Topic 8: Chemical analysis

AQA GCSE Chemistry (8462), topic 4.8

Chemical analysis: choosing evidence

- explain what "pure" means in chemistry, and use melting points as evidence of purity;
- explain what a **formulation** is;
- carry out paper **chromatography** and calculate Rf values;

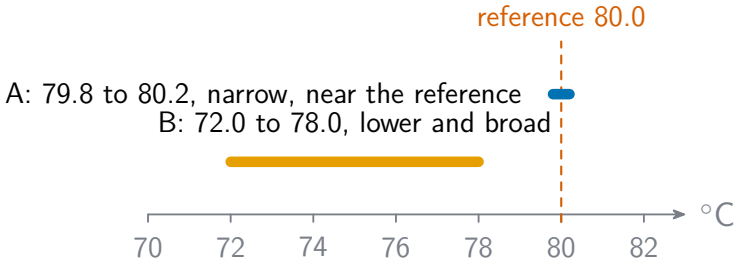
Chemical analysis: choosing evidence (2)

- carry out the tests for four gases;
- (chemistry only) identify metal ions and negative ions with flame tests and **precipitate** tests;
- (chemistry only) explain the advantages of instrumental methods such as **flame emission spectroscopy**.

Purity and formulations

- In everyday language, "pure" means nothing has been added: "pure orange juice".
- In chemistry, a **pure substance** is a single **element** or a single compound, with nothing else mixed in.
- Orange juice is a **mixture** of water, sugars, acids and much more, however natural it is.
- A **pure substance** melts and boils at one exact temperature.

Figure: Purity and formulations



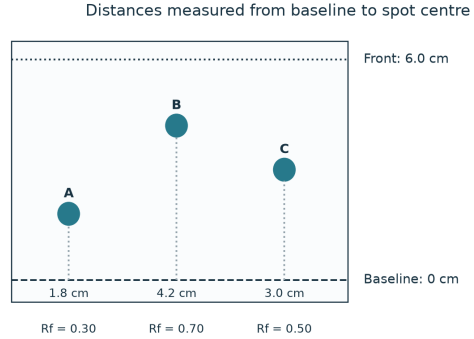
- A **pure substance** melts at one fixed temperature.
- Impurities lower and broaden the range.

Chromatography

- **Chromatography** separates the substances in a **mixture**.
- In paper **chromatography**, the paper is the **stationary phase**, which does not move, and the **solvent** is the **mobile phase**, which moves up through the paper.
- Each substance is shared between the two phases in a different way.
- A substance that is more attracted to the **solvent** moves further up the paper.

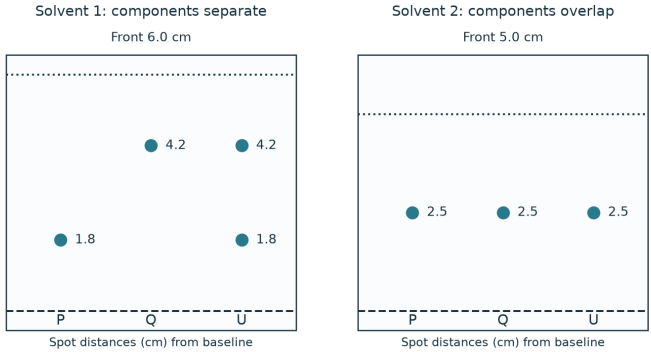
$$R_f = \frac{\text{distance from baseline to centre of spot}}{\text{distance from baseline to solvent front}}$$

Figure: Chromatography



- Measure to the centre of a spot and to the **solvent front**.
- A: 1.8/6.0=0.30; B: 4.2/6.0=0.70; C: 3.0/6.0=0.50.

Figure: Chromatography ·

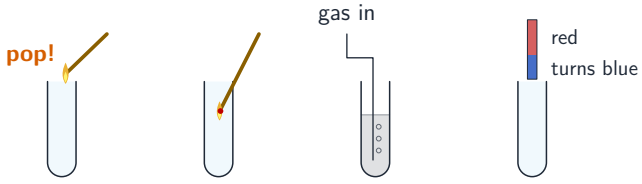


- P and Q separate in **solvent** 1 but overlap in solvent 2.
- A single observed spot can contain both components.

Tests for gases

- **Worked example 4.** A gas makes a glowing splint burst back into flame.
- It is oxygen.
- Notice the splint must be glowing, not burning: a burning splint cannot "relight".
- Chlorine is toxic, so it is tested only in small amounts in a fume cupboard.

Figure: Tests for gases



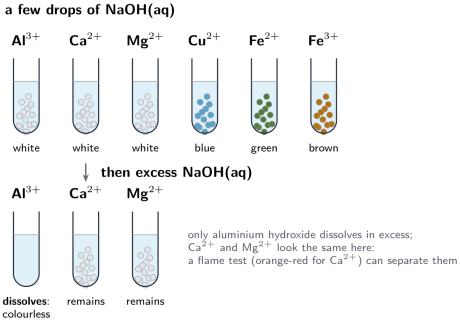
- Pair each test with its **observation**.
- Say what you see, not what it means.

Identifying metal ions (chemistry only)

- **Flame tests.** For a **flame test** , dip a clean wire loop in the solid, hold it in a hot Bunsen flame, and observe the colour.
- Clean the loop between tests to avoid **contamination** .
- In a **mixture**, one colour can hide another: the strong yellow of sodium can mask the others.
- **Sodium hydroxide test.** Add a few drops of sodium hydroxide solution to a solution of the compound.

$$\mathrm{CuCl_2(aq) + 2NaOH(aq) \rightarrow Cu(OH)_2(s) + 2NaCl(aq)}$$

Figure: Identifying metal ions (chemistry only)



- Among Al, Ca, Mg white precipitates, only aluminium dissolves in **excess**.
- Cu^{2+}blue; Fe^{2+}green; Fe^{3+}brown precipitates.

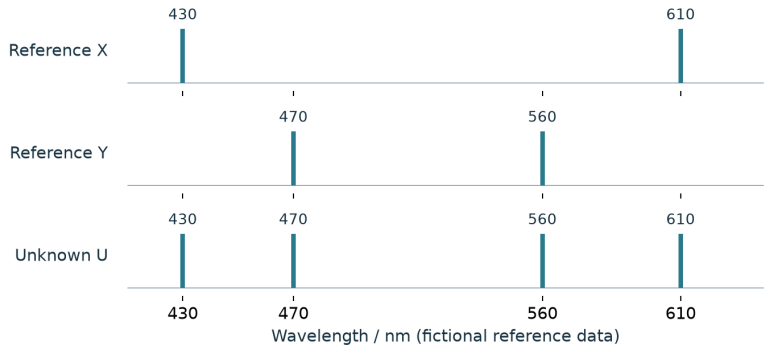
Identifying negative ions (chemistry only)

- The acid removes carbonate ions, which would otherwise also give a **precipitate**.
- Use nitric acid, not hydrochloric acid, in the halide test, because hydrochloric acid contains chloride ions and would always give a white precipitate.
- Use a fresh sample of the unknown for each test, so that the chemicals from one test do not affect the next.
- **Worked example 6.** A white solid gives a lilac flame, and its solution gives a cream precipitate with nitric acid and **silver nitrate**.

Instrumental methods (chemistry only)

- An **instrumental method** uses a machine to analyse a sample.
- Instruments are **accurate** , giving results close to the true value; they have high **sensitivity** , detecting very small amounts; and they are fast.
- They must be set up with known samples first, a process called **calibration** .
- **Flame emission spectroscopy. Spectroscopy** studies light.

Figure: Instrumental methods (chemistry only)



- U contains the lines of both reference metals X and Y.
- Match supplied lines: X at 430 and 610 nm; Y at 470 and 560 nm.

Sources for this lesson

- AQA, *GCSE Chemistry (8462) specification*, section 4.8, and the required practicals handbook (Required practicals 6 and 7).
- J. C. Whorton, *The Arsenic Century: How Victorian Britain was Poisoned at Home, Work, and Play* (2010), on the Bradford sweets poisoning of 1858.
- *Pharmacy Act 1868* (31 & 32 Vict. c. 121), on the sale of poisons.
- G. Kirchhoff and R. Bunsen, "Chemische Analyse durch Spectralbeobachtungen", *Annalen der Physik* (1860), the origin of flame **spectroscopy**.

Common errors

- Saying a natural product with nothing added is "pure"; in chemistry, pure means one substance only.
- Drawing the **baseline** in ink, or putting it below the **solvent** level.
- Measuring to the edge of a spot, or from the bottom of the paper, when calculating Rf.

Common errors (2)

- Testing for oxygen with a burning splint; it must be glowing.
- Using hydrochloric acid in the halide test; it adds chloride ions.
- Confusing copper's green flame with its blue hydroxide **precipitate**, or the green Fe^{2+} precipitate with the brown Fe^{3+} one.
- Writing an **observation** when the question asks for a **conclusion**, or the other way round.

Key terms

- **Pure substance**: a single **element** or compound, not mixed with any other substance.
- **Formulation**: a **mixture** designed as a useful product, with measured amounts of each part.
- **Chromatography**: a method of separating substances that move at different speeds through a **stationary phase**.

Key terms (2)

- **Rf value**: the distance moved by a substance divided by the distance moved by the **solvent**.
- **Precipitate**: an insoluble solid that forms when two solutions react.
- **Flame emission spectroscopy**: an **instrumental method** that identifies metal ions from the lines in the light they give out in a flame.

Check yourself

- 1.
- Is sea water a **pure substance**?
- Explain. 2.
- A solid melts between 61 °C and 66 °C.