

**Chemistry 101**  
**LIGHT AND MATTER**  
**Pre-Lab Exercises**

Student: \_\_\_\_\_

Date: \_\_\_\_\_

Instructor: \_\_\_\_\_

Section: \_\_\_\_\_

1. Describe the process within the atom that causes atoms to absorb and emit light?
2. 100.0 mL of solution was prepared from a silver containing compound. The solution containing the silver ion is found to have a  $\text{Ag}^+$  concentration of 0.223 g/L. Calculate the grams of  $\text{Ag}^+$  in the 100.0 mL of solution (Hint: look at units for concentration and units for volume and obtain units of g  $\text{Ag}^+$ )?

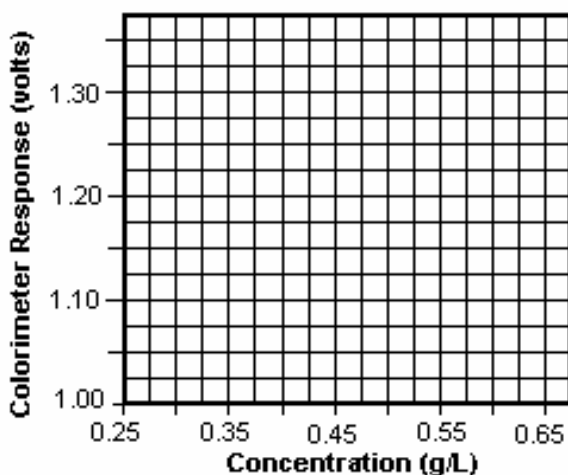
g  $\text{Ag}^+$

3. The original mass of the silver compound described in the above problem was 0.0351 g. Using the mass of the compound and the mass of silver in the compound determined in the previous problem, calculate the percent silver in the unknown compound.

%

4. The following table contains data from a copper analysis experiment like the one described in this lab. Plot the data in the graph, draw a best-fit line, and use the graph to determine the concentration of the unknown sample.

Sample	Concentration (g/L)	Colorimeter Response (volts)
1	0.25 g/L	1.3 volts
2	0.38 g/L	1.2 volts
3	0.52 g/L	1.1 volts
4	0.63 g/L	1.0 volts
Unknown compound		1.12 volts



Unknown Concentration

g/L

# Chemistry 101

## LIGHT AND MATTER

Student: \_\_\_\_\_  
Partner: \_\_\_\_\_  
Instructor: \_\_\_\_\_  
Section: \_\_\_\_\_ Date: \_\_\_\_\_

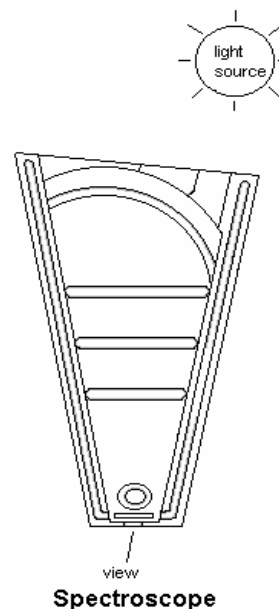
### DISCUSSION

The basis for this laboratory is the interaction between light and matter and how this interaction can be used to analyze matter. Electrons in atoms usually exist in energy levels that allow them to be as close to the positively charged nucleus as possible. When you write electron configurations, the energy levels and sublevels that you use describe this arrangement of electrons in the atom. These electron configurations represent the lowest possible energy state or arrangement for the electrons. When atoms are exposed to energy in the form of heat, light, or electricity, the electrons can be excited to higher energy levels by absorbing some of the energy. To return to the lower energy levels, the electrons give off energy in the form of light. The process of electrons absorbing light and emitting light is very useful in analyzing matter, as you will see in this laboratory.

### PROCEDURE AND REPORT

#### Relationship between Color of Light and Wavelength

View a light bulb through a spectroscope and observe the continuous spectrum of colors. To do this, point the right edge of the spectroscope toward the light source and view the spectrum to the left of the source. Determine and record the approximate ranges in wavelength of red, orange, yellow, green, blue, and violet light. For example, violet light should correspond to a wavelength range of approximately 410 to 450 nm.



Red	Orange	Yellow	Green	Blue	Violet
nm	nm	nm	nm	nm	nm

### **Effect of Concentration on the Absorption Spectrum**

1. Half fill a 100 mL beaker with tap water. Add three drops of potassium permanganate solution and stir well.
2. Place the beaker, on a ring stand, between the spectroscope and a light bulb and look at the absorption spectrum. The potassium permanganate will absorb some of the colors and other colors will be transmitted through the solution. The colors that are absorbed will appear as dark regions in the spectrum.
3. Record the colors that have been removed from the continuous light spectrum. These colors represent the colors absorbed by the permanganate ion.
4. Add three more drops of potassium permanganate, stir, and observe the spectrum. Continue until about 50 drops of potassium permanganate have been used or until no further changes in the spectrum are observed. Describe the changes in the absorption spectrum that result as the concentration of the permanganate increases.

**What colors are absorbed (removed) from the continuous spectrum of the light bulb by permanganate?**

**What changes in the absorption spectrum result as the concentration of permanganate increases?**

**What is the relationship between the last observable color seen through the spectroscope and the color of the permanganate solution?**

### **Using an Absorption Spectrum to Identify Compounds**

Use the spectroscope to observe the absorption spectrum of blue food coloring and copper nitrate solutions. Look specifically at each region (i.e., red, orange, yellow, green, etc.) of the spectrum for each solution. How could the two be distinguished from each other from their spectra? Observe the spectrum of the unknown and tell whether it is food coloring or copper nitrate solution. (Drawing diagrams of the spectra for the known substances may help to identify the unknown.)

**Describe the differences between the absorption spectra of blue food coloring and copper nitrate. Be specific in terms of colors observed and colors missing from the spectrum.**

**Is the unknown solution blue food coloring or copper nitrate?**

## Flame Test: Using Light to Identify Elements

When heated, many of the elements produce colors. Each element produces a unique color that is different from any other element. When an excited electron falls from a higher to lower energy level, it releases energy in the form of a photon of light. The different colors for different atoms correspond to the differences in electron energy levels in each atom. In this section, you will use the different colors emitted (given off) by sodium, lithium and calcium to identify an unknown compound.

Solution	Colors Emitted	Wavelength (nm)
NaCl		nm
SrCl <sub>2</sub>		nm
HBO <sub>3</sub>		nm
LiCl		nm

Unknown 1: \_\_\_\_\_

Unknown 2: \_\_\_\_\_

Unknown 3: \_\_\_\_\_

Unknown 4: \_\_\_\_\_

## Copper Analysis

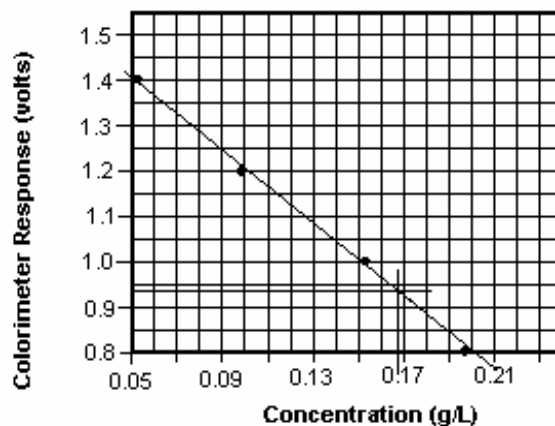
In this section you will prepare a solution of a compound that contains an unknown percentage of copper and analyze the solution to determine the amount of copper present in solution (copper concentration of the solution). You will then be able to determine the mass of copper in the original compound and percent copper in the compound.

The following example illustrates the calculations and data analysis that will be necessary to perform the copper analysis:

A student wanted to determine the percent copper in an unknown copper containing compound. To do this he dissolved **0.123 g** of the unknown compound in **250.0 mL** of solution. He then analyzed four copper solutions of known concentration and the unknown copper solution using a colorimeter and obtained the data shown in the following table.

Sample	Concentration (g/L)	Colorimeter Response (volts)
1	0.052 g/L	1.40
2	0.092 g/L	1.20
3	0.153 g/L	1.00
4	0.197 g/L	0.80
Unknown compound		0.94

The data for the solutions of known concentration was plotted in the following graph and a best-fit straight line was drawn through the four data points. The concentration of the unknown solution was then determined from the graph. Extrapolating down from the point on the line that corresponds to **0.94 volts** leads to a concentration estimate of **0.167 g Cu/L** for the unknown solution.



The original goal of the student was to determine the mass of copper in the **0.123g** of copper compound so that he could determine the percent copper in the compound. By multiplying the concentration of copper by the volume of copper solution, the mass of copper can be calculated:

$$\text{mass Cu} = \text{Concentration Cu} \times \text{Volume Solution} = \mathbf{0.167 \text{ g Cu/L} \times .2500 \text{ L} = 0.0418 \text{ g Cu}}$$

Knowing the mass of copper in the compound, the student was then able to determine the percent copper in the compound:

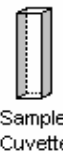
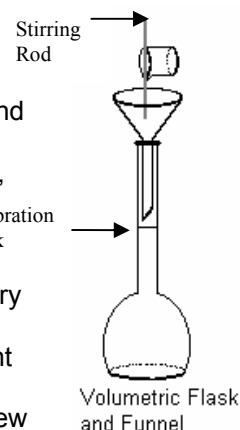
$$\text{Percent Cu} = \text{mass Cu}/\text{mass compound} \times 100\% = \mathbf{0.0418 \text{ g Cu}/0.123 \text{ g compound} \times 100\% = 34.0\%}$$

The analysis showed that the unknown copper compound contains **34.0%** copper.

## Copper Analysis (continued)

### Preparation of Unknown Copper Solution

- Place a dry 50 mL beaker on the balance and press tare. Add 0.1 to 0.2 g of unknown copper compound to the beaker and record the mass to the nearest 0.001g.
- Dissolve the compound in about 20 mL of distilled water. Dissolving the compound may take a long time. Carefully break up clumps of the compound and stir the solution with a stirring rod. Place a small funnel in a 100 mL volumetric flask and, with the aid of the stirring rod, transfer the solution from the beaker through the funnel into the flask. Be careful not to lose any of the solution. Rinse the beaker with several portions of distilled water and transfer them into the flask. Rinse the stirring rod and the inside of the funnel to try to get all of the copper into the flask.
- Add about 15 mL of ammonia solution to the flask. The solution will turn from light blue to dark blue as  $\text{Cu}^{2+}$  is converted to  $\text{Cu}(\text{NH}_3)_4^{2+}$ . Add distilled water until the solution level is exactly at the calibration mark. Use a drip-bottle to add the last few drops of distilled water to the flask so you don't "overshoot" the mark. The final volume is 100.0 mL. Stopper the flask, invert and shake the flask several times to be sure that the solution is uniform.
- Rinse a sample cuvette with several portions of this diluted solution and then fill the cuvette at least  $\frac{1}{2}$  full with the solution. Handle the cuvette only on the top portion of the ribbed sides.
- Four copper solutions of known concentration have been prepared and placed in sample cuvettes. Compare the "darkness" of your unknown copper solution to the solutions of known concentration and estimate the concentration of your unknown.



1. Mass of unknown Cu compound	g
5. Estimated concentration of unknown Cu solution	g/L

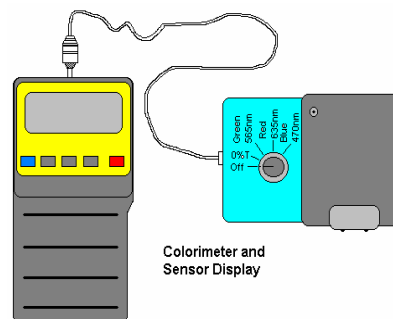
- To illustrate the effect of sample length upon observed color, place a test tube of blue food coloring on white paper and against a white background. Remove the stopper and look at the test tube from the side and from the top. Answer the following two questions.

**As the "thickness" of the solution through which the light passes increases, what happens to the intensity of the color?**

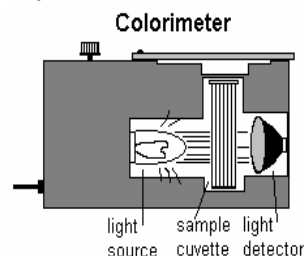
**When estimating the unknown copper solution concentration, why is it important that all the copper samples be in the same size cuvettes?**

### Analysis of Copper Solutions Using Colorimetry

A colorimeter is an instrument designed to measure the amount of light absorbed by solutions. The colorimeter shines a specific color, or wavelength, of light through a sample and detects the intensity of light that passes through the sample. As samples become more concentrated, more light is absorbed by the sample so the intensity of light detected by the colorimeter decreases. You will measure the colorimeter response to the copper solutions of known concentration and your copper solution of unknown concentration. This will allow you to construct a graph which will make it possible to determine the concentration of the copper solution of unknown concentration and eventually find the percent copper in the unknown copper compound.

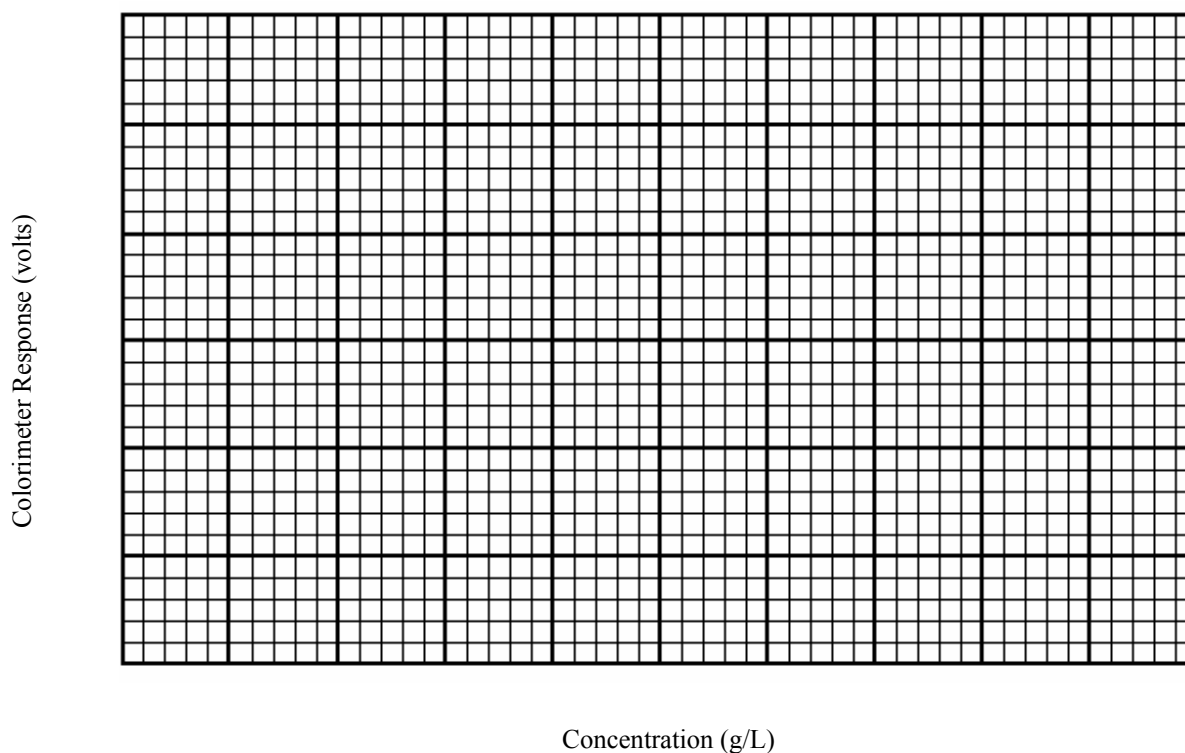


7. Turn on the colorimeter sensor display and press the MODE button until units of V (volts) or mV are displayed. Set the colorimeter dial to 635 nm. Place the 1<sup>st</sup> sample cuvette into the sample holder so that the light will pass through the non-ribbed sides of the cuvette. Handle the cuvette only on the top portion of the ribbed sides so that your fingerprints don't absorb or scatter light in the instrument. Also be sure that the cuvette is dry on the outside before placing it in the instrument. Close the colorimeter lid.
8. Record the concentration and the colorimeter response of copper solution #1 in the table below.
9. Repeat steps #7 and #8 for the remaining 3 copper solutions of known concentration.
10. Place the cuvette containing your copper solution of unknown concentration in the colorimeter and record the response in the table below.
11. Plot the concentration and response data for the copper solutions of known concentration in the graph below. Select the scales on the x- and y-axes so that your data are spread out over the entire graph. Draw a best-fit straight line through the data points.
12. Using the colorimeter response for your unknown copper solution and the graph you constructed, determine the concentration of the copper solution.



Sample	Concentration (g/L)	Colorimeter Response (volts)
1		
2		
3		
4		
Unknown compound		

12. Unknown Copper Solution Concentration: \_\_\_\_\_ g/L



13. Determine how many grams of copper were in your original sample by multiplying the concentration of your unknown copper solution (line #12) by the volume of the volumetric flask in units of L.

**Grams of Copper in Unknown Compound Sample:** \_\_\_\_\_

14. Find the percent copper in the unknown compound by dividing the grams of copper in the compound by the total mass of the compound determined at the beginning of this section (#1) and multiplying by 100%.

**Percent Copper in Unknown Compound:** \_\_\_\_\_