

Orbitals, configurations and ionisation energy patterns

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

Why do salts of different metals colour a flame differently? In this lab you view flame colours through a hand spectroscope, read the wavelengths and convert them to photon energies, linking electron energy levels to the ionisation energies you studied.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.1.1, IB S1.3

Aim

To observe the colours that metal ions give in a flame, to read the wavelength of each colour with a hand spectroscope, and to calculate the energy of the photons emitted.

Equipment

- Bunsen burner and heatproof mat
- Nichrome wire loop or wooden splints soaked overnight in distilled water
- Solutions of the chlorides of lithium, sodium, potassium, calcium and barium (0.5 mol dm^{-3})
- Dilute hydrochloric acid (2 mol dm^{-3}) in a small beaker
- Hand spectroscope with a wavelength scale in nm
- Safety goggles

Safety

Safety

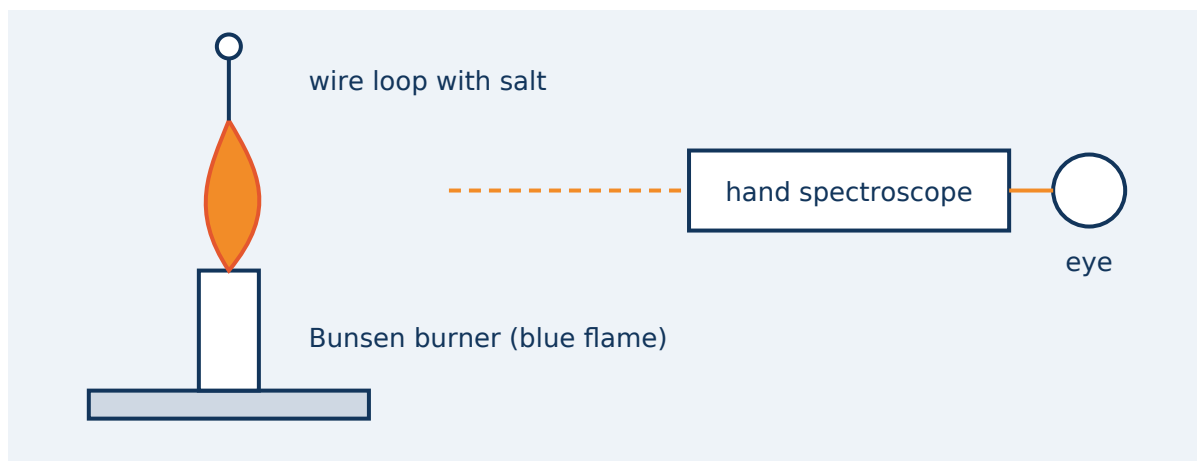
Wear goggles. Tie back long hair. Barium salts are toxic, so wash hands after use and do not taste anything. Keep the dilute acid away from the eyes and never point the spectroscope at the Sun.

Method

1. Light the Bunsen burner and adjust it to a blue flame.
2. Clean the wire loop in the acid, then heat it until it gives no colour.
3. Dip the loop in the first solution and hold it at the edge of the flame.
4. Note the flame colour, then look at the flame through the spectroscope and read the

wavelength of the brightest line.

5. Clean the loop again and repeat for each solution.



A salt on a wire glows in the flame, and the light passes through a spectroscope to the eye.

Results

A student in Lagos recorded these readings (uncertainty ± 5 nm).

Ion	Flame colour	Wavelength / nm
Lithium	crimson	670
Sodium	yellow-orange	589
Potassium	lilac	767
Calcium	orange-red	622
Barium	pale green	554

Analysis questions

Question 1 Photon energy of sodium

Use $E = hc/\lambda$ with $h = 6.626 \times 10^{-34}$ J s and $c = 3.00 \times 10^8$ m/s. Calculate the energy of one photon of the sodium line, in joules.

Question 2 Energy per mole

Convert the sodium photon energy to kJ per mole using 6.022×10^{23} mol⁻¹.

Question 3 Completing the calculation

Calculate the energy per mole, in kJ mol⁻¹, for lithium and potassium.

Question 4 Origin of the colours

Explain how a metal ion in a flame produces light of one colour.

Question 5 Comparison with ionisation

The first ionisation energy of sodium is 496 kJ mol^{-1} . Compare it with your sodium value and explain the difference.

Question 6 Reliability

Calculate the percentage uncertainty in the sodium wavelength and the uncertainty in its energy per mole.

Question 7 Improving the method

Propose two changes to the spectroscope work that would tighten the wavelength readings.