

EXPERIMENT #2 — FLAME TESTS

Note: Experiments #2 and #3 can be completed together in a single lab period (90 minutes). A combined data sheet for the two labs can be found after Experiment #3.

Discussion: Many of the active metals (Group I and II of the Periodic Table) vaporize readily and give characteristic colors when heated in a flame. These colors may be used to identify the metallic ions in the laboratory. This is done by dipping a clean platinum wire into a solution (or dry salt) and then holding it in the hottest part of a Bunsen burner flame. It is believed that the color produced is due to the energy released when outer electrons of the atom drop to lower energy levels as the atoms cool after being heated.

Special Equipment: Cotton tipped applicators with wooden sticks, 24-well microplate.

Materials: 1M barium chloride, 1M calcium chloride, 0.5 M lithium chloride, 1M potassium chloride, 1M sodium chloride, 1M strontium chloride, 0.5 M sodium nitrate, and solid sodium chloride.

Directions: Using separate 1 mL microtip pipets, obtain samples (~1 mL) of each of the solutions listed above. Put each sample in separate clean wells in your 24-well microplate. Also obtain a small sample of solid sodium chloride and put this in one of the wells.

Take a clean cotton tipped applicator and put it into each of the aqueous samples. Allow the applicator to soak in the solution for two to three minutes. When ready, start with the sample of aqueous sodium nitrate. Put the tip of the applicator into the flame. Do not put the cotton tip all the way into the flame as this will cause the wooden stick to catch fire. Observe the color of the flame just above the tip of the applicator. Record your observations.

Test the solution of sodium chloride in the same manner. Repeat the test by soaking an applicator in deionized water and then dabbing the wet applicator in a little dry sodium chloride. Record your observations on the data sheet.

Repeat the procedure using, in turn, the solutions of the chlorides (or nitrates) of lithium, calcium, strontium, barium and potassium. In the cases of lithium and strontium, observe which flame is more persistent and takes longer to form when the applicator is put in the flame. Also note the difference in the shades of color produced. Record your observations on the data sheet.

If two salts are present in the same solution, the color of one flame may obscure that of the other. Sometimes it is possible to selectively absorb one color and not the other. Examine the sodium flame through at least two thicknesses of cobalt blue glass. Repeat using the potassium flame with the cobalt glass.

Prepare a mixture of the solutions of the chlorides (or nitrates) of sodium and potassium. Soak a clean applicator in this mixture. Observe the color the mixture imparts to the flame when viewed both with and without cobalt glasses. Record your observations.

Obtain two unknown solutions from the instructor. The unknowns may contain one of the following metals: sodium, lithium, potassium, strontium, calcium, barium, or a mixture of sodium and potassium. Test each unknown in order to identify it. Turn in your results.

EXPERIMENT #3 — IDENTIFICATION OF ELEMENTS BY THEIR EMISSION SPECTRA

Discussion¹: Spectroscopy is a useful tool for studying the structure of atoms. By examining the bright-line (emission) spectra of elements and compounds, the identity of the atoms in those substances can be determined.

When substances are heated or energized sufficiently, the electrons are promoted to higher energy levels. When these electrons fall back to lower energy levels, energy, in the form of light with wavelengths characteristic of the substance, is released. Different excited atoms produce different emission spectra that can be used as “fingerprints” of particular elements.

¹ Adapted from *Modern Chemistry*, N. D. Tzimopoulos, H. C. Metcalfe, J. E. Williams, J. F. Castka; Holt, Reinhart and Winston, New York, 1990, 103-4.

Materials: Six discharge tubes — argon, helium, hydrogen, krypton, mercury and neon; ionic salts (lithium, sodium and a sodium/lithium mixture); incandescent light source; red, blue and green filters; calibrated spectrosopes; power supplies; colored pencils.

Procedure: [As an alternative to using discharge tubes (particularly as the spectra of argon, krypton and neon are complex), it is often better to use the spectrosopes to observe the spectra of the ionic salts used in the “flame test” lab. In order to observe the spectra of these compounds, it is best to soak a clean, cotton tipped wooden applicator in deionized water and then dip the applicator in samples of the solid salts that have been placed in a 24-well plate.]

Power supplies containing the six different discharge tubes can be found at various stations around the lab. Examine the characteristic emission spectrum of each element by using the calibrated spectroscopy provided. Make your observations as quickly (but accurately!) as possible as it is best not to leave the tubes on for more than 1-2 minutes at a time. Do not touch the power supply or the tube while the power supply is in operation!

Identify the color and wavelength for the characteristic bright lines of each spectrum. For complex spectra, try to identify only the 6-10 brightest lines that you observe. It is important that you read the wavelength scale correctly. You will note that moving the spectroscopy slightly from side to side will cause the lines to shift slightly along the internal scale. Consequently, you will want to record the wavelength value for the brightest lines when those lines are the most intense. The wavelength scale runs from 4.0 to 7.0. These values can be converted to nanometers (nm; $1 \text{ nm} = 10^{-9} \text{ m}$) by multiplying the observed value by 100 (example: 6.5 is 650 nm). Record the wavelengths of the observed lines to the nearest 5 nm.

Draw a diagram of the observed bright line spectrum for each element on the data sheet provided. Color code each line and indicate the wavelength in nm below each line.

Observe the emission spectra of an incandescent white light and a fluorescent white light. Record your observations.

Observe the emission spectra of an incandescent white light through red, blue and green filters. Record your observations.

Turn in your results to your instructor.

Questions:

1. Explain why some spectra are more complex than others.
2. Why do the discharge tubes get hot after running for a period of time?
3. Account for any differences between the emission spectra of an incandescent white light and a fluorescent white.
4. Account for your observations of the emission spectra of an incandescent white light as seen through red, blue and green filters.
5. Which photon has a higher energy, one with a wavelength of 450 nm or with a wavelength of 650 nm. Explain. What are the characteristic colors of each?

Part A — Flame Tests and Emission Spectra

| Compound/Mixture | Flame color | Emission spectrum (Principal lines) |
|-----------------------------------------|-------------|-------------------------------------|
| Barium | _____ | |
| Calcium | _____ | |
| Lithium | _____ | |
| Strontium | _____ | |
| Potassium | _____ | |
| Sodium | _____ | |
| Potassium (w/ cobalt glass) | _____ | no spectrum required |
| Sodium (w/ cobalt glass) | _____ | no spectrum required |
| Sodium + Potassium | _____ | no spectrum required |
| Sodium + Potassium (w/ cobalt glass) | _____ | no spectrum required |
| Sodium + Lithium (Mixture A) | _____ | |
| Sodium + Lithium (Mixture B) | _____ | |

Part B — Gas Discharge Tubes

| Discharge tube | Gas color | Emission spectrum (Principal lines) |
|----------------|-----------|-------------------------------------|
| Hydrogen | _____ | |
| Helium | _____ | |
| Mercury | _____ | |

Part C — Incandescent and Fluorescent Lights

| Type of light source | Description of spectrum |
|-----------------------------------|-------------------------|
| Incandescent | _____ |
| Incandescent (w/ red filter) | _____ |
| Incandescent (w/ green filter) | _____ |
| Incandescent (w/ blue filter) | _____ |
| Fluorescent | _____ |