Some Laws Related to Electromagnetic Radiation

1. ***Molecules which "possess" internal energy (discussed in class) "possess" temperature***. (Quotes mean term is scientifically-improper and only used as an analogy.)

$$T = am_w v^2$$

where T is Temperature (K), a is Avogadro's Number and is a constant, m_w is molecular weight, and v is proportional to the portion of the molecule's motion that is vibrational.

Note that although the general concept is the greater a molecule vibrates, the warmer its temperature, that different molecules (substances) will do this more or less efficiently. For example, for a given vibrational mode, molecules with a high molecular weight will do this more efficiently. We'll see this explains why metals "heat up" more for a given energy receipt than does a comparable mass of water.

2. ***Any object which possesses internal energy also emits another type of energy known as ELECTROMAGNETIC RADIATION (or radiation for short).*** (Note: an alternate but equally accurate definition for radiation is-->that process by which electromagnetic energy is transmitted without the aid of a physical substance.)

To simplify this, we consider a cube shaped object with a volume of V with a small hole in one face and a measuring device facing the hole. The relationship between radiation emitted by this type of object (called a blackbody object) to its temperature is known as Planck's Law.

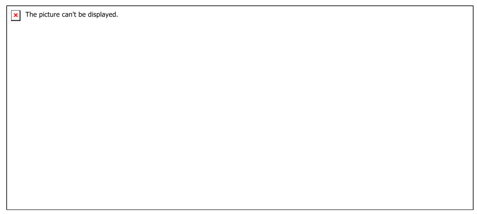
$$U_\lambda = \frac{8\pi^5 V}{15(hc)^3}(kT)^4$$

$$U_\lambda \approx (kT)^4$$

where U on the left is termed "spectral energy density which can in turn be related to "emittance" or "intensity of radiation" that can be visualized as a wave, T on the right is temperature in Kelvin, and the lambda represents the single wavelength characteristic of that emittance, and the other quantities in the equation are constants, h is Plank's constant, k the Stefan-Boltzmann constant, and c the speed of radiation (light).

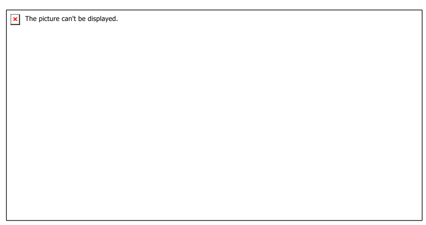
You won't have to work with Planck's Law, but just understand that it implies that any object that is warmer than 0_{o}K will emit energy, and that energy that can be characterized as a wave and is called "radiation". The only variable on the right hand side of the equation is temperature.

3. ***The hotter an object (that is, the more internal energy it possesses), the greater the amount of radiation emitted.*** *(*Stefan-Boltzmann Equation can be derived from Planck's Law)



where E on the left represents the total amount of energy regardless of wavelength of that energy emitted by an object (or molecule) that has a temperature greater than 0_{o}K. The sigma is called the Stefan-Boltzmann constant. You won't have to work with the Stefan-Boltzmann equation, but you will have to apply its concept.

4. **The hotter an object, the shorter the wavelength of radiation it emits. (**Wien's Equation)



where lambda is the wavelength of the peak radiation emitted by the object with a temperature greater than 0_{o}K and a is a constant.

Law 1 allows us to understand "temperature".

Law 2 allows us to conceptualize radiation as a "wave".

Laws 3 and 4 allow us to visualize the range of radiation emitted by an object, as long as it has a temperature greater than 0_{o}K. One such visualization is called a "spectrum".