Name ______________________________________ **Earth Science**
Lab 10: Spectral Messages **Date** ________________

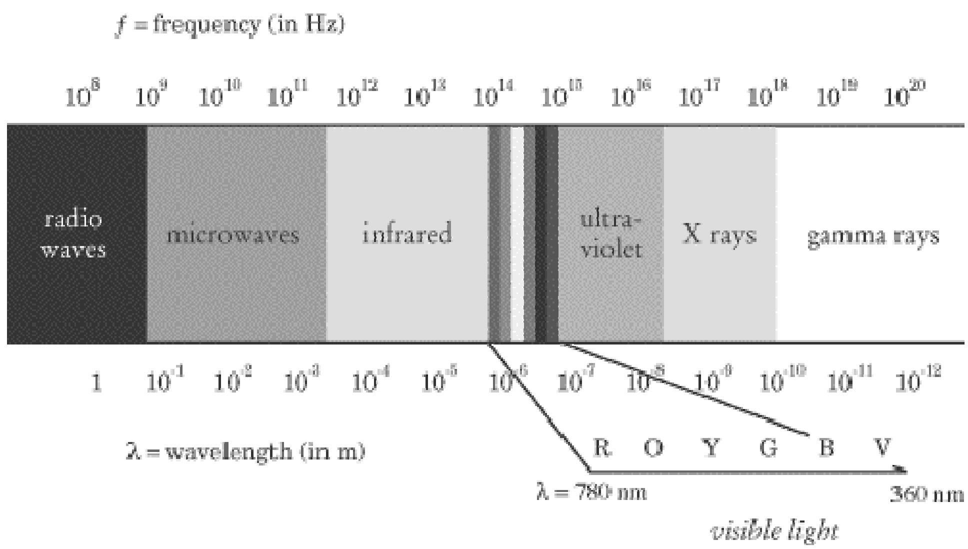
Background information: Most of what scientists have learned about the cosmos has been acquired via the various wavelengths of the electromagnetic spectrum. The unaided human eye is capable of sighting approximately 6000 stars in the night sky.

Telescopes, which came into general use in the seventeenth century, greatly extended the range of discovery with visible light. The Hubble Space Telescope, which was put into orbit in 1990, moved our vantage points above the distortion of Earth's atmosphere. Hubble does not only observe celestial phenomena with the visible light portion of the spectrum, however.

All matter, unless at a temperature of absolute zero (0 Kelvin), emits electromagnetic energy. Any given spectrum is the record of energy transactions for the source producing the spectrum. Astronomers can read much information from the spectra of stars. The chemical composition of a star's atmosphere, temperature, pressure or density, magnetism, and motion can be interpreted from the various type of spectra produced.

In this investigation you will observe the spectra from a variety of energy sources by using a spectroscope. The diffraction grating used in one type of spectroscope has thousands of grooves per centimeter. This diffraction grating breaks down or refracts the incoming light into its color components (such as a raindrops do to produce a rainbow). Isaac Newton used prisms to produce spectra in the 1600s. A combination of genius, lens-making technology, and mathematics led Newton to the following revolutionary conclusion, which he stated in a letter in 1672:

> Hence therefore it comes to pass, the **Whiteness** is the usual color of **Light**; for, Light is a confused aggregate of Rays induced with all sorts of Colors, as they are promiscuously darted from the various parts of luminous bodies.



Problem: How do spectra reveal the properties of energy sources?

Materials: spectroscope, energy sources, colored pencils

Procedure:

1. Be sure to follow the instructions given by your teacher regarding use of the spectroscope. When using the tubular spectroscopes, look through the end with the circular eyepiece. The opposite end has a slit that is pointed toward the energy source. To observe a spectrum, rotate the spectroscope and look toward the inside sides of the spectroscope (while it is still pointed at the light source!).
2. View the solar spectrum by looking out of a window toward a sunny area. Try to discern gaps in the spectrum. These are called absorption spectra and are caused by the absorption of photons by the cooler outer atmosphere of the sun. Dark lines appear at various points in the spectrum and are characteristic of the elements present in the sun's atmosphere.
3. Use the spectroscope to observe a clear incandescent light bulb, a red incandescent light bulb, and a fluorescent light bulb (the ceiling lights in the hallway).
4. Observe electrically charged elements in the supply room where other light sources will not produce interference. **Be extremely careful with these lights! Do not touch them at all!** The bright line spectra you observe are characteristic of the elements in the same way dark line spectra are when absorbed.
5. Draw your observations in the boxes provided using colored pencils.

Solar

Incandescent

Fluorescent

Red Incandescent

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Discussion Questions:

1. List the colors, from longest to shortest wavelength, as observed in the solar spectrum. ________________

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2. How is the spectrum of the fluorescent source different from the spectrum of the incandescent source? ____

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3. What do the dark lines in the absorption spectra of stars indicate? ________________________________

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4. Why are bright-line spectra especially helpful in determining the chemical composition of stars and other heated matter? ____

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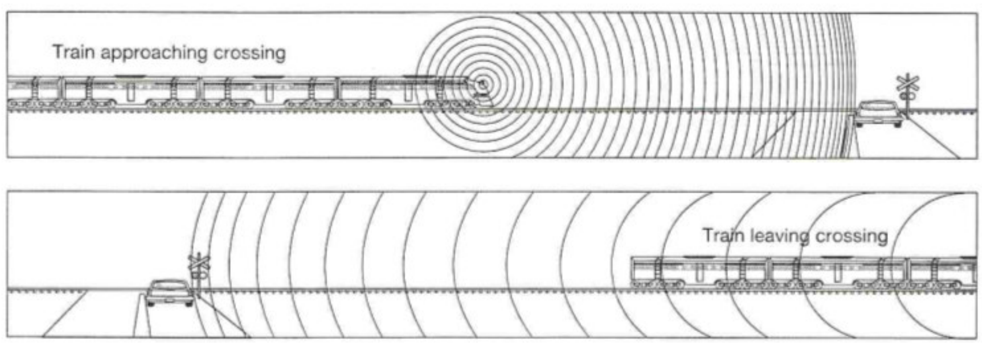
The motion of a star toward or away from Earth may be determined by analyzing the spectra of the star. Waves show shift in wavelength due to changes in direction of motion between the observer and the source. This shift is known as the Doppler effect. See the diagram for an illustration of this effect. The compressed, or shorter, wavelengths produced by the train approaching cause a higher pitched sound. The extended, or longer, wavelengths cause a lower pitched sound, as heard at the car.



Spectrum A in the diagram below represents a star that is not moving toward or away from Earth. Spectra B and C represent stars that are moving relative to Earth.

5. Which spectrum indicates a star moving away from Earth? __________

6. How do you know? ________________

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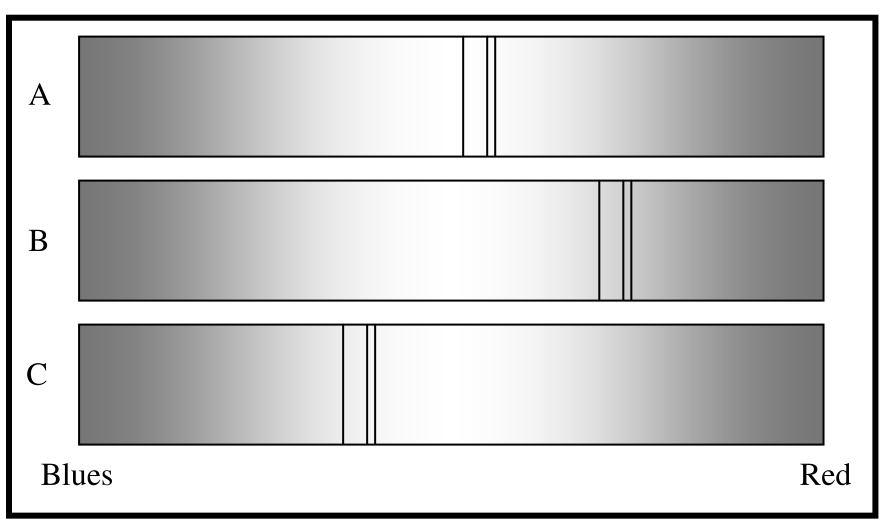

7. How do infrared wavelengths compare with radio waves? ______________________________

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With gamma rays? ____

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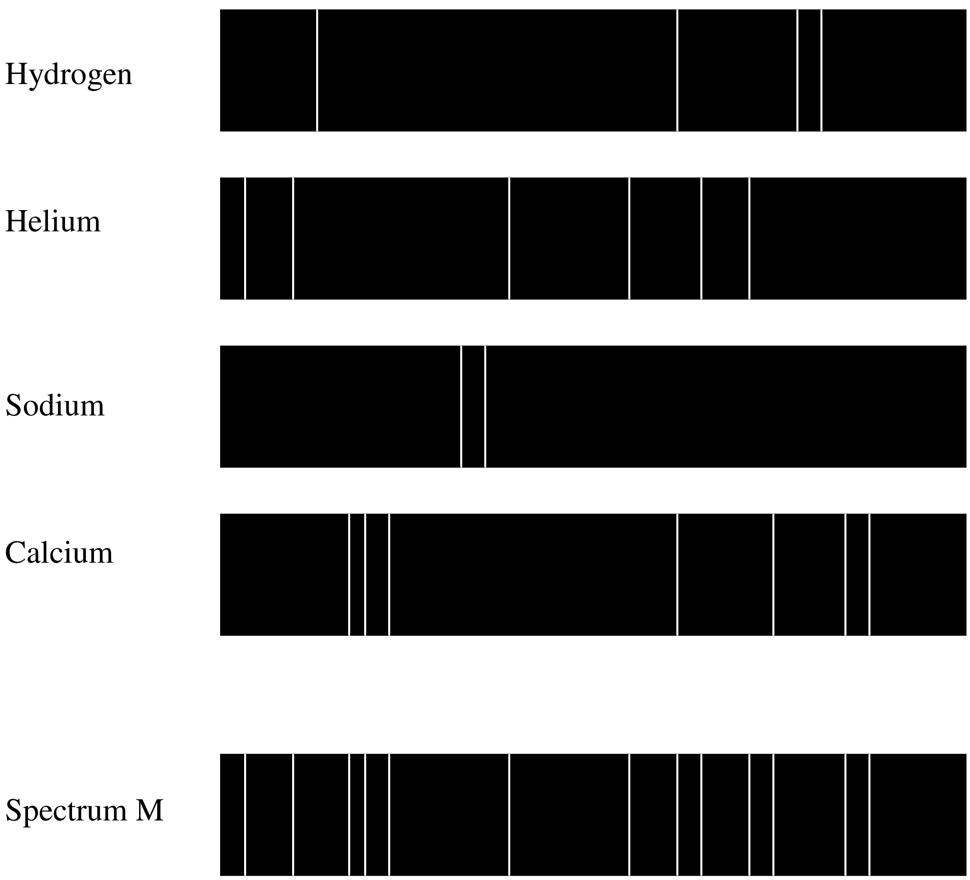
The following diagram shows the spectra of four common elements. Spectrum M was recorded by observing a high-temperature sample of an unknown material.



8. What elements are present in this unknown material? ______________________________

How do you know? ____

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