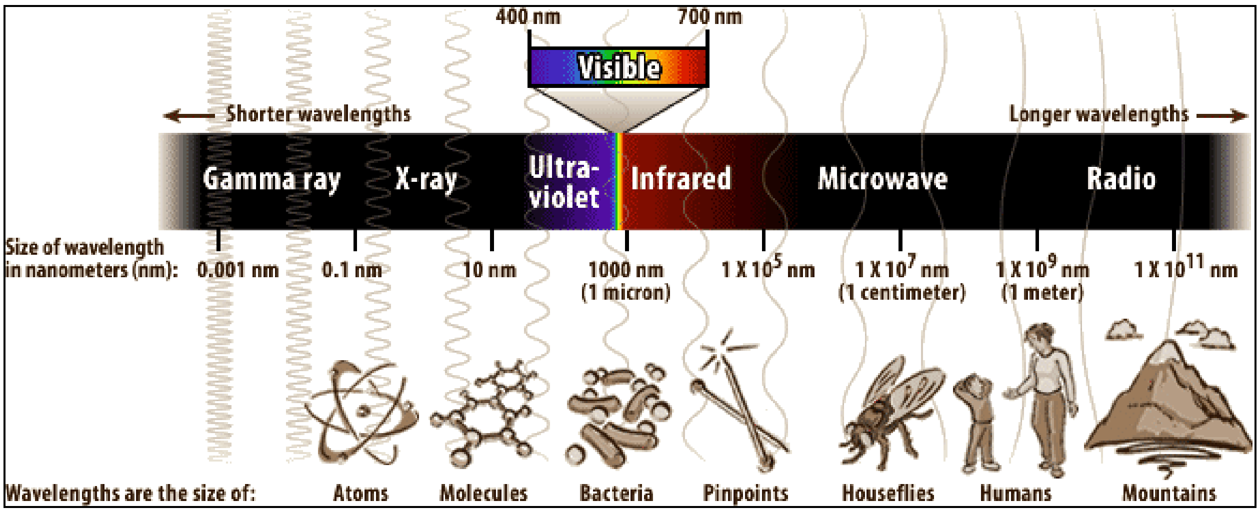
GCC CHM 107LL
Atomic Theory

Introduction

When sunlight strikes your skin, you feel its heat. This is a sign that you are absorbing some of the sun's energy. Light is only one form of energy known as electromagnetic radiation. The electromagnetic spectrum below shows all of the other forms of radiation. In order from high energy to low we have gamma rays, X-rays, ultraviolet (UV) rays, visible light, infrared (IR), microwaves, and radio waves. High energy rays/waves have short wavelengths while low energy rays/waves have long wavelengths.

The Electromagnetic Spectrum:



Light & Color

Light that can be seen with the naked human eye falls within a small range of wavelengths (400-700 nanometers) called the "visible" region. Note that these different forms of radiation possess different energies and present different potential health hazards. For example, patients often wear lead shields when getting dental X-rays, and sunscreens are used to block UVA and UVB rays, forms of ultraviolet radiation that can not only tan skin but can also cause severe sunburns. However, people usually do not worry about exposure to the radio/TV waves being broadcast throughout a city, so they can all listen and watch their favorite stations.

These different forms of radiation travel in the form of a wave. Imagine throwing a pebble into a still pond and watching the circular ripples moving outward. Like those ripples, each energy wave has a series of high points known as crests and a series of low points known as troughs. The next figure shows two different waves:

Wavelength

The **wavelength**, symbolized by the Greek letter lambda (λ), is the distance between two wave crests. Notice that the wavelength for the top wave, indicated by λ_A, is greater than the wavelength for the bottom wave, λ_B. Light and all electromagnetic waves move at the fastest speed possible in a vacuum, defined as the speed of light. The speed of light is equal to 3.00×10^8 m/s which is 300,000,000 m/s.

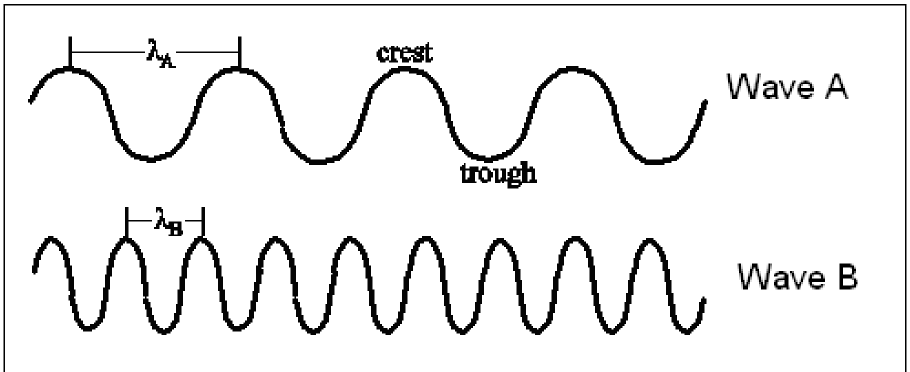
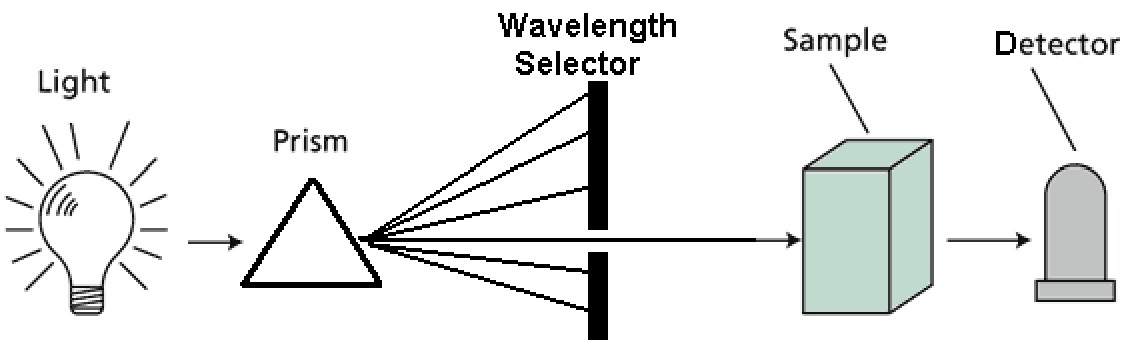


Figure 1

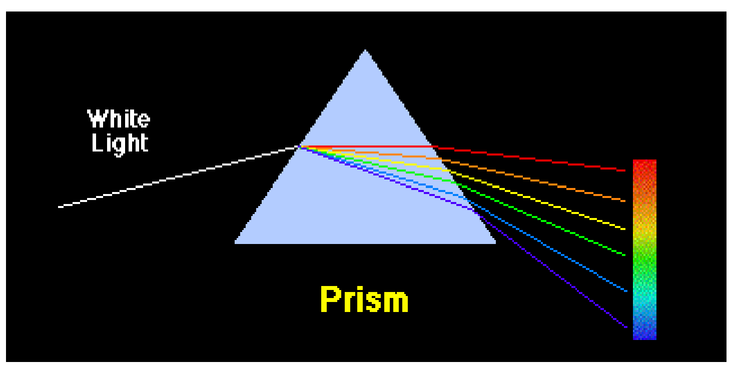
Spec 20's

A spectrophotometer (often abbreviated as "Spec-20") is an instrument that measures how much light can pass through a solution. Most Spec-20's operate in the visible and IR regions; for example, the Spec-20's used in our labs use wavelengths from 325 nm to 1100 nm. Inside a Spec-20, there is a white light source, a prism to separate the white light into the spectrum of colors (each with a different wavelength), a sample compartment, and a detector.



Spec-20's are generally used to analyze colored solutions. Light of a given wavelength (selected by the control buttons) passes through the sample, hits the detector, and the detector measures the amount of light absorbed by the solution's molecules. In general, darker solutions are more concentrated (i.e., containing more molecules), and thus have a higher absorbance.

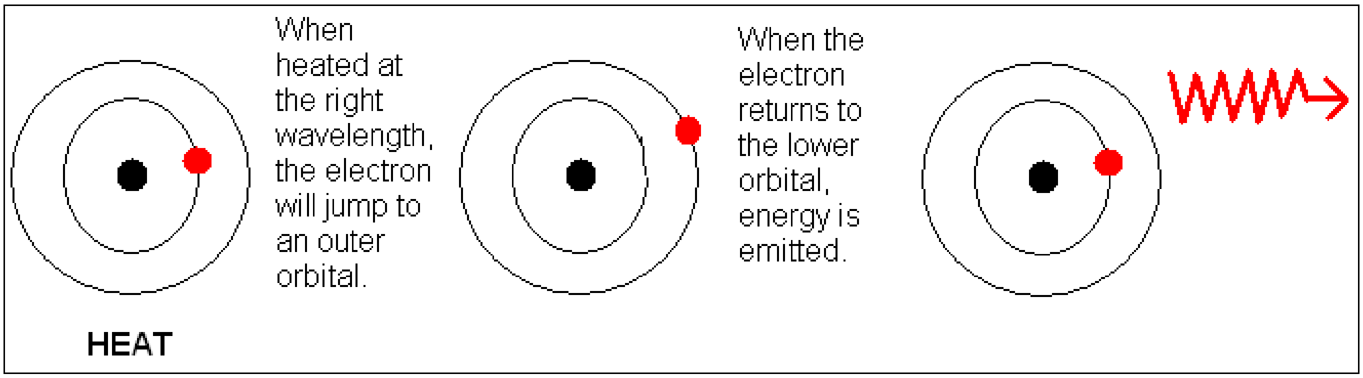
In this experiment, you will use a Spec-20 to determine the color of the light at various wavelengths. Note that as you change the wavelength you are actually turning the prism, so different colors shine through the slit onto the sample. Recall that white light is split into different colors by a prism.



Atomic Emission

The sun is 93 million miles away, and other stars are many light years away. (one light year = six trillion miles or 6 x 10^{12} miles). In spite of these great distances, we can find out what elements are in stars by analyzing the light they give off since the atoms of every element emit light of specific wavelengths, and thus, specific energies. So by looking at their wavelengths, we can find out if a star contains hydrogen, helium, etc.

Electrons exist in orbitals around the nucleus of an atom, and each orbital has a specific energy. When atoms are heated, they can absorb the specific energies needed for their electrons to jump up to higher energy orbitals. Now, the atom is in an "excited" state. Since the electrons prefer to be closer to the nucleus, they quickly return to the lower energy orbitals, and the excess energy is emitted. When the energy emitted falls within the visible range, colors are observed.



Since every element is different, the energy gap between its orbitals varies. As a result, different elements release light at different wavelengths. When an element is heated, it may emit a characteristic color. This accounts for the different colors observed with fireworks.

Procedure

PART I. GAS DISCHARGE TUBES

Turn on the "Spec-20 Genesys" spectrophotometer, using the switch on the back side of the instrument; it will take about 15 minutes to warm up before use. It must be empty and lid closed to initialize.

Your instructor will show samples of gas collected in thin glass tubes known as gas discharge tubes. The ends of the tubes have electrodes that allow a current to pass through the gas and light up. When plugged into a voltage source, the samples will glow a characteristic color. When the electrical current passes through the gases, the result is similar to heating them up in that the electrons of the gas atoms jump to higher orbitals, then relax back down emitting the light you see. Record the color of each lamp on your report sheet.

PART II. SPECTROPHOTOMETRIC ANALYSIS OF LIGHT

On the top right of the instrument is a sample holder that holds the sample containers, called "cuvettes". To the left of the sample holder is a panel of buttons that control the wavelength (in nanometers) and output settings. The up/down arrows by wavelength turn the prism-like device in the Spec-20, so light of only one wavelength strikes the sample in the cuvette.

Use the up/down arrows to adjust the wavelength to 400 nm. Your instructor will demonstrate how to place a piece of filter paper in the sample holder facing the light source. After you properly place the filter paper, stand where each student can see the side of the filter paper that faces the light source. You should see a tiny dot of color on the paper. Since the paper blocks the light rays from reaching the sample, the color observed is the color of light with a wavelength of 400 nm.

Use the up/down arrows to scroll through wavelength values from 400 nm to 750 nm in 25 nm increments to find the colors corresponding to the different wavelengths of the visible spectrum. Use crayons or colored pencils to color in the spectrum in the box on your report sheet to show the correlation between color and wavelength.

PART III: FLAME TESTS

You will conduct flame tests to observe the flame emission colors for solutions containing ions of lithium, copper, strontium, barium, potassium and sodium.

Safety precaution: Do not touch the chemicals on the splints with your fingers! Wash your hands immediately if you accidentally touch the chemicals on any of the splints.

1. Label your 6 test tubes with a pencil – one for each solution listed above. From the reagent station, put about 10 – 12 drops of each solution into the appropriate test tube. Place one splint into each test tube. These should soak for about 5 – 10 minutes in order to absorb enough solution.
2. At this time, **each group** should obtain one unknown from your instructor. Get a splint, and place it in the test tube of the unknown to allow sufficient time to soak. Be sure to record your unknown number on your Report Sheet.
3. Fill your 150 mL beaker with about 20 – 40 mL of water to dispose of the used splints.
4. Light your Bunsen burner with a striker. Your instructor will check to make sure that your flame is adjusted properly for the activity. You should see two blue cones of flame.
5. Grasp the lithium wood splint by the tip and place the damp end of the splint in the middle of the flame (in the tip of the inner cone) for a short time (about 2 – 3 seconds). You should see the color of the metal ion burning in the first few seconds.
6. **Avoid burning the wood splint itself.** If you start to notice the splint burning, immediately remove it from the flame. If it does start to burn, blow the flame out. You may immediately dip the non-burning splint back into the correct test tube and test the flame color again. You can repeat this several times if you have difficulty seeing the color.
7. When you are done testing a splint and its solution, dispose of the burned splint in the 150 mL beaker.
8. **Observe and carefully describe the color of each flame on your report sheet. For example, describe the color as pinkish red or violet red instead of just red.**
9. Observe and record the color given off by your unknown in the same manner. Identify the metal in your unknown solution.
10. When you have finished with all splints and solutions, dispose of all materials in the proper solid or liquid waste container in the hood.

Atomic Theory: Lab Report

Name: ______________________

Partner(s):___________________

Part I: Gas Discharge Lamps

Gas	Color – be descriptive
Hydrogen	
Helium	
Xenon	
Argon	
Mercury	

Part II: Spectrophotometric Analysis of Light

Visible light spectrum (shade in **all colors between the numbers** listed below):

400	425	450	475	500	525	550	575	600	625	650	675	700	725	750 (nm)

A spare box just in case you mess up the first one.

400	425	450	475	500	525	550	575	600	625	650	675	700	725	750 (nm)

Part III: Flame Tests

Metal Ion	Color – be descriptive
Lithium	
Copper	
Strontium	
Barium	
Potassium	
Sodium	

Unknown #: _______________ **Unknown metal is: __________________**

Post Lab Questions

1. Which has higher energy, gamma rays or IR waves? ____________
2. Which has the shorter wavelength, X rays or visible light? ___________
3. In Figure I, which wave has higher energy? A or B? ___________

4. In Figure I, which wave travels faster? A or B? ___________

5. What color is at 500 nm? ___________ at 650 nm? ____________

6. In Vegas you see a pale salmon / peach colored sign. Which gas is in this sign? ________

7. Describe what happens to an electron when it absorbs energy. Describe the movement of the electron when this happens. (complete sentence in your own words)

8. Explain why copper and sodium emit different colors with different wavelengths. (complete sentence in your own words)

9. In your data for **Part II** of the experiment, why did the color eventually disappear as you increased the wavelength to 750 nm? Does it mean there are no wavelengths past that point? Explain. (complete sentences in your own words)

10. You are the student representative for Glendale **Christmas** fireworks display. Propose what chemicals should be used in the fireworks to have the fireworks match the Christmas theme. Consider your flame test results. (short answer)