AY4 Spectra Lab: Fall 2004

Due date: Tuesday Oct 12, 2004

1 Some Background

Light is a form of *electromagnetic radiation*. Visible light, x-rays, infrared radiation and radio waves are all examples of electromagnetic radiation. All travel in a vacuum at "c", the speed of light and the differ in their $wavelength(\lambda)$, $frequency(\nu)$ and $energy(E)$.

Any kind of electromagnetic radiation can be described in terms of particles or waves. When describing it in terms of particles, these particles are called *photons*. When radiation is described as a wave, the radiation is characterized by a wavelength (λ) and a frequency (ν). The wavelength is the distance between any two peaks, and the frequency is the number of peaks per second that pass a given point in space. The frequency and wavelength are related by the velocity of the waves (c):

$$c = \nu\lambda$$

The speed of light in a vacuum is $c = 3.0 \times 10^8$ meters/second.

When described as a particle, the energy of a photon depends on the frequency or wavelength.

$$E = h\nu$$

h is "Planck's constant". $h = 6.6 \times 10^{-34}$ Joules-seconds.

2 Different Types of Spectra

Continuous: All objects with temperature above absolute zero emit electromagnetic radiation. A solid or liquid gives off a *continuous* (or *blackbody* or *Planck*) spectrum. The radiation from a solid is at many wavelengths. If this radiation is spread out in frequency or wavelength my a spectrometer we ve produced a spectrum of the object. Hotter objects have spectra that are skewed toward the higher frequency/shorter wavelength end of the electromagnetic spectrum. The temperature of any solid or liquid can be determined by taking a spectrum of the object and measuring the wavelength or frequency of the peak in the emission using Wien's Law:

$$\lambda_{\mathrm{peak}} T = 0.29$$

where λ_{peak} is the wavelength at which the most emission is seen (measured in centimeters) and T is the temperature measured in Kelvin.

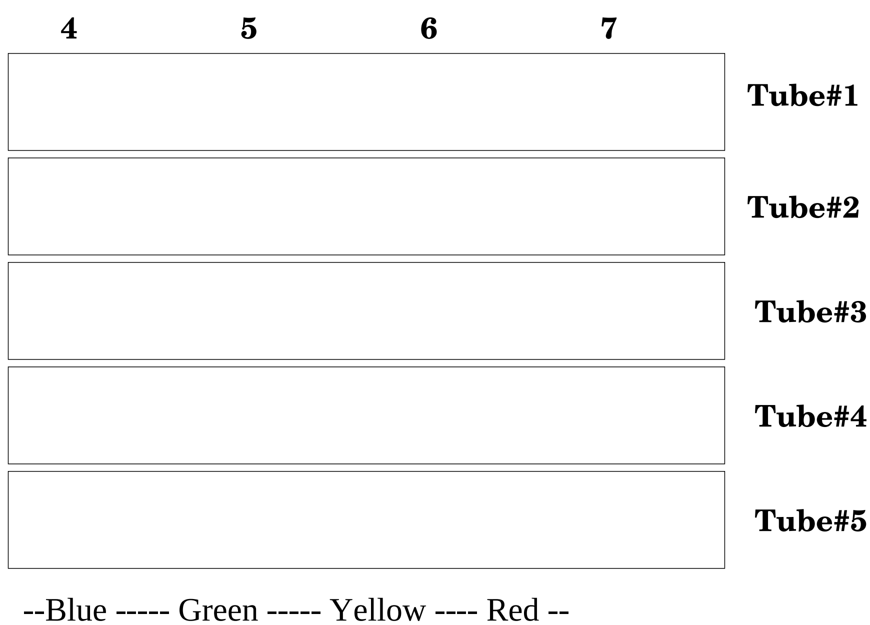
Emission-line: An emission line is created when an electron in an atom in a gas "decays" from a higher-energy orbit to a lower-energy orbit. (The electron gets rid of this extra energy by emitting a photon with that energy.) In order to make this transition, the electron must release a photon with an energy corresponding to the difference between these two levels.

Absorption-line: An absorption line is created when a photon from a background source is absorbed by an electron in an atom. The photon gives its energy to the electron and disappears, boosting the electron into a higher energy orbit.

Because the atoms of different elements have distinct energy levels, every element has a distinctive spectrum. That is, each element has a specific set of emission and absorption lines that uniquely identify the element.

3 Lab Instructions

(1) In the classroom there are three high-voltage power supplies and several tubes filled with gas. When high voltage is applied across a tube, the atoms in the gas are excited (electrons are bumped into higher-energy orbits) and on de-excitation a photon is emitted. The color, wavelength and frequency of the photon emitted is set by the energy difference between the higher and lower level the electron jumps between. You will use the handheld spectroscopes to observe the spectrum of each of tubes with mystery gases, sketch the spectrum (neatly) below and then use one of the identification charts to identify which element is in the tube. The tubes are numbered 1 through 5.



(2) Use the spectrograph to observe the incandescent light. Is this a continuous or an emission-line spectrum?

(3) Use the spectrograph to observe the overhead lights in the classroom and any other lights you can find.

4 Questions and Results

DON'T NEGLECT TO ANSWER THE QUESTIONS IN THE PREVIOUS SECTION!

1. Element Fingerprinting– list your identification for each of the five lamps.
   (a) Tube 1________________
   (b) Tube 2________________
   (c) Tube 3________________
   (d) Tube 4________________
   (e) Tube 5________________
2. Describe the difference between the spectra seen in the lamps and the spectrum from the incandescent bulb
3. Do the overhead lights in the classroom contain hot filaments or hot gases?
4. The temperature of the surface of the Sun is about 5500k. What is the wavelength of light at which the Sun emits most of its radiation. Give the answer in units of centimeters.
5. There are 10^8 angstroms in a centimeter. What is the Sun's peak wavelength in angstrom?

6. A prominent hydrogen emission line has a wavelength of 6563 angstroms.

   (a) What is this wavelength in meters?

   (b) What is the frequency of this light?

   (c) What is the energy of a photon of this light?

   (d) What is the color of this line?