T1 Practice problems (Refer to page C7 in the online manual)

1. Calculate the frequency of the ultraviolet line of wavelength 285 nm in MHz.

$$v = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ m\ s^{-1}}{285 \times 10^{-9}\ m} = 1.05 \times 10^{15}\ s^{-1} = 1.05 \times 10^{9}\ MHz$$

2. Calculate the energy of a photon of wavelength 232 nm. What region of the electromagnetic spectrum does this lie in?

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ J\ s)(3.00 \times 10^{8}\ m\ s^{-1})}{232 \times 10^{-9}\ m} = 8.56 \times 10^{-19}\ J$$

∴ UV region

3. A laser used to weld detached retinas to the human eye produces radiation with a frequency of 4.69×10^{14} Hz. What is the wavelength of this radiation in nm? What color would this wavelength appear?

$$\lambda = \frac{c}{v} = \frac{3.00 \times 10^{8}\ m\ s^{-1}}{4.69 \times 10^{14}\ s^{-1}} = 6.40 \times 10^{-7}\ m = 640\ nm$$

∴ orange

4. Calculate the energy per mole that an object can absorb from the 589 nm wavelength light emitted from a sodium lamp.

$$E = \frac{Nhc}{\lambda} = \frac{(6.022 \times 10^{23}\ mol^{-1})(6.626 \times 10^{-34}\ J\ s)(3.00 \times 10^{8}\ m\ s^{-1})}{589 \times 10^{-9}\ m} = 2.03 \times 10^{5}\ J\ mol^{-1}$$

$$2.03 \times 10^{5}\ J\ mol^{-1} = 203\ kJ\ mol^{-1}$$

5. A unknown element with 1.00×10^{23} molecules in the ground state shows an emission at 656 nm. How many molecules are present in the excited state at 1741 K?

$$using\ R = 8.314\ J\ K^{-1} mol^{-1}$$

$$E = \frac{Nhc}{\lambda} = \frac{(6.022x10^{23}\ mol^{-1})(6.626x10^{-34}\ J\ s)(3.00x10^{8}\ m\ s^{-1})}{656x10^{-9}\ m} = 182477\ J\ mol^{-1}$$

$$N_{upper} = N_{lower} \cdot e^{\frac{-\Delta E}{RT}} = 1.00x10^{23} \cdot e^{\frac{-182477\ J\ mol^{-1}}{(8.314\ J\ K^{-1} mol^{-1})(1741\ K)}} = 3.35x10^{17}$$

<u>*OR*</u>

$$using\ k = 1.383x10^{-23}\ J\ K^{-1}$$

$$E = \frac{hc}{\lambda} = \frac{(6.626x10^{-34}\ J\ s)(3.00x10^{8}\ m\ s^{-1})}{656x10^{-9}\ m} = 3.03018x10^{-19}\ J$$

$$N_{upper} = N_{lower} \cdot e^{\frac{-\Delta E}{kT}} = 1.00x10^{23} \cdot e^{\frac{-3.03018x10^{-19}\ J}{(1.383x10^{-23}\ J\ K^{-1})(1741\ K)}} = 3.42x10^{17}$$