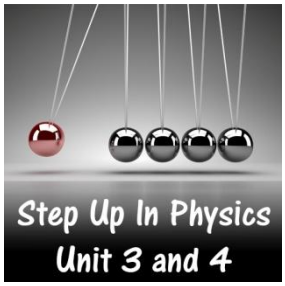
Spectra and Black Bodies

Problems Worksheet

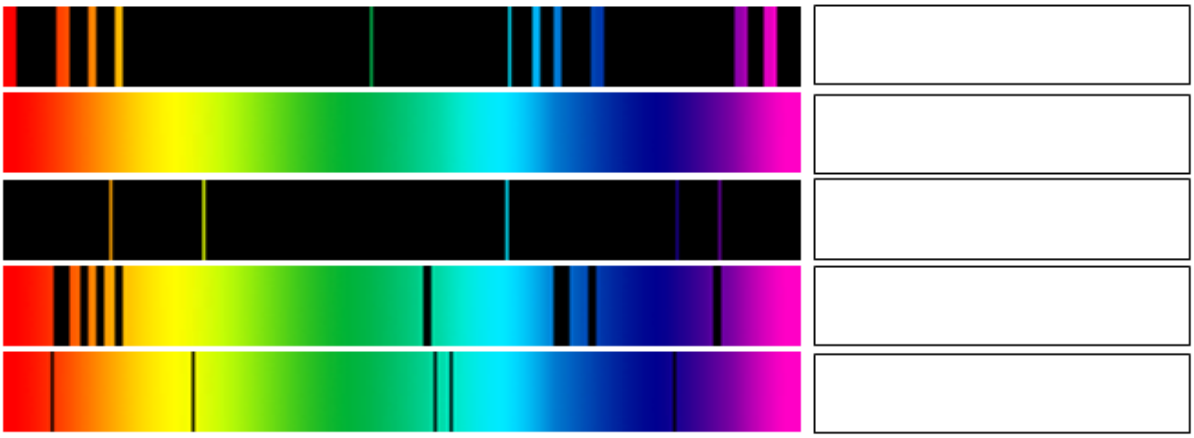


1. A black body is a theoretical object that absorbs all incoming electromagnetic waves, reflects none and emits all possible wavelengths. The black body appears black when at room temperature.

    a. Explain why a black body appears black at room temperature.

    b. Describe the changes in colour of a black body as it increases in temperature.

2. Name each type of spectrum shown below. Place your answer in the box to the right of each spectrum.



3. Stars in the night sky have a range of colours, including red and blue. When comparing two otherwise identical stars, an observer on Earth sees blue stars are brighter than red stars.

    a. Using a suitable graph to help justify your answer, explain why some stars appear red while others appear blue.

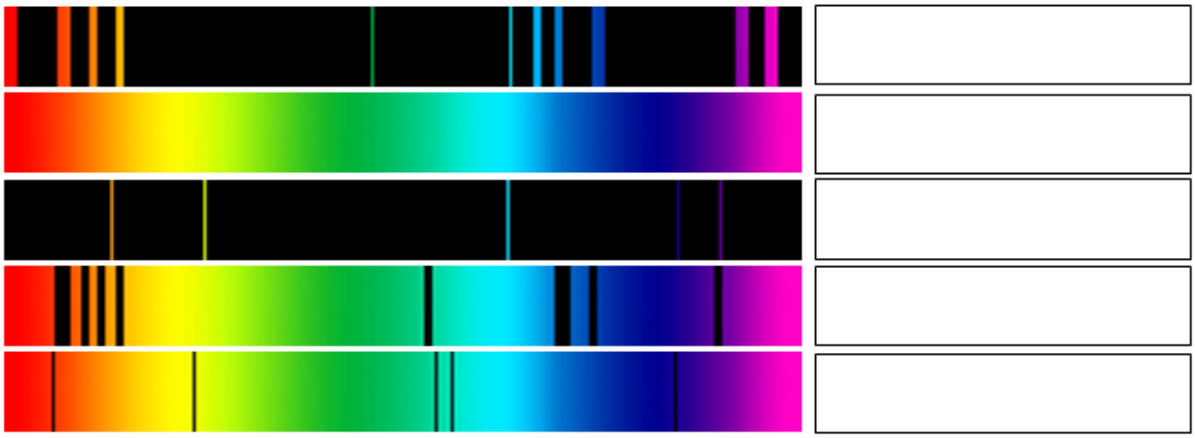
    b. Using the same graph, justify why the blue stars are brighter than red stars.

    c. One particular red star observed in the sky is clearly brighter than other stars, including blue ones. Describe how this is possible despite your answers to part (a) and (b).

4. The spectra below were produced by:

   A. A gas discharge chamber filled with a monatomic gas
   B. Burning ionic salt in a Bunsen flame
   C. Viewing an incandescent globe
   D. Shining white light through a solution containing large molecules
   E. Shining white light through a very dilute, simple gas.

   In the box to the right of each spectrum, place the letter A, B, C, D, or E to indicate how the spectrum was produced.

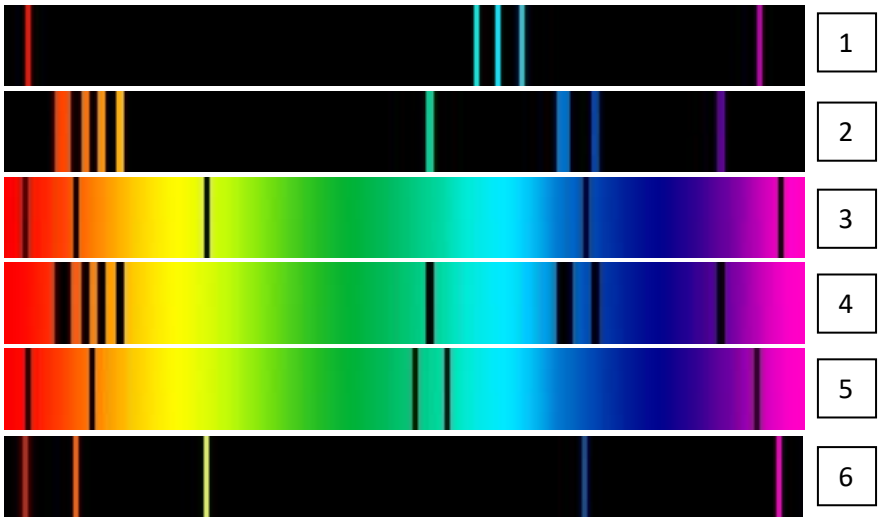


5. The spectrum below contains useful information for identifying the substance that created this particular spectrum.

   a. Use an arrow to identify the line on the spectrum that represents the longest wavelength unique to this substance. Clearly label this arrow.

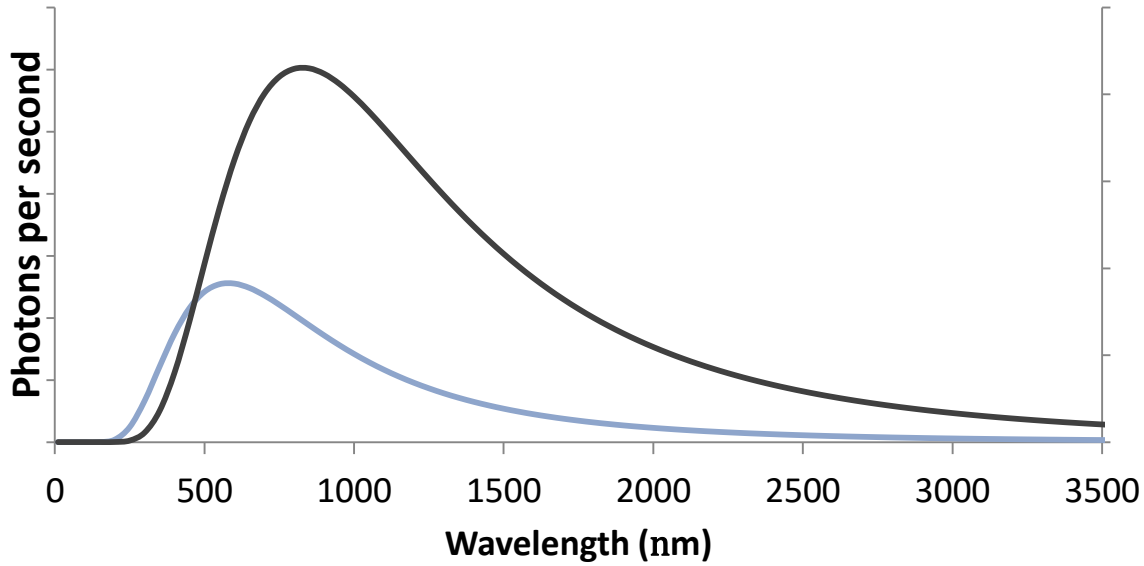
   b. Describe one method by which this type of spectrum could have been produced.

6. A research student collected a pair of spectra from a monatomic gas. The first spectrum was taken by shining a white light through a cold sample of the gas. The other spectrum was recorded by placing the low pressure gas in a discharge tube and energising the sample with an electric current. The student managed to mix up the spectra with others that were lying on her desk. All the spectra are shown below.



Which pair of spectra (1 to 6) are the original spectra of the monatomic gas taken by the student? Justify your answer.

7. A yellow star and red star have their spectrums analysed and compared. The plot of their spectra is provided below. The vertical axis is a measure of the number of photons that reach the spectrometer each second.



a. Label each curve, indicating whether it is for the red star or the yellow star. Justify your choice.

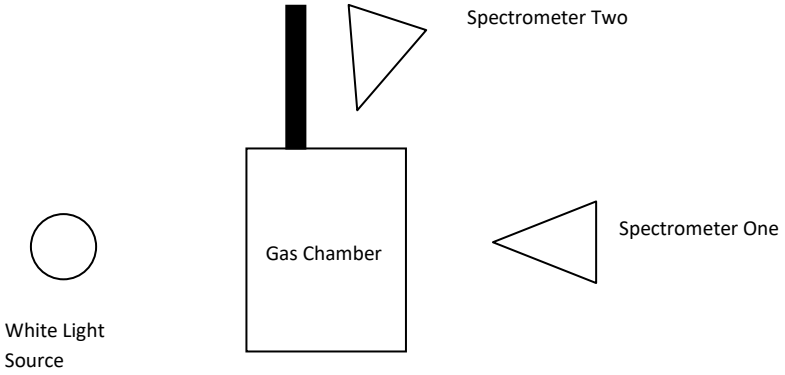
b. The yellow star is larger than the red star. Explain why there is a difference in the intensity between the stars recorded by the spectrometer.

8. The Sun can be approximated as a black body. It is a yellow star because of the correlation between colour and temperature of a black body.

a. Explain why a blue star emits more yellow light than the Sun.

b. It might be expected that observing the spectra of the Sun from Earth would produce a continuous emission spectrum because of its black body approximation. Instead a line absorption spectrum is clearly observed. Explain the cause of the solar absorption spectrum.

9. An experimental setup involving a white light source, two spectrometers and a gas chamber filled with a dilute, monatomic gas was arranged as shown below. Spectrometer one is placed on the opposite side of the gas chamber to the white light source. Spectrometer two has a clear view of the gas chamber but is blocked from seeing the white light source. There are no other sources of light and the experiment is conducted in a room that does not reflect any light off its walls.



a. State what type of spectrum will be observed by spectrometer one. Explain how this spectrum is formed.

b. State what type of spectrum will be observed by spectrometer two. Explain how this spectrum is formed.

10. Tungsten filament light bulbs operate by emitting electromagnetic radiation based on their temperature, similar to a theoretical black body. This causes them to glow yellow-white. Tungsten filament technology is becoming less popular because they waste a lot of energy to produce light. The loss of thermal energy to the immediate surroundings is one form of wasted energy, the other is the emission of unwanted electromagnetic radiation.

a. What is the main type unwanted electromagnetic radiation?

b. Explain why the filament produces the unwanted electromagnetic radiation.

c. A bread toaster is based on a very similar concept; an electric current passes through a metal conductor, which causes resistive heating. Describe why the toaster metal glows red while the tungsten filament glows yellow-white.