

# Chapter 12: Chemical analysis

## Knowledge organiser

### Pure and impure

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

Pure substances melt and boil at specific temperatures.

An **impure** substance contains more than one type of element or compound in a **mixture**.

Impure substances melt and boil at a range of temperatures.

### Formulations

**Formulations** are examples of mixtures. They have many different components (substances that make them up) in very specific proportions (amounts compared to each other).

Scientists spend a lot of time trying to get the right components in the right proportions to make the most useful product.

Formulations include fuels, cleaning agents, paints, alloys, fertilisers, and foods.

### Testing gases

Common gases can be identified using the follow tests:

Gas	What you do	What you observe if gas is present
hydrogen	hold a lighted splint near the gas	hear a squeaky pop
oxygen	hold a glowing splint near the gas	splint re-lights
carbon dioxide	bubble the gas through limewater	the limewater turns milky (cloudy white)
chlorine	hold a piece of damp litmus near the gas	bleaches the litmus white

### Flame tests

Substances containing metals can produce a coloured light in a flame. This can be used to identify the metal. However, if there is more than one metal in the substance then this method will not work, as the colours mix and intense colours mask more subtle colours.

Metal	Flame colour
lithium	crimson
sodium	yellow
potassium	lilac
calcium	orange-red
copper	green

### Instrumental methods

**Instrumental analysis** involves using complex scientific equipment to test substances.

Instrumental methods are rapid and accurate. They are also sensitive, which means they can give results even with very small amounts of substance.

### Flame emission spectroscopy

**Flame emission spectroscopy** is a type of instrumental analysis similar to a **flame test**.

The sample solution is put into a flame and the light given off is passed through a spectroscope. Instead of a human observing a colour, the instrument tells you exactly which wavelength of light is being given off as a line spectrum. You can then compare the spectrum to a reference to establish the identity of your sample. You can also measure the concentration of the substance in your sample solution.

### Chromatography

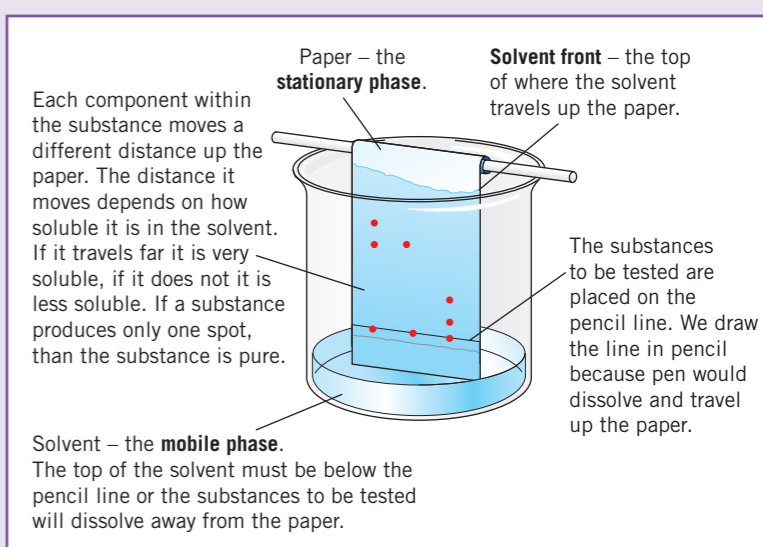
**Chromatography** is a method to separate different components in a mixture. It is set up as shown here, with a piece of paper in a beaker containing a small amount of solvent.

The **R<sub>f</sub> value** is a ratio of how far up the paper a certain spot moves compared to how far the **solvent** has travelled.

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

It will always be a number between 0 and 1.

The R<sub>f</sub> value depends on the solvent and the temperature, and different substances will have different R<sub>f</sub> values. The R<sub>f</sub> values for particular solvents can be used to identify a substance.



### Testing for cations

Metal ions always have a positive charge (i.e., they are cations). Sodium hydroxide solution can be used to identify some metal ions.

Cation	Positive result
aluminium ions, Al <sup>3+</sup>	on slow addition of excess sodium hydroxide solution, white <b>precipitate</b> forms that eventually dissolves again with excess sodium hydroxide
calcium ions, Ca <sup>2+</sup>	on addition of excess sodium hydroxide solution, white precipitate that does not dissolve
magnesium ions, Mg <sup>2+</sup>	on addition of excess sodium hydroxide solution, white precipitate that does not dissolve
copper(II) ions, Cu <sup>2+</sup>	forms a blue precipitate
iron(II) ions, Fe <sup>2+</sup>	forms a green precipitate
iron(III) ions, Fe <sup>3+</sup>	forms a brown precipitate

### Testing for anions

Anion	Test	Positive result
carbonate, CO <sub>3</sub> <sup>2-</sup>	add dilute acid	carbon dioxide gas formed which can be test for with limewater
chloride, Cl <sup>-</sup>	add silver nitrate solution in the presence of nitric acid	white precipitate formed
bromide, Br <sup>-</sup>	add silver nitrate solution in the presence of nitric acid	cream precipitate formed
iodide, I <sup>-</sup>	add silver nitrate solution in the presence of nitric acid	yellow precipitate formed
sulfate, SO <sub>4</sub> <sup>2-</sup>	add barium chloride solution in the presence of hydrochloric acid	white precipitate formed

### Key terms

Make sure you can write a definition for these key terms.

chromatography    flame emission spectroscopy    flame test    formulation    impure    instrumental analysis  
mobile phase    precipitate    pure    R<sub>f</sub> value    solvent    solvent front    stationary phase

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## Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

### C12 questions

### Answers

1	In chemistry, what is a pure substance?	Put paper here	something made of only one type of substance
2	What is the difference between the melting and boiling points of a pure and impure substance?	Put paper here	pure – sharp/one specific temperature impure – broad/occurs across a range of temperatures
3	What is a formulation?	Put paper here	a mixture designed for a specific purpose
4	What are some examples of formulations?	Put paper here	fuels, cleaning agents, paints, medicines, alloys, fertilisers, and foods
5	What is chromatography?	Put paper here	a process for separating coloured mixtures
6	How is $R_f$ calculated?	Put paper here	$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$
7	What is the test for hydrogen?	Put paper here	a lit splint gives squeaky pop
8	What is the test for oxygen?	Put paper here	re-lights a glowing splint
9	What is the test for carbon dioxide?	Put paper here	turns limewater milky if bubbled through it
10	What is the test for chlorine?	Put paper here	bleaches damp litmus paper
11	What is the test for aluminium, calcium, and magnesium ions?	Put paper here	forms white precipitate with sodium hydroxide solution
12	How can aluminium ions be distinguished from calcium and magnesium ones?	Put paper here	the white precipitate will dissolve with excess sodium hydroxide
13	What colour precipitates are formed when sodium hydroxide solution is added to solutions of copper(II), iron(II), and iron(III) ions?	Put paper here	copper(II) ions form blue precipitate, iron(II) ions form green precipitate, iron(III) ions form brown precipitate
14	What is the test for a halide ion?	Put paper here	add silver nitrate and nitric acid: chloride forms white precipitate, bromide forms cream precipitate, iodide forms yellow precipitate
15	What is the test for a carbonate ion?	Put paper here	carbon dioxide gas formed on addition of acid
16	What is the test for a sulfate ion?	Put paper here	white precipitate formed with hydrochloric acid and barium chloride
17	What colours are produced by different metals in a flame test?	Put paper here	lithium – crimson; sodium – yellow; potassium – lilac; calcium – orange-red; copper – green
18	What is instrumental analysis?	Put paper here	using complex scientific equipment to identify substances
19	What are the three advantages of instrumental analysis?	Put paper here	rapid, accurate, and sensitive
20	What information does flame emission spectroscopy produce?	Put paper here	the wavelength of light given off by a metal in a flame to identity of the metal and its concentration