

Predicting Spectra

Background Information

Some materials are **transparent** to nearly all frequencies of visible light. This means that these materials transmit most of the light that strikes them. For example, window glass is transparent to nearly all frequencies of visible light. Most materials, however, transmit some frequencies and absorb others. These materials can appear colored.

If you observe the spectrum of light before and after it passes through a material, you can determine which frequencies the material absorbs. You can view the spectrum of light through a prism or an instrument known as a **spectroscope**. These instruments separate white light into its colors, a process called **dispersion**.

In this investigation, you will predict and observe how the spectrum of white light changes as the light passes through several solutions of different colors. Then, you will use your observations to explain how the color of a material is related to the wavelengths of light that it absorbs.

Problem

How is the color of a solution related to the wavelengths of light that it absorbs?

Pre-Lab Discussion

Read the entire investigation. Then, work with a partner to answer the following questions.

1. Predicting Imagine observing a white light through a piece of blue glass.

a. What color would the light appear to be?

b. What color of light would the glass transmit?

c. What colors of light would the glass absorb?

2. Predicting Describe the spectrum you would see if you passed white light through a piece of blue glass.

3. **Controlling Variables** Identify the manipulated, responding, and controlled variables in this investigation.
- Manipulated variable _____
 - Responding variable _____
 - Controlled variables _____
4. **Formulating Hypotheses** State a hypothesis about how the spectrum of white light changes as the light passes through a colored solution.
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Materials *(per group)*


lamp and incandescent bulb
spectroscope
colored pencils
stoppered test tube of chlorophyll solution
stoppered test tube of phenolphthalein-sodium hydroxide solution
stoppered test tube of potassium permanganate solution

Safety

Put on safety goggles, a lab apron, and plastic gloves. Be careful to avoid breakage when working with glassware. Observe proper laboratory procedures when using electrical equipment. Never touch or taste any chemical unless instructed to do so. The chemicals used in this investigation are toxic and corrosive. Do not open any of the test tubes. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

Procedure

-  1. With the room darkened, turn on the incandescent lamp.
 Observe the light from the bulb. In the data table, draw the spectrum that you expect to see when you view the bulb through the spectroscope. If necessary, use colored pencils to draw the spectrum.


2. Now, use the spectroscope to observe the spectrum of the light from the incandescent bulb. In the data table, draw and describe the spectrum that you observed.
-  3. Examine the test tube of the chlorophyll solution. Observe the light from the incandescent bulb through this test tube. Record in the data table the color that you see.


4. In the data table, draw the spectrum that you expect to see when you view the chlorophyll solution through the spectroscope.

5. Hold the test tube of chlorophyll solution against the far end of the spectroscope so that the light from the bulb passes through the solution before entering the spectroscope. In the data table, draw the spectrum of the chlorophyll solution. Record any differences between this spectrum and the one you observed in Step 2. You may note gaps or differences in the brightness of some colors.
6. Repeat Steps 3 through 5 with the test tube of phenolphthalein-sodium hydroxide solution.
7. Repeat Steps 3 through 5 with the test tube of potassium permanganate solution.
-  8. Return the test tubes to your teacher. Wash your hands thoroughly after carrying out this investigation.

Observations

DATA TABLE

Solution	Color	Drawing of Predicted Spectrum	Drawing of Observed Spectrum	Description of Observed Spectrum
None				
Chlorophyll				
Phenolphthalein-sodium hydroxide				
Potassium permanganate				

Analysis and Conclusions

1. **Analyzing Data** Did passing white light through the colored solutions add colors to the light or remove colors from the light?

2. Formulating Hypotheses What happened to the colors of light that did not pass through the solutions? Explain your answer.

3. Inferring Which colors of light were absorbed in the spectrum of each of the following solutions?

a. Chlorophyll solution

b. Phenolphthalein-sodium hydroxide solution

c. Potassium permanganate solution

4. Drawing Conclusions What is the relationship between the color of a solution and the colors of light that the solution absorbs?

5. Drawing Conclusions What is the relationship between the color of a solution and the colors of light that the solution transmits?

6. Applying Concepts If you shine a red light through a block of red gelatin, the red beam of light is clearly visible in the gelatin. However, if you shine a red light through a block of blue gelatin, the light is not visible in the gelatin. Explain these observations.

Go Further

The spectroscope that you used in this investigation enabled you to see whether there were any gaps in the spectrum of the light you observed and to judge whether some parts of the spectrum were brighter than others. A more precise instrument called a spectrophotometer enables you to measure the percentage of the light falling on a sample of a solution that the solution absorbs or transmits. The spectrophotometer can make this measurement at any visible wavelength.

Ask your teacher to show you how to use the spectrophotometer. Then, design an experiment to determine whether it is possible to use the spectrophotometer to measure the concentration of a light-absorbing substance in a solution. Write a detailed plan of your experiment. Your plan should state the hypothesis to be tested, identify the manipulated, responding, and controlled variables, and describe the procedures and safety precautions that you will use. Show your plan to your teacher. When your teacher approves your plan, carry out your experiment and report your results and conclusions.