Chem 1020
Fall 2004
Frequency/Wavelength practice problems

1. Most microwave ovens use microwaves with a frequency of 2.450 GHz (gigahertz). Find the wavelength of these waves, in centimeters. How does this relate to the size of an average microwave oven? (1 GHz = 10^9 Hz)

$$2.450 \text{ GHz} \times \frac{10^9 \text{ Hz}}{1 \text{ GHz}} = 2.450 \times 10^9 \text{ Hz}$$

$$c = \lambda \times \nu$$

$$\lambda = \frac{c}{\nu} = \frac{2.997925 \times 10^8 \text{ m/s}}{2.450 \times 10^9 \text{ s}^{-1}} = 0.122\underline{3}64 \text{ m} \times \frac{1 \text{ cm}}{10^{-2} \text{ m}} = 12.2\underline{3}64 \text{ cm} \xrightarrow{\text{4 s.f.}} 12.23 \text{ cm}$$

The area inside most microwave ovens is about 15-25 centimeters tall (mine is 21 cm). This corresponds to a distance of somewhere around 2 wavelengths of the microwaves that are used to cook food. It turns out waves of that frequency have the right wavelength to cook food the most efficiently from the height of the average microwave. You can use this idea to actually calculate the speed of light from your microwave! Visit http://www.physics.umd.edu/ripe/icpe/newsletters/n34/marshmal.htm to find out how.

2. We deal with frequencies of radio waves nearly every day. Specifically, the frequencies of FM radio stations are given in MHz (megahertz). Find the wavelengths in meters of each of these radio station frequencies: 92.5 MHz, 97.1 MHz, 101.9 MHz, and 104.1 MHz. (1 MHz = 10^6 Hz)

$$92.5 \text{ MHz} = 92.5 \times 10^6 \text{ Hz}$$

$$\lambda = \frac{c}{\nu} = \frac{2.997925 \times 10^8 \text{ m/s}}{92.5 \times 10^6 \text{ Hz}} = 3.24 \text{ m}$$

$$\frac{2.997925 \times 10^8 \text{ m/s}}{97.1 \times 10^6 \text{ Hz}} = 3.09 \text{ m}$$

$$\frac{2.997925 \times 10^8 \text{ m/s}}{101.9 \times 10^6 \text{ Hz}} = 2.94 \text{ m}$$

$$\frac{2.997925 \times 10^8 \text{ m/s}}{104.1 \times 10^6 \text{ Hz}} = 2.88 \text{ m}$$

3. The wavelength of light given off by laser pointers is often quoted in nm. For instance, a 532 nm laser pointer gives off green light, while a 635 nm laser pointer gives off red light. What are the frequencies of each of these types of light, in Hz?

$$532 \text{ nm} = 532 \times 10^{-9} \text{ m}$$

$$\nu = \frac{c}{\lambda} = \frac{2.997925 \times 10^{8} \text{ m/s}}{532 \times 10^{-9} \text{ m}} = 5.64 \times 10^{14} \text{ s}^{-1} = 5.64 \times 10^{14} \text{ Hz}$$

$$\nu = \frac{2.997925 \times 10^{8} \text{m/s}}{635 \times 10^{-9} \text{ m}} = 4.72 \times 14 \text{ Hz}$$

4. Black lights make use of long-wave ultraviolet light, usually with a wavelength around 365 nm (they also give off some purple-colored visible light) and is generally harmless. Short-wave ultraviolet light around 254 nm is used in the goggle sanitizer units in our labs, and would damage our eyes if we looked at it directly. What are the frequencies of each of these types of ultraviolet light, in Hz? Which is higher in energy? How does their energy correspond to their respective uses?

$$365 \text{ nm} = 365 \times 10^{-9} \text{ m}$$

$$\nu = \frac{2.997925 \times 10^{8} \text{ m/s}}{365 \times 10^{-9} \text{ m}} = 8.21 \times 10^{14} \text{ Hz}$$

$$\nu = \frac{2.997925 \times 10^{8} \text{ m/s}}{254 \times 10^{-9} \text{ m}} = 1.18 \times 10^{15} \text{ Hz}$$

The wave with the higher frequency is the wave with the higher energy. In this case, the short-wave ultraviolet light with wavelength of 254 nm has the higher energy since its frequency is higher than the long-wave ultraviolet light. The increase in energy corresponds with their utility in that the lower-energy long-wave light is perfectly safe to be used in our homes, while high-energy short-wave light can kill bacteria and is damaging to skin and eyes. Light at this wavelength actually has enough energy to begin to break covalent chemical bonds. Some types of chemical reactions can be initiated by exposing them to short-wave ultraviolet light.