WS 13.1 *Name:* KEY *p.*_____

Formulas to Use

$c = \lambda\nu$	$c = 3.00 \times 10^8$ m/s	1 m = 10^9 nm	(or 1 nm = 10^{-9} m)
$E = h\nu$	Hz = s^{-1} = cycles per second		

M = Mega = 10^6 k = kilo = 10^3 $h = 6.63 \times 10^{-34}$ J-s

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1a. List the types of electromagnetic radiation in order from lowest energy to highest energy:

Radio, Microwave, IR, Visible, UV, X-Ray, Gamma Ray

b. Which type of EM radiation has the longest wavelength? Radio

c. Which has the highest frequency? Gamma

2. Fill in the blanks with "directly" or "inversely" for electromagnetic radiation.

Energy of electromagnetic radiation is directly related to frequency.

Frequency of electromagnetic radiation is inversely related to wavelength.

Energy of electromagnetic radiation is inversely related to wavelength.

C **3.** Radio waves travel at ____________ visible light waves.
a. a faster speed than b. a slower speed than c. the same speed as

A **4.** Radio waves travel at ____________ sound waves.
a. a faster speed than b. a slower speed than c. the same speed as

5. For each pair of photons below, circle the photon with higher energy. — higher frequency — shorter λ

a. a photon with a wavelength of 10^{-7} m or (a photon with a wavelength of 10^{-10} meters.)

b. a photon with a frequency of 102.3 MHz or (a photon with a frequency of 105.5 MHz.)

c. an (X-ray) or a radio wave

e. a photon with a frequency (of 1.7×10^{15} Hz) or a photon with a frequency of 7.1×10^{14} Hz.

f. a photon of yellow light or a photon (of green light)

g. a photon with a (wavelength of 480 nm) or a photon with a wavelength of 1200 nm

6. Determine the wavelength (in m and nm), the frequency (in Hz), the photon energy, and the type of EM radiation (part of the spectrum) for each problem, below. (You will need the chart on WS 13.0)

a. Electromagnetic radiation emitted by a laser pen, with a wavelength of 410. nm

$\lambda =$ 410. nm

$\lambda =$ 4.10×10^{-7} m

$\nu =$ 7.32×10^{14} 1/sec (Hz)

E = 4.85×10^{-19} J

Part of spectrum: Visible (violet)

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ m/s}{4.10 \times 10^{-7}\ m} = 7.32 \times 10^{14}\ 1/s$$

$$E = h \cdot \nu$$

$$E = (6.63 \times 10^{-34}\ J \cdot s)(7.32 \times 10^{14}\ 1/s)$$

b. EM radiation with a frequency of 104.7 MHz (MegaHertz)

$$\left(\frac{1 \times 10^{6}\ Hz}{1\ MHz}\right) = 1.047 \times 10^{8}\ Hz$$

$\lambda =$ 2.87×10^{9} nm

$\lambda =$ 2.87 m

$\nu =$ 1.047×10^{8} Hz

E = 6.942×10^{-26} J

Part of spectrum: radio

$$E = h \cdot \nu = (6.63 \times 10^{-34}\ J \cdot s)(1.047 \times 10^{8}\ Hz)\ \ \frac{1}{s}$$

$$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^{8}\ m/s}{1.047 \times 10^{8}\ 1/s} = 2.87\ m \left(\frac{1 \times 10^{9}\ nm}{1\ m}\right) =$$

c. A photon absorbed by a H_2O molecule in a microwave oven, with an energy of 1.62×10^{-24} J .

$$\frac{E}{h} = \nu \quad \frac{1.62 \times 10^{-24}\ J}{(6.63 \times 10^{-34}\ J \cdot s)} = 2.44 \times 10^{9}\ 1/s\ (Hz)$$

$\lambda =$ 1.23×10^{8} nm

$\lambda =$ 0.123 m

$\nu =$ 2.44×10^{9} Hz

E = 1.62×10^{-24} J

$$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^{8}\ m/s}{2.44 \times 10^{9}\ 1/s} = 0.123\ m \left(\frac{1 \times 10^{9}\ nm}{1\ m}\right)$$

Part of spectrum: microwave *

* this would be "radio" according to the chart on 13.0… but many charts for EM radiation show an overlap of microwaves with the higher energy radio waves., and would classify this as a microwave.

d. EM radiation emitted when a C=O bond in carbon dioxide (O=C=O) vibrates, with a wavelength of 5200 nm.

$$5200\ nm \left(\frac{1\ m}{1 \times 10^{9}\ nm}\right) = 5.2 \times 10^{-6}\ m$$

$\lambda =$ 5200 nm

$\lambda =$ 5.2×10^{-6} m

$\nu =$ 5.8×10^{13} Hz

E = 3.8×10^{-20} J

Part of spectrum: IR

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ m/s}{5.2 \times 10^{-6}\ m} = 5.769 \times 10^{13}\ 1/s$$

$$E = h \cdot \nu$$

$$= (6.63 \times 10^{-34}\ J \cdot s)(5.769 \times 10^{13}\ 1/s)$$

$$= 3.8 \times 10^{-20}\ J$$