ANSWER KEY. Colors match the simulation readouts. Every possible unknown is listed.

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Flame Test Virtual Lab

Chemistry | ANSWER KEY

Open **activities.zornscience.org/flame-test-lab/** and follow each step. Record what the simulation shows.

Objective

Find out why metal salts give off colored light in a flame and why each metal has its own color. Then identify an unknown salt.

NGSS alignment: HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

Practices and concepts: Planning and carrying out investigations; Constructing explanations; Patterns; Energy and matter (PS1.A, PS4.B).

Meet the simulation

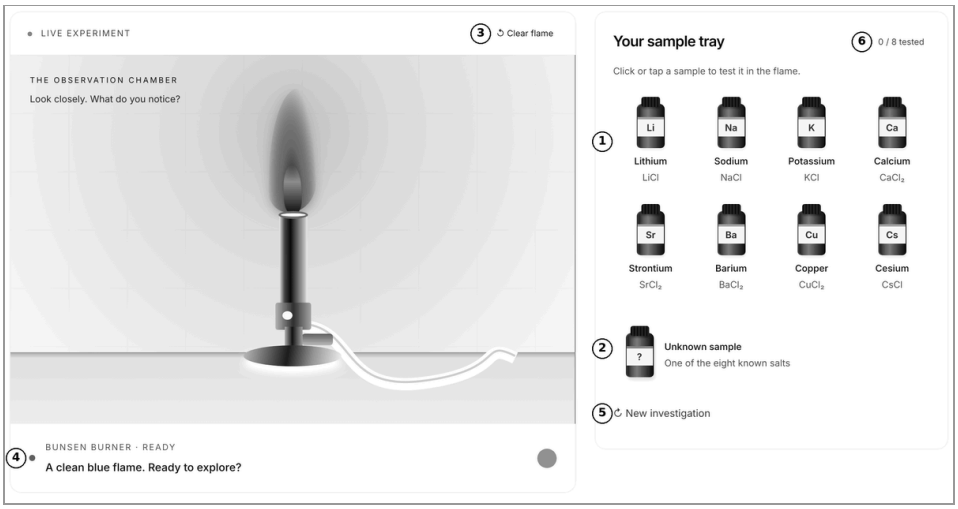


Figure 1. The Virtual Flame Test Lab. The dark flame chamber is shown inverted for printing.

(1) Eight known metal chlorides. Click a bottle to put it in the flame.

(2) The unknown sample. It is one of the eight known salts.

(3) Clear flame returns to the clean blue flame.

(4) Readout: the sample name and the flame color in words.

(5) New investigation picks a new random unknown.

(6) Counts how many known samples you have tested.

Pre-lab

1. Define **ground state** and **excited state** for an electron.

Ground state: the lowest energy arrangement of an atom's electrons (its normal, most stable state). Excited state: an electron has absorbed energy and moved up to a higher energy level.

2. In a flame test, where does the energy that excites the electrons come from? What does an electron give off when it drops back to a lower energy level?

The heat of the Bunsen burner flame excites the electrons. When an electron drops back down, it releases the extra energy as light.

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3. Prediction: will all eight metal chlorides give the same flame color? Explain your prediction.

No. Each element has its own set of energy levels, so the energy drops (and the colors of light) are different for each metal.

Part A. Test the known samples

1. Click each of the eight known bottles, one at a time. The wire loop is cleaned between tests.
2. Record the flame color exactly as the readout words it (Figure 2).
3. Use the color chart below to record the wavelength range for that color.



Figure 2. The readout after testing sodium chloride.

Color of light	Wavelength (nm)
Violet	400 to 450
Blue	450 to 495
Green	495 to 570
Yellow	570 to 590
Orange	590 to 620
Red	620 to 700

Table 1. Approximate wavelength ranges of visible light.

Metal	Formula	Flame color (readout)	Wavelength range (nm)
Lithium	LiCl	**Crimson red**	**620 to 700 (red)**
Sodium	NaCl	**Intense golden yellow**	**570 to 590 (yellow)**
Potassium	KCl	**Pale lilac**	**400 to 450 (violet)**
Calcium	$CaCl_2$	**Orange-red / brick red**	**590 to 620 (orange)**
Strontium	$SrCl_2$	**Scarlet red**	**620 to 700 (red)**
Barium	$BaCl_2$	**Apple green**	**495 to 570 (green)**
Copper	$CuCl_2$	**Blue-green**	**about 480 to 510 (blue-green)**
Cesium	CsCl	**Blue-violet**	**about 430 to 470 (blue-violet)**

Table 2. Flame colors of eight known metal chlorides.

4. Every sample contains chlorine. Is the color caused by the metal or by the chlorine? Use your data to explain how you can tell.

The metal. Chlorine is in all eight samples, but the color changes every time the metal changes. If chlorine caused the color, every flame would be the same color.

5. Which two known samples are the hardest to tell apart by eye? Why?

Lithium (crimson red) and strontium (scarlet red). Both give red light in the same wavelength range, so the colors look very similar. (Calcium's orange-red is also close.)

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Part B. Identify the unknown

1. Click the **Unknown sample** bottle. Record its flame color from the readout.
2. Compare it with Table 2 and identify the metal. Click that known sample again to check that the readouts match.
3. Click **New investigation** to get a second random unknown. Repeat steps 1 and 2. (Your two unknowns may be the same salt.)

Unknown	Flame color (readout)	Identity (name and formula)
Unknown 1		
Unknown 2		

Unknowns are random. Match the readout to Table 2: Crimson red = lithium chloride, LiCl. Intense golden yellow = sodium chloride, NaCl. Pale lilac = potassium chloride, KCl. Orange-red / brick red = calcium chloride, $CaCl_2$. Scarlet red = strontium chloride, $SrCl_2$. Apple green = barium chloride, $BaCl_2$. Blue-green = copper(II) chloride, $CuCl_2$. Blue-violet = cesium chloride, CsCl. Check that the student's identity matches the color they recorded.

6. What evidence supports your identification of Unknown 1? Why is it important to test the matching known sample again?

The unknown's readout matched one known salt exactly (same color words and same wavelength range) and no other known. Testing the known again side by side confirms the match and rules out a similar color (such as crimson red vs. scarlet red).

Analysis

7. Explain how a flame test makes colored light. Use the words **electron**, **energy level**, **absorb**, and **light**.

Electrons in the metal absorb energy from the flame and jump to a higher energy level (excited state). They are unstable there, so they fall back to a lower energy level and give off the extra energy as light. That light is the color we see.

8. Why does each element give off its own color?

Each element has a different number of protons and electrons, so its energy levels are spaced differently. The size of each energy drop sets the wavelength of light, so each element gives its own colors.

9. Potassium gives violet light and lithium gives red light. Which element has the larger energy drop? Explain using wavelength.

Potassium. Violet light has a shorter wavelength than red light, and shorter wavelength means higher energy. A larger energy drop gives higher energy light.

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10. This simulation uses pure samples and ideal colors. In a real lab, a tiny bit of sodium can hide other colors. How would this affect your results, and how could a chemist confirm an identity when two colors look alike?

Sodium's bright yellow could cover a weaker color, so the sample could be misidentified as sodium. Clean the wire loop well between tests. To confirm, look at the flame through a spectroscope: each element has its own line spectrum (or use a different chemical test).

11. Fireworks use metal salts to make colors. Which metal from this lab would you use for green fireworks? For orange fireworks?

Green: barium ($BaCl_2$). Orange: calcium ($CaCl_2$).

Conclusion

12. Write a claim that answers the objective: why do metal salts give colored flames, and why is each color different? Support it with evidence from Parts A and B (specific samples and colors), then explain your reasoning using electrons and energy levels.

Claim: Metal salts give colored flames because their electrons absorb energy and then release it as light. Each metal has its own color because its energy levels are spaced differently, so a flame color can identify a metal.
Evidence: All eight samples had chlorine, but each metal gave a different color: sodium was intense golden yellow, barium was apple green, and lithium was crimson red. My unknown matched exactly one known salt (sample answer: the unknown gave an apple green flame, the same as $BaCl_2$).
Reasoning: The flame excites electrons to higher energy levels. When they fall back down, they emit light. The size of the energy drop sets the wavelength and color. Because every element has a unique set of energy levels, every metal gives a characteristic color.

13. Your teacher gives you a salt that makes a red flame. Name all the salts from this lab it could be, and describe one way to decide between them.

Lithium chloride (crimson red) or strontium chloride (scarlet red). Calcium chloride (orange-red / brick red) is also possible. Test each known side by side with the unknown and compare the shade, or view each flame through a spectroscope and match the line spectrum.

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