\_\_\_ [1]

- (iii) Which **two** inks contain one common component?

\_\_\_\_\_ [1]

- (iv) What do you understand by the term solvent?

\_\_\_\_\_ [1]

- (v) Which ink is a pure substance?

\_\_\_\_\_ [1]

(vi) What is meant by the term **pure substance**?

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[1]

(vii) Calculate the  $R_f$  value for green ink. Take your measurements to the centre of the spot.

[2]

(viii) Name the stationary phase in this experiment.

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[1]

2. Describe the method of a flame test, and state the result if copper(II) chloride is tested in a flame test.

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[4]

3. Describe a chemical test for water including what you would observe.

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[3]

