The Case of the Contaminated Well

Scenario

Local commissioners decided it was time for the county to have its own Crime Investigative Service. Since you are a highly decorated chemistry student in high school, you have been hired to start this new crime fighting division. On your first day on the job, you get a call from an elderly woman with a complaint against the "lousy, good-for-nothin' teenagers who lived next door." She reports that these kids contaminated her well with some type of liquid. "I saw them do it! They put something in there and now I am afraid to drink my water!" You decide to take a sample of her well water for analysis. While interviewing the accused, you notice an unmarked container of water sitting on the workbench of the neighbor's garage. Possibly, this contained the liquid that was added to the well. To be sure, you collect a sample to compare to the well sample. Fortunately, you remember a procedure that you conducted in chemistry class, called a flame test. It is a way to identify certain metal ions in a solution. You create a series of known solutions with possible contaminants and test them against both the garage sample and the neighbor's well.

Materials

- Metallic Salt Solutions in labelled 100mL beakers:
    - 1.0M Barium Chloride ($BaCl_2$)
    - 1.0M Calcium Chloride ($CaCl_2$)
    - 1.0M Copper Chloride ($CuCl_2$)
    - 1.0M Lithium Chloride (LiCl)
    - 1.0M Potassium Chloride (KCl)
    - 1.0M Sodium Chloride (NaCl)
    - 1.0M Strontium Chloride ($SrCl_2$)
    - Evidence Sample from Well
    - Evidence Sample from Neighbor's Garage
- 250mL beakers of water (for extinguishing flame)
- Bunsen burners
- Wooden splints

Directions for each station:

- **Read the given contaminant name** in the data table
- **Record** the contaminant formula **from the Materials List above** in the data table
- **Watch** the **flame test video** for information about the known samples
- **Record** the metallic ion and flame color in the data table for each contaminant
- **Watch** the **video** for information about the **forensic evidence samples**
- **Read the background passage** about flame tests and spectral lines
- Complete the forensic analysis section using the CER format (claim, evidence, reasoning)

Safety

- Barium chloride is highly toxic. Do not ingest the salt or solution.
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher's instructions for cleanup of materials and disposal of chemicals.
- Always use caution around open flames. Keep flames away from flammable substances.
- Always be aware of an open flame. Open flames can cause burns. Do not reach over it, tie back hair, and secure loose clothing.

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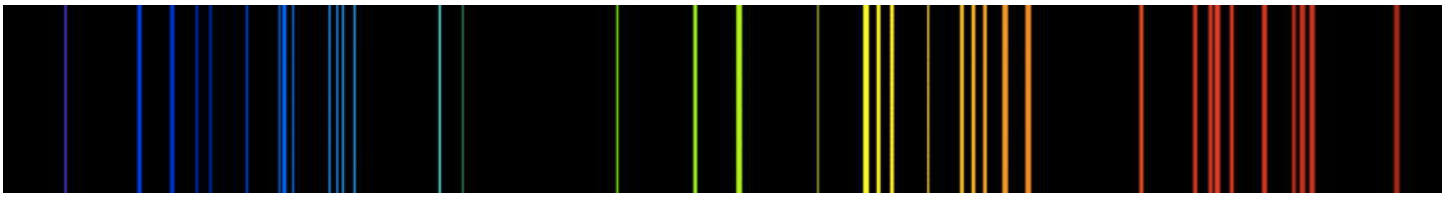
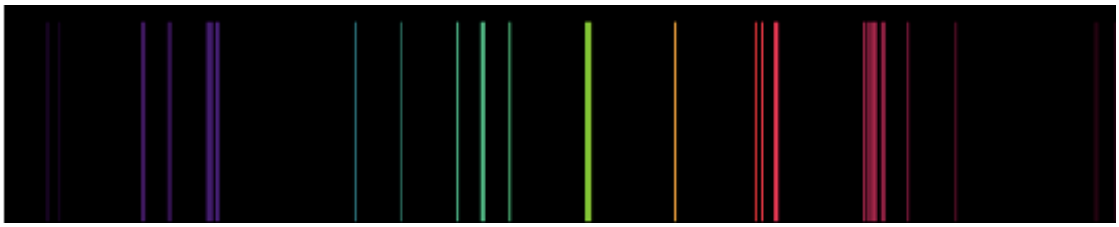
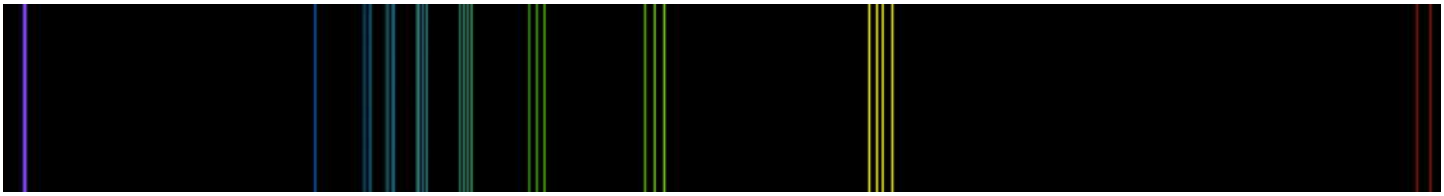
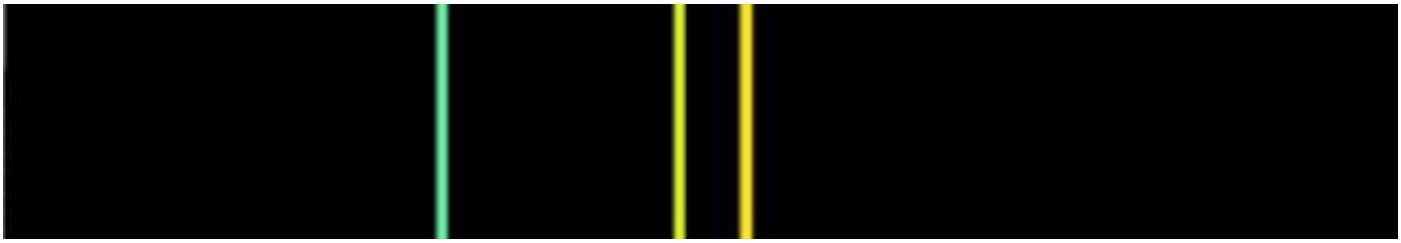
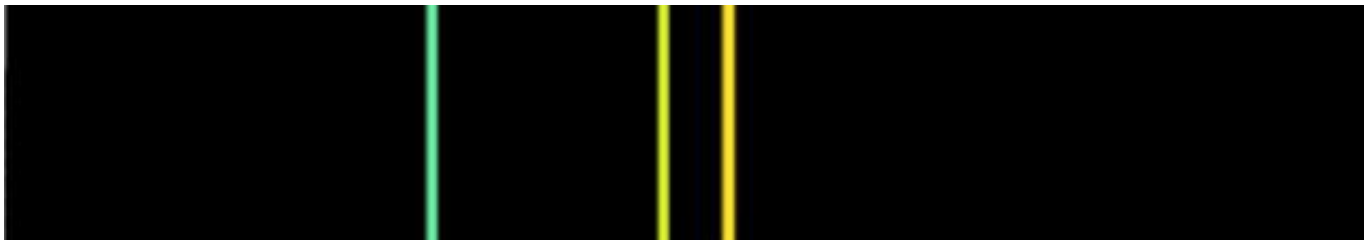
Data

Known Samples				
Station	*Contaminant Name*	*Contaminant Formula*	*Metal Ion*	*Flame Color*
1	Barium Chloride			
				
2	Calcium Chloride			
				
3	Copper Chloride			
				
4	Lithium Chloride			
				

Known Samples				
Station	*Contaminant Name*	*Contaminant Formula*	*Metal Ion*	*Flame Color*
5	Potassium chloride			
				
6	Sodium Chloride			
				
7	Strontium Chloride			
				

Forensic Evidence Samples		
Evidence type	*Color Observed*	*Possible Contaminant Identification*
Garage Sample		

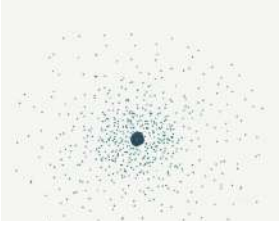
Forensic Evidence Samples		
Evidence type	*Color Observed*	*Possible Contaminant Identification*
Well Sample		



When you are thinking about what you have discovered, you remember the following information about flame tests

Electrons are found around the nucleus in regions called **orbitals** based upon the electron cloud model.

Orbitals represent the potential position of an electron at any given point in time. Orbitals are located at different distances from the nucleus and have different energy levels associated with them. The electrons of an atom fill low-energy orbitals, which are the ones closer to the nucleus, before they fill higher-energy ones.



Wave Mechanical Model

Electrons are in the **ground state** when under stable conditions. When the electrons in an atom are bombarded with energy from an outside source, however, they **absorb** that energy and jump temporarily to a higher energy level. The electrons are said to be in an **excited state** when this happens.

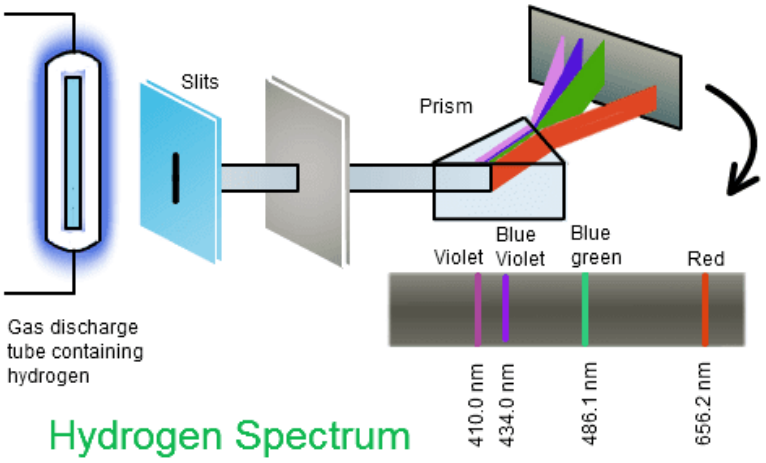
When those electrons **release** that energy, it is emitted in the form of electromagnetic radiation. If that electromagnetic radiation falls between 400 and 700 nanometers (nm) in wavelength, it is given off in the form of visible light.

Many common metal ions, such as Li^{+}, Na^{+}, K^{+}, Ca^{+2}, Ba^{+2}, Sr^{+2}, and Cu^{+2}, produce a distinct color of visible light when they are heated. These ions emit (release) a unique color of light because they consist of atoms that have a unique electron configuration. Chemists can therefore identify these elements with a flame test.

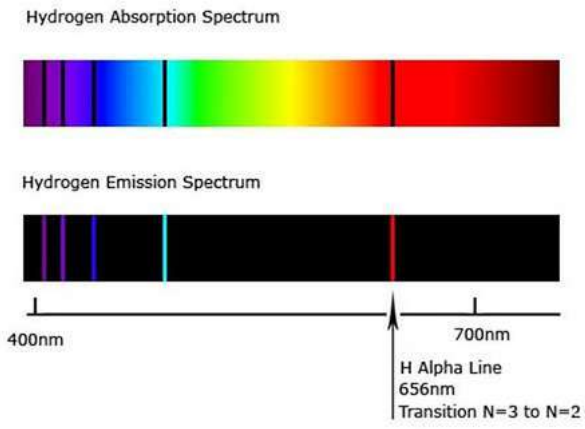
The unique color observed during a flame test is actually mixture of several different wavelengths of visible light. Neils Bohr recognized that electrons have distinct energies when he observed that elements make specific colors of light when the excited electrons *"fall back or de-excite"* to the ground state. The energy released as the electron transitions for higher energy levels to lower energy levels is seen by our eyes as visible light. Every color of light is specific to a particle wavelength. These wavelengths of light can be separated and measured using the diffraction paper in a **spectrometer**. The resulting image is called a Bright Line Spectrum (BLS). Every element has its own unique bright line spectrum which can be used to identify it.

Chemists can use a spectroscope to identify these various wavelengths. This technique is known as spectroscopy. A spectroscope splits light to form an emission line spectrum. The emission line spectrum for hydrogen is provided below. The emission line spectrum for hydrogen consists of four different wavelengths of light (410 nm, 434 nm, 486 nm, and 656 nm).

The hydrogen emission spectrum with wavelength labels



When the excited state electrons return to ground state, the absorbed energy is released as spectral lines. **Since spectral lines are unique to an element, they can be used to identify elements.**



Forensic Analysis

The leading detective of the case is wondering if he should press charges against the teenager who lives next door. Write a report explaining your test and how he should proceed with the case.

Be sure to include in your write up:

- **Your claim** about whether or not the neighbor should be arrested.
- **Two pieces** of **evidence** to support your claim (hint: one claim should be comparing and contrasting the flame test colors. The other piece of evidence should be information pertaining to the electromagnetic spectrums)
- **Your reasoning statement.** Explain why you chose those pieces of evidence and how the flame tests and electromagnetic spectrum images were involved.

Type your response below.

Claim: (**Single sentence** that **does not** start with yes or no. The claim answers the driving question, "Should the lead detective press charges against the teenager who lives next door?" You should restate parts of the driving question in your claim)

Evidence: (Two selections of evidence that comes from the **Data Table)**

Reasoning:

(Hint) A common sentence starter to use to begin the reasoning section is: "The evidence supports my claim because…." The reasoning statement is NOT repeating the evidence. Instead, the statement explains the WHY. Why did you decide to use the above evidence statements to support your decision? This is where scientific concepts about flame tests and spectral lines would be included.