WKS Chem H
Waves, Frequency & Energy WS

Name: Answer Key
Period: ____ Date: ____________

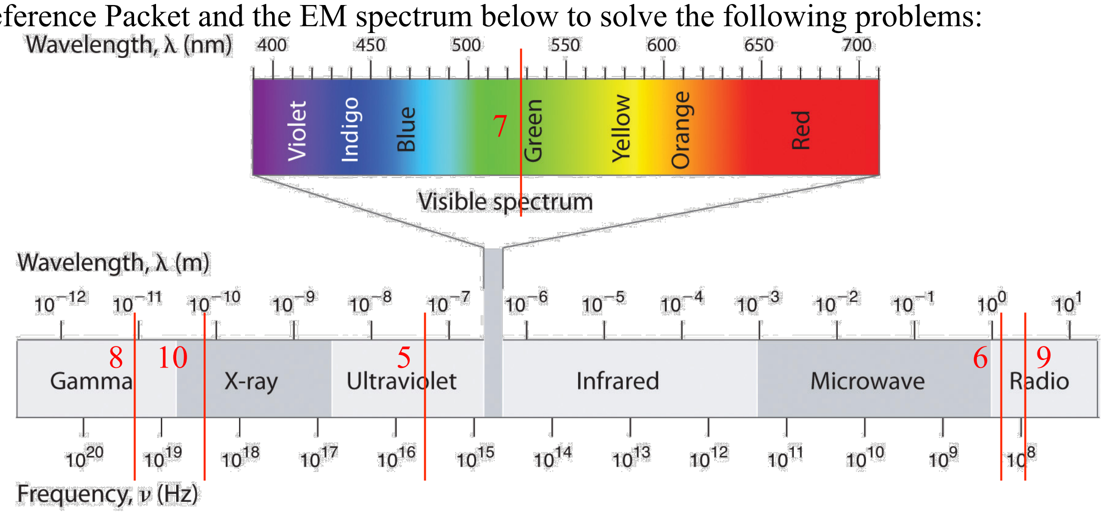
1. What is the cause of all electromagnetic radiation?
EM radiation is caused by electrons or other charged particles changing direction (accelerating).

2. What is wavelength? What symbol is used to represent it? What are its units?
Wavelength is the distance between successive wave crests (or any equivalent point). It is represented by the Greek letter λ, lambda. Since it is a distance, its units are generally meters (m), or any related unit such as mm, μm, nm (used commonly for visible light) or pm.

3. What is frequency? What symbol do we use to represent it? What are its units?
Frequency is the number of waves passing a given point in 1 second. It is represented by the Greek letter ν, nu. Its units are s^{-1} ("per second"), 1/s, or Hz. Radio waves are typically given in units of megahertz (MHz) for FM or kilohertz (KHz) for AM stations.

4. What is the type of relationship between wavelength and frequency? Describe it.
Wavelength and frequency have an inverse relationship. As one quantity increases, the other decreases. Thus, long wavelength corresponds to low frequency, and short wavelength is high frequency.

Use the Reference Packet and the EM spectrum below to solve the following problems:



5. What are the frequency and energy of an electromagnetic wave with a wavelength of 3.5×10^{-8} m? Use the EM spectrum above to determine the region of the electromagnetic spectrum that this light is in.

$$c = \lambda\nu \Rightarrow \nu = \frac{c}{\lambda} = \frac{3.00\times10^{8}\ \cancel{m}/s}{3.5\times10^{-8}\ \cancel{m}} = 8.6\times10^{15}/s = \boxed{8.6\times10^{15}\ Hz}$$

$$E = h\nu = \left(6.626\times10^{-34}\ J\cdot s\right)\left(8.6\times10^{15}\ s^{-1}\right) = \boxed{5.7\times10^{-18}\ J}$$

This is in the **ultraviolet (UV)** region of the spectrum (see above)

6. What are the wavelength and energy of an electromagnetic wave with a frequency of 2.29×10^8 Hz? What region of the EM spectrum is this in?

$$c=\lambda\nu \Rightarrow \lambda=\frac{c}{\nu}=\frac{3.00\times10^8\ \text{m}/\cancel{\text{s}}}{2.29\times10^8\ \cancel{\text{s}^{-1}}}=\boxed{1.31\ \text{m}}$$

$$E=h\nu=\left(6.626\times10^{-34}\ \text{J}\cdot\text{s}\right)\left(2.29\times10^8\text{s}^{-1}\right)=\boxed{1.52\times10^{-25}\ \text{J}}$$

This is a **radio wave**.

7. Calculate the wavelength (in nm) and energy of electromagnetic radiation with a frequency of 5.70×10^{14} Hz *[hint: calculate m first then convert]*. This is visible light—what color is it?

$$\lambda=\frac{c}{\nu}=\underbrace{\frac{3.00\times10^8\ \cancel{\text{m}}/\cancel{\text{s}}}{5.70\times10^{14}\ \cancel{\text{s}^{-1}}}}_{5.26\times10^{-7}\ \text{m}}\times\frac{1\ \text{nm}}{1\times10^{-9}\ \cancel{\text{m}}}=\boxed{526\ \text{nm}}$$

$$E=h\nu=\left(6.626\times10^{-34}\ \text{J}\cdot\text{s}\right)\left(5.70\times10^{14}\text{s}^{-1}\right)=\boxed{3.78\times10^{-19}\ \text{J}}\textbf{; Green}$$

8. Calculate the frequency and energy of electromagnetic radiation that has a wavelength of 9.35 pm *(convert to m first)*. Solve for E using the combine equation E=hc/λ. What region of the EM spectrum is this in?

$$\lambda=9.35\ \text{pm}\times\frac{1\times10^{-12}\ \text{m}}{1\ \text{pm}}=9.35\times10^{-12}\ \text{m};\ \nu=\frac{c}{\lambda}=\frac{3.00\times10^8\ \cancel{\text{m}}/\text{s}}{9.35\times10^{-12}\ \cancel{\text{m}}}=\boxed{3.21\times10^{19}\ \text{Hz}}$$

$$E=\frac{hc}{\lambda}=\frac{\left(6.626\times10^{-34}\ \text{J}\cdot\cancel{\text{s}}\right)\left(3.00\times10^8\ \text{m}/\cancel{\text{s}}\right)}{9.35\times10^{-12}\ \cancel{\text{m}}}=\boxed{2.13\times10^{-14}\ \text{J}}\textbf{; Gamma rays}$$

9. A popular radio station broadcasts with a frequency of 94.7 MHz. What are the wavelength and energy of the broadcast? (You must first convert MHz to Hz.)?

$$\nu=94.7\ \text{MHz}\times\frac{1\times10^6\ \text{Hz}}{1\ \text{MHz}}=9.47\times10^7\ \text{Hz};\ \lambda=\frac{c}{\nu}=\frac{3.00\times10^8\ \text{m}/\cancel{\text{s}}}{9.47\times10^7\ /\cancel{\text{s}}}=\boxed{3.17\ \text{m}}$$

$$E=\left(6.626\times10^{-34}\ \text{J}\cdot\text{s}\right)\left(9.47\times10^7\text{s}^{-1}\right)=\boxed{6.27\times10^{-26}\ \text{J}}$$

Notice that these are **Radio waves**, as would be expected for a radio station!

10. X-rays used in medical diagnosis have energies around 1.60×10^{-15} J. What are the frequency and wavelength (in pm) of this radiation? Solve for λ using the combine equation E=hc/λ.

$$E=h\nu \Rightarrow \nu=\frac{E}{h}=\frac{1.60\times10^{-15}\ \text{J}}{6.626\times10^{-34}\ \text{J}\cdot\text{s}}=\boxed{2.41\times10^{18}\ \text{s}^{-1}=2.41\times10^{18}\ \text{Hz}}$$

$$E=\frac{hc}{\lambda}\Rightarrow\lambda=\frac{hc}{E}=\underbrace{\frac{\left(6.626\times10^{-34}\ \text{J}\cdot\text{s}\right)\left(3.00\times10^8\ \text{m/s}\right)}{1.60\times10^{-15}\ \text{J}}}_{1.24\times10^{-10}\ \text{m}}\times\frac{1\ \text{pm}}{1\times10^{-12}\ \text{m}}=\boxed{124\ \text{pm}}$$