Electromagnetic Spectrum and Light Laws Activity

Some helpful websites include:

Electromagnetic Spectrum,
http://csep10.phys.utk.edu/astr162/lect/light/spectrum.html
Wikipedia Light, http://en.wikipedia.org/wiki/Light
Wikipedia Planck's Law, http://en.wikipedia.org/wiki/Planck_law
Wikipedia Stefan-Boltzmann Law, http://en.wikipedia.org/wiki/Stefan-Boltzmann_law
Wikipedia Wein's Law, http://en.wikipedia.org/wiki/Wein%27s_law
Blackbody Curves and Filters Explorer Module,
http://nw.pima.edu/dmeeks/ast101/101sim/bbexplorer.html (source: Astronomy Education at the University of Nebraska-Lincoln
Electromagnetic Spectrum Module,
http://nw.pima.edu/dmeeks/ast101/101sim/emspectrum.html (source: Astronomy Education at the University of Nebraska-Lincoln)

1. Before starting this exercise we need to review a few of the units and conversions that astronomers utilize to measure light. Write the conversion factor required to do each of the following:

a. convert meters to centimeters

b. convert meters to microns

c. convert meters to nanometers

d. convert meters to Angstroms

e. convert centimeters to nanometers

f. convert Angstroms to nanometers

2. Complete column B of the following table by matching the portion of the electromagnetic spectrum with the characteristics listed below the table. You need to only write the letters for the characteristic, not its entire description. Each portion of the spectrum has 4 answers.

Table 1 Spectrum Characteristics

A	B	C
Portion of the electromagnetic spectrum	Characteristics	Wavelength range in nanometers
Radio		
Microwave		
Infrared		
Visible		
Ultraviolet		
X-ray		
Gamma ray		

a. why we can be seen in the dark by someone using night vision goggles
b. has a wavelength about the size of bacteria
c. highest energy and shortest wavelength
d. has a wavelength about the size of an atomic nucleus
e. lowest frequency and longest wavelength
f. longer than microwaves
g. our tv remotes use this to change the channel
h. has a wavelength about the size of an atom
i. wavelength approximately 400 to 700 nm
j. most, but not all, of it, is absorbed by the ozone layer
k. wavelength between 1 mm and 30 cm
l. can be generated by black holes as they devour gas from nearby stars
m. why we get sunburned
n. has a wavelength about the size of a grain of sugar
o. next to and shorter than visible light
p. used to get a view of bones and teeth
q. created by radioactive materials, in particle accelerators, and by the universe
r. from red to blue
s. has a wavelength about the size of protozoans
t. used to cook popcorn
u. shorter than x-rays
v. has a wavelength about the size of a molecule
w. telephone satellites use these
x. is translated into sound
y. wavelength between 1 and 100 microns
z. wavelength about the size of a building
aa. the only part of the spectrum we can see
bb. shorter than ultraviolet but longer than gamma rays

3. Complete Table 1 column C of the table above with the wavelength range for each of the parts of the electromagnetic spectrum listed in Table 1 column A. If the source you use provides the wavelengths in units other than nanometers, you will need to convert the values into nanometers before recording them in the table.

4. According to the website *Wikipedia Light*, what are the four properties of light?
a.

b.

c.

d.

5. Wein's Law states that the hotter an object is, the shorter the wavelength at which it will emit most of its radiation:

$$T = \frac{2.898\ x\ 10^{-3}}{\lambda_{max}}$$

where T is its temperature in Kelvin and λ_{max} is the peak wavelength in meters. Solve this equation for λ_{max}, show your work.

6. Calculate the peak wavelength in meters for each of the stars in the table below. **Write the answers in Table 2 column C in scientific notation with two decimal places.**

7. Convert the answers in meters in Table 2 column C to nanometers and write them in Table 2 column D.

8. Using one of the websites above or another source of your choice, determine in which part of the electromagnetic spectrum (radio, microwave, infrared, visible, ultraviolet, x-ray, gamma ray) λ_{max} is for each of the stars in the table below, and write your answers in Table 2 column E.

9. The Stefan-Boltzmann Law is:

$$P = \sigma T^4$$

where P is the energy in watts/m^2, T is the temperature in kelvins, and σ is a constant equal to 5.67 x 10^{10} watts/nm^2 K^4. Calculate the energy emitted for each of the stars in the table below. **Write the answers in Table 2 column F in scientific notation with two decimal places.**

10. Which star gives off the most energy? Why isn't it the brightest star as seen from Earth? Hint: the answer is not "because the Sun is closer."

11. Access and experiment with the Blackbody Curves and Filters Explorer Module, http://nw.pima.edu/dmeeks/ast101/101sim/bbexplorer.html Click in the box next to **indicate peak wavelengths** and check your answers in Table 2.

12. If a star's temperature increases, how does its peak wavelength change?

13. If a star's temperature increases, how does its energy change?

Table 2 Ten Brightest Stars as Seen from Earth in Order of Apparent Brightness

A	B	C	D	E	F
Star	Temperature in K	Peak wavelength λ_{max} in m	Peak wavelength λ_{max} in nm	Location in electromagnetic spectrum of λ_{max}	Energy P in watts/m^2
Sun	5,800				
Sirius	9,880				
Canopus	7,800				
Alpha Centauri	5,770				
Arcturus	4,290				
Vega	9,600				
Capella	5,800				
Rigel	11,000				
Procyon	6,530				
Achernar	14,500				

14. Access and experiment with the Electromagnetic Spectrum Module, http://nw.pima.edu/dmeeks/ast101/101sim/emspectrum.html Move the slider all the way to the left. Note that the part of the electromagnetic spectrum at that end of the display consists of gamma rays, as indicated in the Spectrum Screen. Slowly move the slider to the right and note how the Blackbody Color changes. Write one or two sentences to describe this change.

15. Repeat this process, but this time, note how much of the spectrum consists of visual light. Write one or two sentences to describe your observation