Introduction to the Spectrophotometer

Purpose: To determine the absorption spectrum of a given aqueous solution.

Background: Many compounds absorb light from regions of the electromagnetic spectrum. A spectrophotometer is a device designed to determine the wavelengths of light that a compound absorbs. When an aqueous sample of a compound is placed in the light path of a spectrophotometer, the sample may absorb all the light, some of the light, or no light at all. The absorption of light depends upon the materials in the sample and the wavelength of the light. Light absorption occurs at wavelengths whose energy corresponds to the energy necessary to cause electronic excitations of atoms, ions, or molecules in the sample. From the spectrophotometer data, a graph can be made that plots the light intensity transmitted through the sample versus the wavelength of the light; such a graph is called an absorption spectrum. The range of wavelengths absorbed by the sample appear as bands of minimum intensity.

Absorption spectra are useful for two reasons. First, the absorption spectrum of a substance is a unique characteristic of that substance. This makes the spectrum useful for the identification of unknown substances. Second, the intensity of the absorption bands can be related to the concentration of the substance in the sample. Thus, the intensity of the absorption band can be used to determine the amount of a particular substance in a mixture.

In this experiment, you will determine the absorption spectrum of an aqueous solution of chromium(III) ions.

Materials:

Spectrophotometer
2 glass cuvettes
10 ml graduated cylinder
0.02 M chromium(III) nitrate solution
distilled water

Procedure:

1. Turn on the spectrophotometer an allow it to warm up for about 20 minutes.
2. Set the wavelength control knob to 375 nanometers (375 nm). Adjust the amplifier control knob to produce 0 percent transmittance (0%T) at this wavelength.

Note- To avoid damage, the spectrophotometer knobs must not be twisted past the point at which resistance is encountered

3. Add 3 ml of distilled water to a clean small test tube (cuvette). Wipe the outside of the tube with a tissue to make certain that it is clean and dry. Avoid getting fingerprints on the tube. Dislodge any air bubbles present in the water by gently tapping the tube with a finger.

4. Place the tube in the sample holder and close the cover. Adjust the light control knob until the spectrophotometer reads 100%T.

5. Remove the first sample from the spectrophotometer. Add 3 ml 0.02M chromium(III) nitrate to another clean test tube. Use a tissue to clean and dry the tube. Insert the tube of chromium(III) nitrate into the sample holder. Close the cover of the holder. Read the percent transmittance and record the reading in the table. Remove the sample from the holder

6. Turn the wavelength dial to 400 nm. Use the amplifier control knob to adjust the percent transmittance to 0%T. Place the water sample in the holder. With the light control knob, adjust the meter to 100%T. Replace the water sample with the chromium(III) nitrate sample. Measure and record the percent transmittance at 400nm.

Note- You must adjust to 100%T each time a new wavelength of light is used. Failure to do so will produce an absorption spectrum that includes an energy profile of the light source as well as the spectrum of your sample solution.

7. Continue the procedure for the remainder of the wavelengths listed in the table.

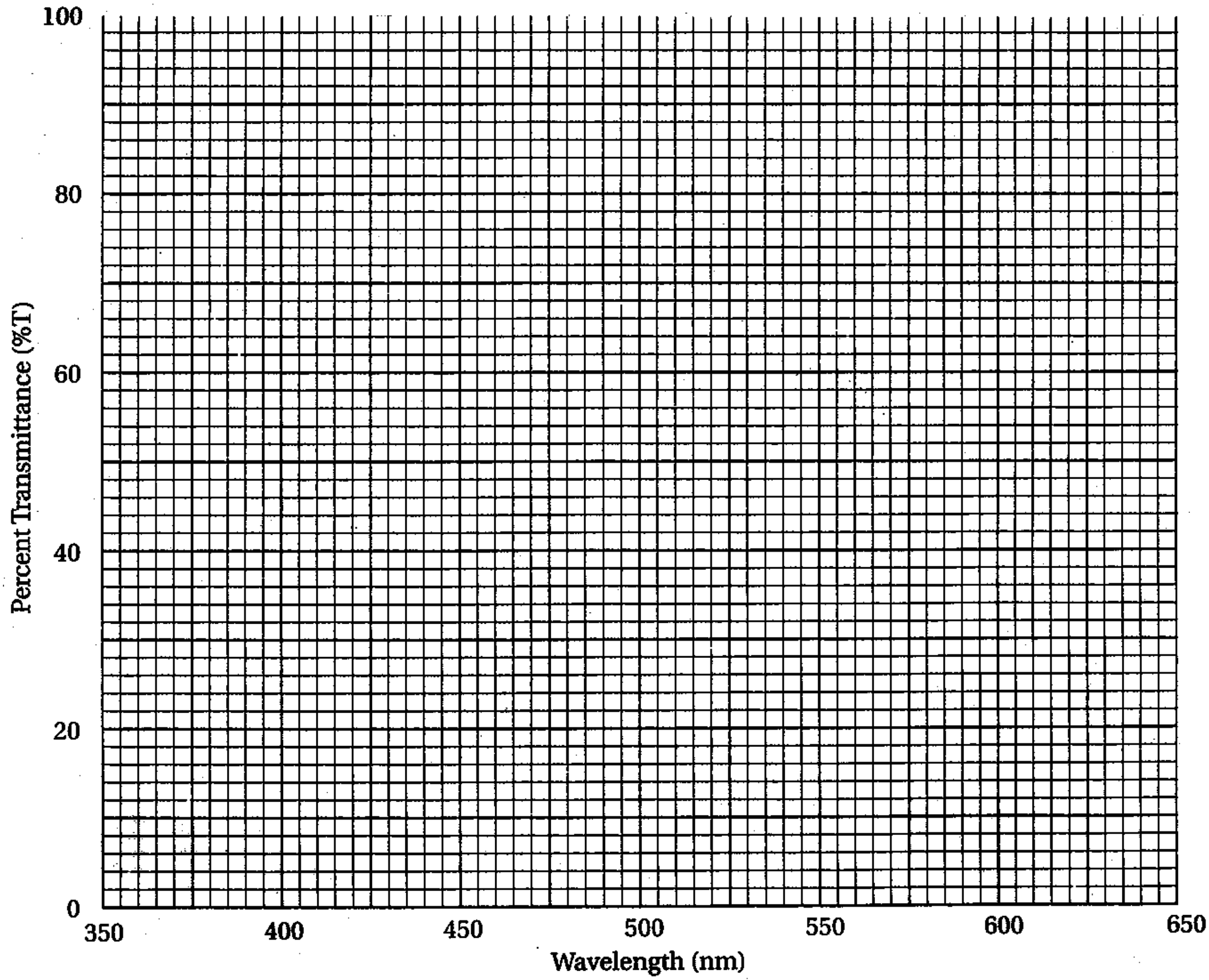
8. Unless directed otherwise, you may return the chromium(III) nitrate solution.

DATA TABLE 1: PERCENT TRANSMITTANCE AND ABSORBANCE OF 0.02*M* $Cr(NO_3)_3$ SOLUTION AT VARIOUS WAVELENGTHS

Wavelength (nm)	% Transmittance (%T)	Absorbance
375		
400		
405		
415		
425		
440		
455		
470		
490		
500		
520		
530		
540		
550		
570		
575		
580		
600		
625		

Analyses and Conclusions:

1. Graph percent transmittance versus wavelength. The curve you plat is the absorption spectrum of chromium(III) ions in the visible region of the electromagnetic spectrum.



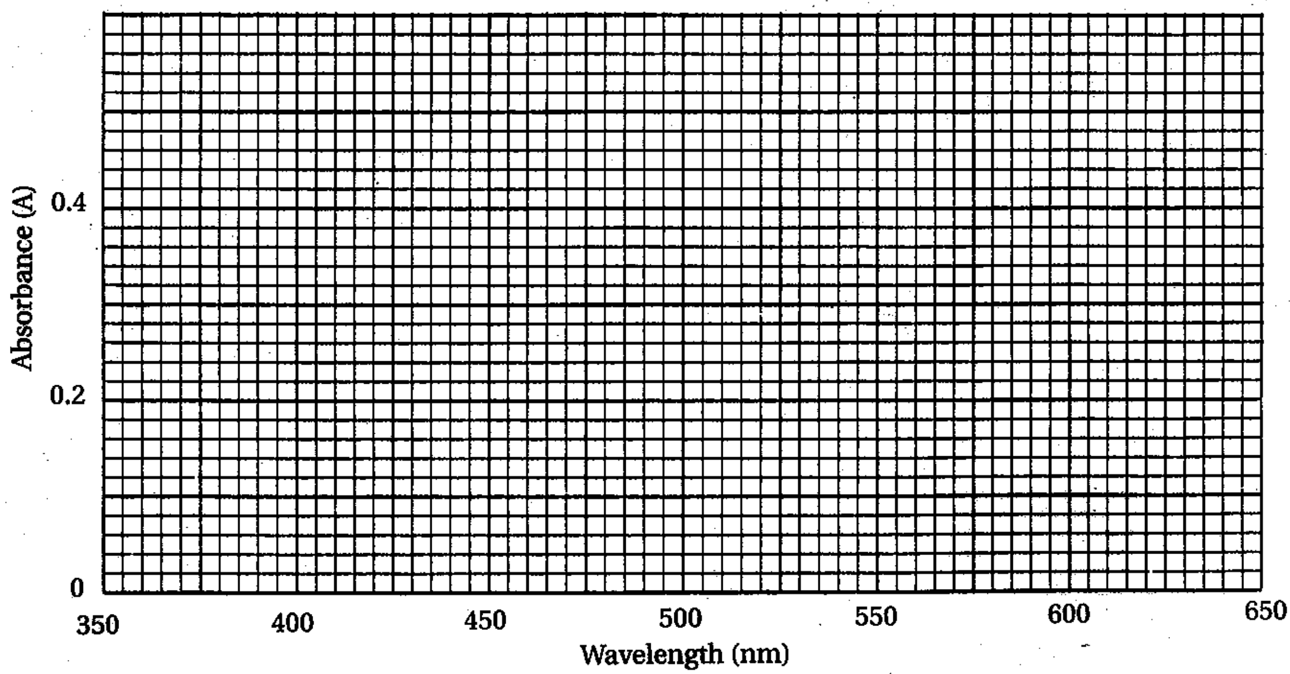
2. At what wavelengths do chromium(III) ions absorb the maximum amounts of light? What colors of light correspond to these wavelengths?

3. Based on the answer to problem 2, would you expect a red solution to absorb or transmit red light? Explain:

4. The amount of light that is absorbed by a solution is commonly expressed wither in terms of percent transmittance, as in this experiment, or in terms of absorbance (A). Absorbance is defined as:

$$A = 2 - \log\%T$$

Given the relationship is the formula, convert the percent transmittance values in the table to absorbance values. Plot a graph of absorbance versus wavelength. Compare and analyze the shapes of the two curves.



5. Based on the results of this lab, propose a hypothesis about how the absorption of light by a solution of chromium(III) nitrate varies with the concentration of chromium ions in solution. (Hint- look up Beers Law)

6. Propose an experiment to test your hypothesis. In your protocol, include a method for determining the concentration of chromium ions in an unknown solution of chromium(III) nitrate.