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.

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

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 0ºK will emit energy, and that energy 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)

$$E^* = \sigma_{SB} \cdot T^4$$

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 0ºK. 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)

$$\lambda_{\max} = \frac{a}{T}$$

where lambda is the wavelength of the peak radiation emitted by the object with a temperature greater than 0ºK 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 0ºK. One such visualization is called a "spectrum".