Wein's Law Activity II – Candle Flame

Based on - http://heasarc.gsfc.nasa.gov/docs/xte/outreach/HEG/si/activity2.html
Background information from - http://www.ldeo.columbia.edu/dees/ees/climate/lectures/energy/wavelength.html

Introduction

Students will need a brief knowledge of Wein's law, the electro-magnetic spectrum, lab rules, and basic algebra. The following worksheet contains the student information and questions to answer. The students only need supervision and eye protection when lighting the candle.

Materials

- Candle
- Matches
- Glass or metal container to extinguish the candle
- Fire extinguisher
- Oven mitts or heavy-duty gloves
- Eye protection
- Colored pencils
- Diagram or chart of the EM spectrum
- Student handout (included in this write-up)
- Optional - Computer with internet connection
- Optional - LCD projector and screen
- Optional - Movies of heated lava, heated metal and other heated objects
- For classrooms with more than one computer, visit http://csep10.phys.utk.edu/guidry/java/wien/wien.html for visual aids and additional activities dealing with Wein's Law.

Background

Wein's Law describes the relationship between the wavelength of maximum intensity of a black body to its temperature:

$$I_{max} = a/T$$

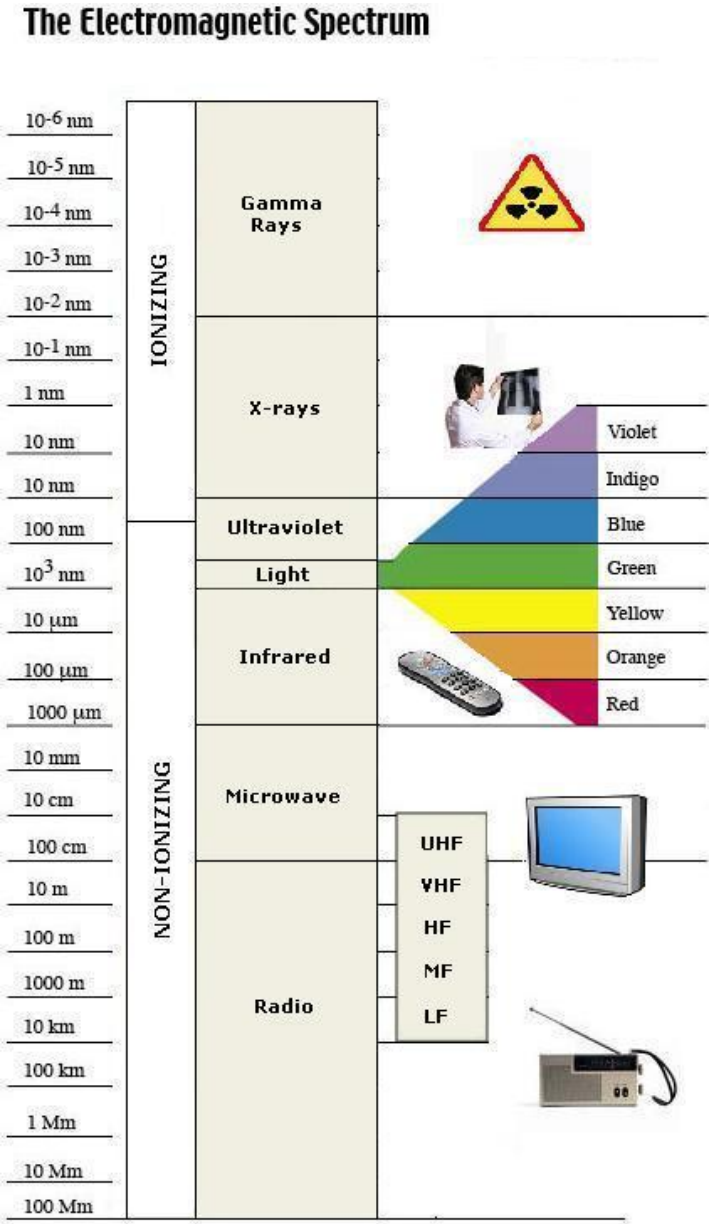
Where:

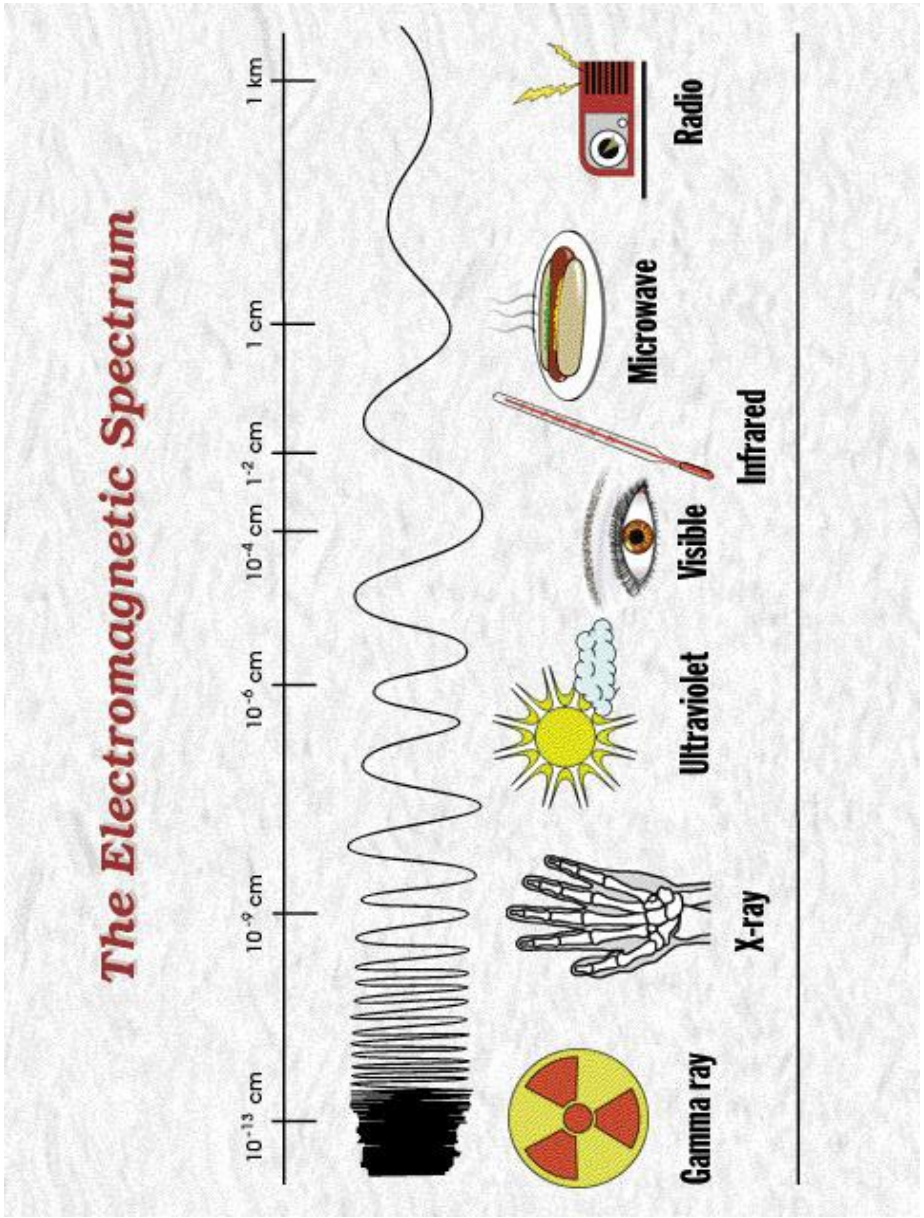
I_{max} = maximum intensity

a = 2989 (constant) [when intensity (I) measured in microns]

T = temperature measured in Kelvin [Remember that K = 273 + C]

(From - http://www.ldeo.columbia.edu/dees/ees/climate/lectures/energy/wavelength.html)


The Electromagnetic Spectrum
10-6 nm
10-5 nm
10-4 nm
10-3 nm
10-2 nm
10-1 nm
1 nm
10 nm
10 nm
100 nm
10^3 nm
10 µm
100 µm
1000 µm
10 mm
10 cm
100 cm
10 m
100 m
1000 m
10 km
100 km
1 Mm
10 Mm
100 Mm
IONIZING
NON-IONIZING
Gamma Rays
X-rays
Ultraviolet
Light
Infrared
Microwave
Radio
Violet
Indigo
Blue
Green
Yellow
Orange
Red
UHF
VHF
HF
MF
LF


The Electromagnetic Spectrum
1 km
1 cm
10-2 cm
10-4 cm
10-6 cm
10-9 cm
10-13 cm
Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma ray

Thought Experiment

1. An example (From - http://www.geography4kids.com/files/en_temp.html, no longer available): Picture liquid iron. It starts out as a very hot liquid and gives off a very bright, white light. As the liquid iron cools, its color changes to yellow then to orange and finally to red. At room temperature it is gray or black. At this point the peak wavelength of emission is outside the visible spectrum, and we can no longer detect any changes with our eyes. This, however, is a good example of how the temperature is affecting the intensity and type of radiation given off by an object.

Questions

1. According to the above data how are the color of an object and the radiation emitted by it interrelated?

2. Give another example of the same phenomenon described in #2 above.

Activity

****YOU WILL NEED EYE PROTECTION FOR THIS PART OF THE ACTIVITY!****

1. Carefully light the candle in front of you. Make sure that you strike the match away from you and that the match is completely out and cool before you throw it into the trash can. Watch the candle burn. Make a note of your observations.

2. Look carefully at the flame.
   A. What color is the flame closest to the bottom of the wick? _____
   B. What is the color of the flame farthest from the wick? _____

3. Sketch and COLOR the flame and wick as it appears on the candle. Make sure that you include all of the subtle color changes found on the flame in your sketch.

A. What colors do you observe within the flame?

B. What do the different colors of the candle tell you about the temperatures of the flame? Describe one "real life" experience where this data is helpful.

Calculations

1. Use Wein's law to determine the following answers.
   A. A scientist measured the temperature of a celestial body at 270 degrees Celsius. What would the maximum wavelength intensity of this body be? Show your work.

   B. What part of the EM spectrum does this wavelength fit into?

   C. Would you be able to detect this type of radiation on the surface of the Earth? Why?

   D. How would this information be useful if you were trying to study this celestial body? (three ways)