

## Solutions: Exploring Blackbody Radiation using the PhET Simulation

### Temperature = 4800K:

1. What would you say is the color of the EM “blackbody” source shown at the top as a star burst?  
*off-white / yellow*
2. Are all three spectral colors - blue, green, red – needed to produce this color?  
*yes*
3. What is the temperature shown for this EM blackbody source?  
*4800 K*
4. What would this temperature be in Celsius?  
 *$4800 - 273.15 = 2526.85 \text{ }^\circ\text{C}$*
5. Would a sensor that responds only to infrared be able to detect this EM source?  
*Yes – some energy is emitted at infrared wavelengths (longer than red light)*
6. Would a sensor that responds only to ultraviolet be able to detect this EM source?  
*Yes – some energy is emitted at ultraviolet wavelengths (shorter than blue light)*
7. The energy output of the EM source is spread over a wide band of wavelengths and varies in strength. At what wavelength is the source’s output intensity the greatest?  
*The source’s output is greatest at a wavelength of about 600 nm (0.6  $\mu\text{m}$ )*

### Lower the temperature of the source:

8. Describe the change in color of the source.  
*It gets redder*
9. Describe the change in shape of the graph.  
*It gets smaller at all wavelengths, and peaks further to the right.*
10. How does the wavelength of the maximum intensity change?  
*The peak shifts to longer wavelengths*

### Raise the temperature of the source:

11. Describe the change in color of the source.  
*The source gets bluer*
12. Describe the change in shape of the graph.  
*The graph is taller at all wavelengths, and peaks further to the left*
13. How does the wavelength of the maximum intensity change?  
*The peak shifts to shorter wavelengths*

Applications:

## 14. Everyday objects:

- a. At what temperature would an oven heating element just begin to glow red?  
*About 650 K*
- b. According to this simulation, what is the color of an operating incandescent light bulb? *Orange*
- c. What is the wavelength at which the most power is emitted for a light bulb?  
*About 950 nm (0.95  $\mu\text{m}$ )*
- d. Is an incandescent light bulb primarily a light source or a heat source?  
*Primarily a heat source – most of the energy is emitted at infrared wavelengths.*
- e. Explain why regular incandescent bulbs waste a lot of energy. Be sure to include your reasoning.  
*Because most of the area under the graph is at infrared wavelengths, most of the energy of the bulb is output in the “heat” (infrared) region of the spectrum, with much less producing usable visible light.*

## 15. Earth:

- a. What does this simulation assume is the average temperature of the earth’s surface?  
*About 300 K*
- b. What would this be in Celsius? *26.85°C*
- c. We see the earth by reflected light, but why don’t we see the earth glowing except at a few spots where there is an active volcano?  
*The Earth doesn’t get hot enough to glow in visible light, except where active volcanoes are heating the rock.*

## 16. Other Solar System Objects:

- a. What part of the EM spectrum would be useful to determine the surface temperature of objects such as asteroids? Explain your answer.  
*Infrared*
- b. The surface of Mars appears reddish. Is Mars ‘red-hot’? If so, what is its surface temperature? If not, where is the red light coming from?  
*Mars is not “red-hot”, but rather red because it’s surface is absorbing some of the blue light from sunlight, and so reflecting more red light than blue light.*

## 17. Stars:

- a. If we observe a star's spectrum and find that the peak power occurs at the border between red and infrared light, what is the approximate surface temperature of the star?  
*About 4000K*
- b. If we observe a stars spectrum and find that the peak power occurs at the border between blue and ultraviolet light, what is the surface temperature of the star?  
*About 7000 K*
- c. Which star is hotter, a red star, or a blue star?  
*A blue star is hotter than a red one...*