

Lab 1: Flame Tests for Metals

Purpose

To observe and identify metallic ions using flame tests.

Background

The characteristic yellow of a candle flame comes from the glow of burning carbon fragments. The carbon fragments are produced by the incomplete combustion reaction of the wick and candle wax. When elements, such as carbon, are heated to high temperatures, some of their electrons are excited to higher energy levels. When these excited electrons fall back to lower energy levels, they release excess energy in packages of light called photons, or light quanta.

The color of the emitted light depends on its energy. Blue light is more energetic than red light, for example. When heated, each element emits a characteristic pattern of light energies, which is useful for identifying the element. The characteristic colors of light produced when substances are heated in the flame of a gas burner are the basis of flame tests for several elements.

In this experiment, you will perform the flame tests used to identify several metallic elements.

Procedure

1. Start *Virtual ChemLab* and select *Flame Tests for Metals* from the list of assignments. The lab will open in the Inorganic laboratory.
2. Enter the stockroom by clicking inside the *Stockroom* window. Once inside the stockroom, drag a test tube from the box and place it on the metal test tube stand. You can then click on a bottle of metal ion solution on the shelf to add it to the test tube. When you have added one metal ion, click *Done* to send the test tube back to the lab. Continue doing this until you have sent one test tube for each the following metal ions to the lab: Na^+ , K^+ , Ca^{2+} , Ba^{2+} , Sr^{2+} , and Cu^{2+} .
3. On the right end of the supply shelf is a button labeled *Unknowns*. Click on the *Unknowns* button to create a test tube with an unknown. Now click on each of the following bottles on the shelf: Na^+ , K^+ , Ca^{2+} , Ba^{2+} , Sr^{2+} , and Cu^{2+} . Do not change the maximum and minimum on the left side. Click *Save*. An unknown test tube titled *Practice* will show in the blue rack. Drag the practice unknown test tube from the blue rack to place it in the metal stand and click *Done*. Now click on the *Return to Lab* arrow.

Lab 23: Identification of Cations in Solution

Purpose

Identify the ions in an unknown solution through the application of chemical tests.

Background

The process of determining the composition of a sample of matter by conducting a chemical test is called qualitative analysis. Solutions of unknown ions can be subjected to chemical tests and the results can be compared to the results given by known ions. By conducting the appropriate tests and applying logic, the identities of the ions present in an unknown solution can be determined.

In this experiment, you will observe several types of chemical reactions commonly used as tests in qualitative analysis. These reactions include the color of a flame as the chemical is placed in the flame and the formation of a precipitate (solid).

Procedure

1. Start *Virtual ChemLab* and select *Identification of Cations in Solution* from the list of assignments. The lab will open in the Inorganic laboratory.
2. Enter the stockroom by clicking inside the *Stockroom* window. Once inside the stockroom, drag a test tube from the box and place it on the metal test tube stand. You can then click on a bottle of metal ion solution on the shelf to add it to the test tube. When you have added one metal ion, click *Done* to send the test tube back to the lab. Repeat this process with a new metal ion. Continue doing this until you have sent one test tube for each of the following metal ions to the lab: Na^+ , K^+ , and a Na^+/K^+ mixture. Fill one test tube with just water by clicking on the bottle of distilled water. Now click on the *Return to Lab* arrow.
3. When you return to the lab you should note that you have four test tubes. Just above the periodic table there is a handle. Click on the handle to pull down the TV monitor. With the monitor down you can drag your cursor over each test tube to identify what metal ion the test tube contains, and you will see a picture of what it looks like in the lower left corner.

Part 1, Flame Tests

1. You will use two of the buttons across the bottom, *Flame* and *Flame w/ Cobalt* (blue glass held in front of the flame.) A test tube must be moved from the blue test tube rack to the metal test tube stand in order to perform the flame test. You can drag a test tube from the blue rack to the metal test tube stand to switch places with a test tube in the metal test tube stand.

Analyze

1. Translate the following word equations into balanced chemical equations and explain how the equations represent what happens in grid spaces *a* and *g*.
 - a. In grid space *a*, sodium carbonate reacts with silver nitrate to produce sodium nitrate and solid silver carbonate.

- b. In grid space *g*, sodium sulfide reacts with lead (II) nitrate to produce sodium nitrate and solid lead (II) sulfide.

2. Write a word equation to represent what happens in grid space *m*.

3. What happens in grid space *d*? What other reactions gave similar results? Is it necessary to write an equation when no reaction occurs? Explain.

4. Write balanced equations for all precipitation reactions you observed.

5. Write balanced net ionic equations for all precipitation reactions you observed.

Lab 22: Precipitation Reactions: Formation of Solids

Purpose

Observe, identify, and write balanced equations for precipitation reactions.

Procedure

1. Start *Virtual ChemLab* and select *Precipitation Reactions: Formation of Solids* from the list of assignments. Lab will open in the Inorganic laboratory.
2. React each of the cations (across the top) with each of the anions (down the left) according to the table below using the following procedures:

	AgNO_3 (Ag^+)	$\text{Pb}(\text{NO}_3)_2$ (Pb^{2+})	$\text{Ca}(\text{NO}_3)_2$ (Ca^{2+})
Na_2CO_3 (CO_3^{2-})	<i>a</i>	<i>f</i>	<i>k</i>
Na_2S (S^{2-})	<i>b</i>	<i>g</i>	<i>l</i>
NaOH (OH^-)	<i>c</i>	<i>h</i>	<i>m</i>
Na_2SO_4 (SO_4^{2-})	<i>d</i>	<i>i</i>	<i>n</i>
NaCl (Cl^-)	<i>e</i>	<i>j</i>	<i>o</i>

- a. Click in the *Stockroom*. Once inside the stockroom, drag a test tube from the box and place it on the metal test tube stand. Then click on the bottle of Ag^+ metal ion solution on the shelf to add it to the test tube. Click *Done* to send the test tube back to the lab. *Return to Lab*.
- b. Drag the test tube containing the Ag^+ from the blue rack to the metal test tube stand. Click on the *Divide* button (the large red arrow) four times to make four additional test tubes containing Ag^+ . With one test tube in the metal stand and four others in the blue rack, click on the Na_2CO_3 bottle on the reagent shelf, observe what happens in the window at the bottom left. Record your observation in the table above. If the solution remains clear, record NR, for no reaction. Drag this test tube to the red disposal bucket on the right.
- c. Drag a second tube from the blue rack to the metal stand. Add Na_2S , record your observations and discard the tube. Continue with the third, fourth and fifth tube, but add NaOH , Na_2SO_4 , and NaCl respectively. Record your observations and discard the tubes. When you are completely finished, click on the red disposal bucket to clear the lab.
- d. Return to the stockroom and repeat steps a through c for five test tubes of Pb^{2+} and Ca^{2+} .

8. Repeat steps 4–7 for sucrose. Record your observations in the table.

	benzoic acid (C ₇ H ₆ O ₂)	sucrose (C ₁₂ H ₂₂ O ₁₁)
mass of sample (g)		
initial temperature (°C)		
final temperature (°C)		

Calibration of calorimeter

1. Calculate ΔT for the water in the benzoic acid combustion by $\Delta T = |T_f - T_i|$.

Calculate the moles of benzoic acid (MW = 122.13 g/mol). $n = \text{mass sample/molecular weight}$

2. ΔH_{comb} for benzoic acid can be calculated by $\Delta H = (C_{\text{system}} \Delta T)/n$, where n is the moles of benzoic acid in the sample and C_{system} is the heat capacity of the calorimetric system. If the accepted value for the heat of combustion for benzoic acid is 3226 kJ/mol, calculate the heat capacity (C_{system}) of the calorimetric system.

Heat of combustion of sucrose

1. Calculate ΔT for the water by $\Delta T = |T_f - T_i|$.

2. Calculate the moles of sucrose in the sample (MW_{sucrose} = 342.3 g/mol).

3. ΔH_{comb} for sucrose can be calculated by $\Delta H_{\text{comb}} = (C_{\text{system}} \Delta T)/n$, where n is the moles of benzoic acid in the sample and C_{system} is the heat capacity of the calorimetric system. Using the value you calculated for C_{system} , calculate the heat of combustion for sucrose.

4. If the accepted value for the heat of combustion for sugar is 5639 kJ/mol, calculate the percent error.

$$\%Error = \frac{|your\ answer - accepted\ answer|}{accepted\ answer} \times 100$$

Lab 19: Heat of Combustion

Purpose

Measure the heat of combustion of sugar.

Background

The heat of combustion is the heat of reaction for the complete burning of one mole of a substance. Calorimetry experiments such as the determination of the heat of combustion (ΔH_{comb}) can be performed at constant volume using a device called a bomb calorimeter.

In this assignment you will calculate the heat of combustion of table sugar (sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$). The calorimeter must also be calibrated by first combusting benzoic acid.

Procedure

1. Start Virtual ChemLab and select *Heat of Combustion* from the list of assignments. The lab will open in the Calorimetry laboratory with the bomb calorimeter out, disassembled, and a sample of benzoic acid in the calorimeter cup on the balance. The balance has already been tared.

Calibration of the calorimeter

2. Click on the *Lab Book* to open it. Highlight and delete any data links left by a previous student.
3. Record the mass of the benzoic acid sample from the balance. If you cannot read it, click on the *Balance* area to zoom in, record the mass, and return to the laboratory.
4. Double-click in this order to assemble the calorimeter: (1) the cup on the balance pan, (2) the bomb head, (3) the screw cap, and (4) the bomb. Click the calorimeter lid to close. Combustion experiments can take a considerable length of time. Click the clock on the wall labeled *Accelerate* to accelerate the laboratory time.
5. Click the Bomb control panel and the Plot window to bring them to the front. Click on the *Save* button to save data to the lab book. Allow the graph to proceed for 20–30 seconds to establish a baseline temperature.
6. Click *Ignite* and observe the graph. When the temperature has leveled off (up to 5 minutes of laboratory time), click *Stop*. A blue data link will appear in the lab book. Click the blue data link to view the collected data. Record in the Data Table the temperature before and after ignition of the benzoic acid sample.

Combustion of sugar

7. Click the red disposal bucket to clear the lab. Click on the Stockroom to enter. Click on the clipboard and select Preset Experiment #13. Return to the laboratory.

2. Calculate the mass of the reaction mixture in each reaction. (To do this, first determine the total volume of the solution. Then calculate the mass of the solution, based on the assumption that the added solid does not change the volume and that the density of the solution is the same as that of pure water, 1.0 g/mL.) Remember to add the mass of the solid. Record your results in the table.
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3. Calculate the total heat released in each reaction, assuming that the specific heat capacity of the solution is the same as that of pure water, $\frac{4.184\text{J}}{\text{K}\cdot\text{g}}$. Record the result in the table.
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4. Calculate the number of moles of NaOH used in reactions 1 and 2 where $n = m/MW$. Record the results in the table.
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5. Calculate the number of moles of NaOH used in reaction 3 by multiplying the volume of NaOH times the molarity (1.000 mol/L). Record the results in the table.
-

6. Calculate the energy released in **kJ/mol** of NaOH for each reaction and record the results in the table.

# Rxn	Mass of Rxn Mixture	DT	Total Heat Released	mol NaOH	Heat Released per mol NaOH
1					
2					
3					

7. Show that the equations for reactions 1 and 3, which are given in the Background section, add to give the equation for reaction 2. Include the energy released per mole of NaOH in each equation.
-
-
-
-
-
-

Reaction 2

1. Click the red disposal bucket to clear the lab. Click on the Stockroom to enter. Click on the clipboard and select Preset Experiment #5. Return to the laboratory.
2. There will be a bottle of NaOH near the balance. A weigh paper will be on the balance with approximately 4 g NaOH on the paper. The calorimeter will be on the lab bench and filled with 100 mL water, and there will be a beaker containing 100 mL of 1.000 M HCl on the lab bench. In the thermometer window click *Save* to begin recording data. Allow 20–30 seconds to obtain a baseline temperature of the water.
3. Make sure the beaker of HCl is visible and drag it to the calorimeter and pour it into the calorimeter. The HCl and the water are at the same temperature so there should be no temperature change. Now drag the weigh paper with the NaOH to the calorimeter until it snaps into place and pour the sample into the calorimeter. It is important that the HCl be added first and the NaOH added second. Observe the change in temperature until it reaches a maximum and then record data for an additional 20–30 seconds. Record the temperature before adding the HCl and after adding the NaOH.

Reaction 3

1. Click the red disposal bucket to clear the lab. Click on the Stockroom to enter. Click on the clipboard and select Preset Experiment #4. Return to the laboratory.
2. In the thermometer window click *Save* to begin recording data. Allow 20–30 seconds to obtain a baseline temperature of the water. Pour the first beaker containing the HCl into the calorimeter and then pour the second beaker containing the NaOH into the calorimeter. Observe the change in temperature until it reaches a maximum and then record data for an additional 20–30 seconds. Record the initial and final temperatures.

Parameter	Reaction 1	Reaction 2	Reaction 3
Mass NaOH			
initial temperature (°C)			
final temperature (°C)			

Analysis and Conclusions

1. Determine the change in temperature, ΔT , for each reaction. Record your results in the table.

- Repeat the experiment with a metal sample of your choosing. Click the red disposal bucket to clear the lab. Click on the Stockroom to enter. Double-click the Dewar calorimeter to move it to the Stockroom counter. Click the metal sample cabinet. Click a drawer (the samples are alphabetically arranged), and select a sample by double-clicking and zoom out. Double-click on the petri dish with the selected sample to move it to the Stockroom counter. Return to the laboratory.
- Move the petri dish with metal sample to the spotlight next to the balance. Click on the *Balance* area to zoom and make sure the balance has been tared. Move the metal sample to the balance pan and record the mass in the table. Return to the laboratory.
- Double-click the calorimeter to move it into position in the laboratory. Click the oven to open the door. Move the metal sample from the balance pan to the oven and click to close the oven door. Click above the tens place several times on the front of the oven to change the temperature to 200°C. Fill the 100 mL graduated cylinder with water by holding it under the tap until it returns to the counter and then pour it into the calorimeter. Turn on the thermometer. Click on the *Graph* and *Save* buttons. Move your metal sample from the oven to the calorimeter. Follow the procedures used with Pb to obtain the equilibrium temperature. Record your observations in the table.

	Pb	your choice
mass of metal (g)		
volume of water (mL)		
mass of water (g)		
initial temperature of water (°C)		
initial temperature of metal (°C)		
max temp of water + metal (°C)		

Analysis and Conclusions

- Determine the changes in temperature of the water (ΔT_{water}).

- Calculate the heat (q) gained by the water using the following equation:

$$q_{\text{water}} = m_{\text{water}} \cdot \Delta T_{\text{water}} \cdot C_{\text{water}}$$
 given $C_{\text{water}} = 4.184 \text{ J}/(\text{g}^\circ\text{C})$

Lab 16: The Specific Heat of a Metal

Purpose

Determine the specific heat of a metal using a calorimeter.

Background

On a sunny day, the water in a swimming pool may warm up a degree or two while the concrete around the pool may become too hot to walk on with bare feet. This may seem strange since the water and concrete are being heated by the same source—the sun. This evidence suggests it takes more heat to raise the temperature of some substances than others, which is true. The amount of heat required to raise the temperature of 1 g of a substance by 1 degree K is called the *specific heat capacity*, or *specific heat*, of that substance. Water, for instance, has a specific heat of $4.18 \text{ J/K} \cdot \text{g}$. This value is high in comparison with the specific heats for other materials, such as concrete or metals. In this experiment, you will use a simple calorimeter and your knowledge of the specific heat of water to determine the specific heat of several metals.

Procedure

1. Start *Virtual ChemLab* and select *The Specific Heat of a Metal* from the list of assignments. The lab will open in the Calorimetry laboratory.
2. Click on the *Lab Book* to open it. Record the mass of Pb on the balance. If it is too small to read click on the *Balance* area to zoom in, record the mass of Pb in the Data Table, and return to the laboratory.
3. Pick up the Pb sample from the balance pan and place the sample in the oven. Click the oven door to close. The oven is set to heat to 200°C .
4. The calorimeter has been filled with 100 mL water. The density of water at 25°C is 0.998 g/mL . Use the density of the water to determine the mass from the volume and record the volume and mass in the Data Table.

Make certain the stirrer is *On* (you should be able to see the shaft rotating). Click the thermometer window to bring it to the front and click *Save* to begin recording data. Allow 20–30 seconds to obtain a baseline temperature of the water.

5. Click on the *Oven* to open it. Drag the hot lead sample from the oven until it snaps into place above the calorimeter and drop it in. Click the thermometer and graph windows to bring them to the front again and observe the change in temperature in the graph window until it reaches a constant value and then wait an additional 20–30 seconds. Click *Stop* in the temperature window. You can click on the *Accelerate* button on the clock to accelerate the time in the laboratory. A blue data link will appear in the lab book. Click the blue data link and record in the Data Table the temperature before adding the Pb and the *highest* temperature after adding the Pb.

Lab 8: Photoelectric Effect

Purpose

To duplicate photoelectric effect experiments.

Background

Though Albert Einstein is most famous for $E = mc^2$ and his work in describing relativity in mechanics, his Nobel Prize was for understanding a very simple experiment. It was long understood that if you directed light of a certain wavelength at a piece of metal, it would emit electrons. In classical theory, the energy of the light was thought to be based on its intensity and not its frequency. However, the results of the photoelectric effect contradicted classical theory. These inconsistencies led Einstein to suggest that we need to think of light as being comprised of particles (photons) and not just as waves.

Each wavelength corresponds to another property of light called frequency. You will use the wavelength (λ) value in the experiment to calculate the frequency (ν) given that $\nu = \frac{c}{\lambda}$ where $c = 2.998 \times 10^{17}$ nm/s (2.998×10^8 m/s). The energy (E) of a quantum of light an atom emits is related to its frequency (ν) by $E = h\nu$ where h (Planck's constant) = 6.63×10^{-34} J-s.

Procedure

1. Start *Virtual ChemLab* and select *Photoelectric Effect* from the list of assignments. The experiment opens in the Quantum laboratory.
2. What source is used in this experiment and what does it do?

At what intensity is the laser set?

At what wavelength is the laser set?

Record the wavelength (in nm) in the data table. Calculate the frequency (in 1/s) and the energy (in J) using the equations given in the Background section of this lab. Determine the color of the light by clicking on the *Spectrum Chart* (just behind the laser); the markers indicate what color is represented by the wavelength selected.

Which metal foil is used in this experiment?

4. Now, investigate the emission spectra for a different element, helium. Helium is the next element after hydrogen on the periodic table and has two electrons. Do you think the emission spectra for an atom with two electrons instead of one will be much different than hydrogen?
-

5. To exchange gas samples, turn off the *Spectrometer* with the *On/Off* switch in the top right corner. Double-click on the *Electric Field* to place it on the stockroom shelf. Double-click on the *Gas (H₂)* sample tube to place it on the stockroom shelf.
6. Click in the *Stockroom*. Click on the *Gases* samples on the top shelf. Click on the cylinder labeled *He* to select helium as the gas and it will fill the gas sample tube. If you point to the gas sample tube it should read *He*.
7. *Return to lab*. Drag the gas sample tube off the stockroom shelf. When you select it, a white spotlight will appear indicating where you can place the gas sample tube—place it there. Drag the *Electric Field* and place it on the gas sample tube. Carefully click the button just above the left zero on the volt meter and change the voltage to 300 V. Turn on the *Spectrometer*. Click the *Visible/Full* switch to convert to only the visible spectrum.
8. Draw the visible spectrum for helium. Is it different from hydrogen?
-
-

9. Determine the wavelength (in nm), the frequency (in 1/s) and the energy (in J) for the peak on the far right.

	Wavelength (nm)	Frequency (1/s)	Energy (J)
Line (far right)			

Lab 7: Atomic Emission Spectra

Purpose

To view atomic emission spectra and use a spectrometer to measure the wavelength. The wavelength will be used to calculate frequency and energy.

Procedure

Start *Virtual ChemLab* and select *Atomic Emission Spectra* from the list of assignments. The lab will open in the Quantum laboratory.

The *Spectrometer* is on the right of the lab table. The emission spectra is in the detector window in the upper right corner with a graph of the Intensity vs λ (wavelength).

Analyze

- How many distinct lines do you see and what are their colors? Draw what you see.

- Click on the *Visible/Full* switch to magnify only the visible spectrum. You will see four peaks in the spectrum. If you drag your cursor over a peak, it will identify the wavelength (in nm) in the x -coordinate field in the bottom right corner of the window. Record the wavelength in the table below for the four peaks in the hydrogen spectrum. (Round to whole numbers.)
- Each wavelength corresponds to another property of light called its frequency. Use the wavelength value of each of the lines to calculate its frequency given that $\nu = \frac{c}{\lambda}$ where $c = 2.998 \times 10^{17}$ nm/s (2.998×10^8 m/s). The energy (E) of a quantum of light an atom emits is related to its frequency (ν) by $E = h\nu$. Use the frequency value for each line and $h = 6.63 \times 10^{-34}$ J·s to calculate its corresponding energy.

	Wavelength (nm)	Frequency (1/s)	Energy (J)
Line #1 (left)			
Line #2			
Line #3			
Line #4 (right)			

Lab 3: Counting by Measuring Mass

Purpose

Determine the mass of several samples of chemical elements and compounds and use the data to count atoms.

Procedure

Start *Virtual ChemLab* and select *Counting by Measuring Mass* from the list of assignments. The lab will open in the Calorimetry laboratory.

Part 1, Measuring Metal

1. Click on the *Stockroom*. Click on the *Metals* sample cabinet. Open the top drawer by clicking on it. When you open the drawer, a petri dish will show up on the counter. Place the sample of gold (Au) in the sample dish by double-clicking on it. *Zoom Out*. Double-click on the petri dish to move it to the stockroom counter. Click the green arrow to *Return to Lab*.
2. Drag the petri dish to the spotlight near the balance. Click on the *Balance* area to zoom in. Drag the gold sample to the balance pan and record the mass in Table 1.
3. Click on the red disposal bucket to clear the lab after each sample. Repeat for lead (Pb), uranium (U), sodium (Na) and a metal of your choosing.

Table 1

	gold (Au)	lead (Pb)	uranium (U)	sodium (Na)	Your Choice
Mass (grams)					
Molar Mass (g/mol)					
Moles of each element					
Atoms of each element					

Name _____ Date _____ Class _____

	Ag⁺	Pb²⁺	Ca²⁺	Fe³⁺	Cu²⁺
Na₂S (S²⁻)					
Na₂SO₄ (SO₄²⁻)					
NaCl (Cl⁻)					
NaOH (OH⁻)					
Na₂CO₃ (CO₃²⁻)					

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**Names and Formulas of
Ionic Compounds**

Lab 2: Names and Formulas of Ionic Compounds

Purpose

To observe the formation of compounds and write their names and formulas.

Procedure

1. Start *Virtual ChemLab* and select *Names and Formulas of Ionic Compounds* from the list of assignments. The lab will open in the Inorganic laboratory.
2. Enter the stockroom by clicking inside the *Stockroom* window. Once inside the stockroom, drag a test tube from the box and place it on the metal test tube stand. You can then click on the bottle of Ag^+ ion solution on the shelf to add it to the test tube. Click *Done* to send the test tube back to the lab. Click on the *Return to Lab* arrow.
3. Place the test tube containing the Ag^+ solution in the metal test tube stand. Click on the *Divide* button on the bottom (with the large red arrow) four times to make four additional test tubes containing Ag^+ . With one test tube in the metal stand and four others in the blue rack, click on the Na_2S bottle located on the lab bench. You will be able to observe what happens in the window at the bottom left. Record your observation in the table below and write a correct chemical formula and name for the product of the reaction. If the solution remains clear, record NR, for no reaction. Drag this test tube to the red disposal bucket on the right.
4. Place a second tube from the blue rack on the metal stand. Add Na_2SO_4 . Record your observations and discard the tube. Use the next tube but add NaCl , and record your observations. Use the next tube but add NaOH , and record your observations. With the last tube add Na_2CO_3 and record your observations. When you are completely finished, click on the red disposal bucket to clear the lab.
5. Return to the stockroom and repeat steps 2–4 for Pb^{2+} , Ca^{2+} , Fe^{3+} , and Cu^{2+} . Complete the table below.

Analyze

Each cell should include a description of what you observed when the reagents were mixed and a correct chemical formula and name for all solutions which turned cloudy and NR for all solutions which remained clear. Remember to include roman numerals where appropriate.

8. Flame test the practice unknown. Determine which of the six metal ions it most closely matches. You may repeat the flame test on any of the six metal ions if necessary. When you are confident that you have identified the unknown, open the *Lab Book* by clicking on it. On the left page, click the *Report* button. On the right page, click on the metal ion that you think is in the practice unknown. Click *Submit* and then *OK*. If all of the ion buttons turn green you have successfully identified the unknown. If any turn red then you were incorrect. *Flame* test the practice unknown again to correctly identify your metal ion. Click on the red disposal bucket to clear all of your samples.

Analysis and Conclusions

1. The energy of colored light increases in the order red, yellow, green, blue, violet. List the metallic elements used in the flame tests in increasing order of the energy of the light emitted.

2. What is the purpose of using the cobalt glass in the identification of sodium and potassium?



- When you return to the lab you should note that you have seven test tubes. You will use two of the buttons across the bottom, *Flame* and *Flame w/ Cobalt* (blue glass held in front of the flame.) A test tube must be moved from the blue test tube rack to the metal test tube stand in order to perform the flame test. You can drag a test tube from the blue rack to the metal test tube stand to switch places with a test tube in the metal test tube stand. Just above the periodic table there is a handle. Click on the handle to pull down the TV monitor. With the monitor down you can mouse-over each test tube and it will identify what metal ion the test tube contains. As you mouse over each test tube, you will also see a picture of what it contains in the lower left corner. One of your test tubes is labeled *Practice* and when you mouse over it, the TV monitor tells you it is an unknown.
- Select the test tube containing Na^+ and place it on the metal stand. Click the *Flame* button. Record your observations in the data table below. Click the *Flame w/Cobalt* button and record your observations in the same table.
- Drag the K^+ test tube to the metal stand to exchange it with the Na^+ . Flame test K^+ with and without cobalt glass. Record your observations in the table below.
- For the other four ions, *Flame* test them only. Do not use cobalt glass. Record your observations in the table below.

Ion	Flame Color
sodium, Na^+	
sodium, Na^+ (cobalt glass)	
potassium, K^+	
potassium, K^+ (cobalt glass)	
calcium, Ca^{2+}	
barium, Ba^{2+}	
strontium, Sr^{2+}	
copper, Cu^{2+}	
unknown #1	
unknown #2	
unknown #3	
unknown #4	