Astronomy
Blackbody Lab

Name: Key Period ___

Website for virtual lab
https://phet.colorado.edu/sims/blackbody-spectrum/blackbody-spectrum_en.html

Background: A "blackbody" is a term used to describe the light given by an object that only gives off emitted light, in other words it doesn't reflect light. Of course in order for such an object to emit light it must get hot. In this lab you are going to observe the nature of light given off by hot objects and determine if there is an empirical relationship between an object's temperature and the light emitted.

Part I Characteristics of the blackbody spectrum of an incandescent light bulb.

Set the temperature of the blackbody to 3000 K. This is approximately the temperature of the tungsten filament *in an incandescent light bulb which is a good black body. Use the zoom tools so that you can* observe a large peak (3.16 on the vertical axis and 3 on the horizontal axis would be good. Be clear about the information on each axis. Intensity is the amount of light given off and the wavelength of light is given on the horizontal axis.

1. Based on the graph, does the light bulb produce visible light? How can you tell?
   Yes because of the visible light bands under the curve
2. Does the light bulb produce X-rays? How can you tell?
   NO – Flat line at small x
3. *In the spectrum made by the light bulb, which wavelength is most intense and how would you classify* it (what kind of light)? ~ 1 μm (1000nm) Infrared Light
4. Given your answer to #3 is an incandescent light bulb very good for it's intended use? Explain and suggest alternatives.
   No alot (most) of light given off in infrared, not visible
5. Based on the shape of the graph would you expect the light bulb to emit radio waves? Would the amount be significant? Explain.
   ~~Yes~~ No – flat line

Click Save. (The curve will turn yellow)

Part II Comparing spectra of different objects.

Set the temperature to 615 K, this is comparable to the temperature in a very hot oven. Notice that the RED line is the radiation emitted by the oven. The line should appear flat, but it isn't. Zoom the y axis in to read .001 and zoom the x-axis out.

1. How is the curve produced by the oven similar to the line produced by the light bulb?
   Black same shape = blackbody curves
2. How is the curve produced by the oven different from the curve produced by the light bulb?
   Peak further into the infrared & less intense

3. If the power goes out in your kitchen, could you see in the dark using light from hot oven? Explain.

No – not visible light under the curve

Set the temperature to 5600K. This is approximately the surface temperature of the sun. You'll need to zoom in on the horizontal axis and zoom out on the vertical axis.

4. Compared the most intense wavelength (peak wavelength) produced by the light bulb to the most intense produced by the sun.

the peak is in the visible range for the Sun & in the infrared for the oven

5. Explain the relationship you see between the radiation emitted by the sun and the visible spectrum.

The peak is in visible (orange-red)

6. Is there evidence of the sun producing harmful ultraviolet radiation? Explain.

Yes – there is UV light under the curve

Part III The relationship between peak wavelength and temperature.

1. Use Wein's law to estimate the temperature of the Red Supergiant star Betelgeuse. Obviously Betelguese appears red but its blackbody curve actually peaks in the infrared with a wavelength of 855 nanometers.

$\lambda = \frac{2.9 \times 10^6 \text{ nmK}}{T}$ $\quad T = \frac{2.9 \times 10^6}{\lambda} = \frac{2.9 \times 10^6 \text{ nmK}}{855 \text{ nm}} = 3392 \text{ K}$

2. Now use the applet to create a blackbody curve with the temperature you found above. How well do they match? What is the color of the star in the applet?

Close – Dark Red (no B or G)

3. Now lets flip the problem on its head. The star Rigel has a temperature of 11,000 K. Use Wien's law to find the peak wavelength of the star. What color does this correspond to?

$\lambda = \frac{2.9 \times 10^6 \text{ nmK}}{T} = \frac{2.9 \times 10^6 \text{ nmK}}{11{,}000 \text{ K}} = 264 \text{ nm}$

4. Here is an exercise comparing the energy output of two stars with the same temperature but different sizes. The temperature of both stars is 4000 K. Use Wien's law and the Applet to find the peak wavelength.

$\lambda = \frac{2.9 \times 10^6 \text{ nmK}}{4000 \text{ K}} = 725 \text{ nmK}$

80 Sun $\qquad$ 0.8 Sun

5. Now imagine one star is a giant and has a radius that is 80 times bigger than the Sun. The other star is smaller and has a radius that is .8 times that of the sun. Can you use the Luminosity relation for blackbodies to compare how much more luminous the big star is compared to the small one? (Note, you are only being asked to make a comparison so you should be able to do this problem without actually using the value of the Stefan-Boltzmann constant or calculating the 4pp in the problem).

$L = 4\pi R^2 \sigma T^4$ $\quad \frac{4\pi (80)^2 \sigma T^4}{4\pi (0.8)^2 \sigma T^4} = \frac{80^2}{0.8^2} = \left(\frac{80}{0.8}\right)^2 = (100)^2 = 10{,}000$ times more luminous

6. If the peak of the curve falls outside the visible range, what determines the color of a star? White light has an approximately equal mix of colors. White dwarfs are high temperature stars (T > 30,000 K). Use the Applet to figure out how they got their name. Explain.

How much visible (& what kind of visible) is under the curve

$\lambda = \frac{2.9 \times 10^6}{30{,}000} = 96 \text{ nm}$ There is a small amount of visible light under the graph – about equal amounts of colored light