Class Examples – Light and Matter

EM Radiation

1. "Hard" X-rays are commonly used for diagnostic radiography, and have wavelengths between 10 and 100 pm. Calculate the frequency of hard X-rays with a wavelength of 55 pm.

2. The radio station KCRW broadcasts at 89.9 MHz. Calculate the wavelength of this broadcast.

Planck’s Equation

3. When heated, a sample of copper emits radiation in the blue region of the electromagnetic spectrum, with a wavelength of 451 nm. Calculate the energy of a single photon (in J) and the energy of a mole of photons (in kJ/mol) of this radiation. What is ΔE for the copper atoms?

4. When light is absorbed by the human eye, specific cells in the eye are able to detect as little as $1.478 \times 10^{-17}$ J of red light with a wavelength of 672 nm. Calculate the minimum number of photons of red light than can be detected by the human eye.

Photoelectric Effect

5. The work function of a metal is the minimum (or threshold) energy required to eject electrons from the surface of the metal. The work function for Cr metal is 652.7 kJ/mol. Find:

a. The energy (in J) needed to remove an electron from one atom of Cr.
b. The minimum energy (in J) a photon must have to eject an electron from an atom of Cr.
c. The minimum (threshold) frequency of Cr metal.
d. The maximum wavelength (in nm) of light that would be needed to eject electrons from Cr.
e. Can light at 255 nm eject electrons from the surface of chromium?

6. When light with a wavelength of 86.0 nm is incident upon a metal surface, electrons are ejected with a velocity of $4.25 \times 10^7$ m/s. What is the threshold frequency for this metal? What is the work function of this metal, in kJ/mol?