

Key

• Problems:

Convert the following wavelengths to frequencies:

$$c = \lambda \nu$$

$$\nu = \frac{c}{\lambda}$$

1. $\lambda = 1.098 \times 10^{-7} \text{ m}$

$$\nu = \frac{3.00 \times 10^8 \frac{\text{m}}{\text{s}}}{1.098 \times 10^{-7} \text{ m}} = 2.73 \times 10^{15} \text{ Hz}$$

s^{-1}

2. $\lambda = 3.54 \times 10^{-3} \text{ m}$

$$\nu = \frac{3.00 \times 10^8 \frac{\text{m}}{\text{s}}}{3.54 \times 10^{-3} \text{ m}} = 8.47 \times 10^{10} \frac{1}{\text{s}}$$

3. $\lambda = 653 \text{ nm} \rightarrow 653 \times 10^{-9} \text{ m}$ or $6.53 \times 10^{-7} \text{ m}$

$$\nu = \frac{3.00 \times 10^8 \frac{\text{m}}{\text{s}}}{653 \times 10^{-9} \text{ m}} = 4.59 \times 10^{14} \text{ Hz}$$

4. $\lambda = 2.043 \text{ km} \rightarrow 2.043 \times 10^3 \text{ m}$

$$\nu = \frac{3.00 \times 10^8 \frac{\text{m}}{\text{s}}}{2.043 \times 10^3 \text{ m}} = 1.47 \times 10^5 \text{ s}^{-1}$$

5. $\lambda = 5.32 \times 10^{-7} \text{ m}$

$$\nu = \frac{3.00 \times 10^8 \frac{\text{m}}{\text{s}}}{5.32 \times 10^{-7} \text{ m}} = 5.64 \times 10^{14} \text{ Hz}$$

Convert the following frequencies to wavelengths:

$$c = \lambda \nu$$
$$\lambda = \frac{c}{\nu}$$

1. $\nu = 1.20 \times 10^{16} \text{ Hz}$

$$\lambda = \frac{3.00 \times 10^8 \text{ m/s}}{1.20 \times 10^{16} \text{ Hz}} = 2.5 \times 10^{-8} \text{ m}$$

2. $\nu = 5.42 \times 10^{14} \text{ s}^{-1}$

$$\lambda = \frac{3.00 \times 10^8 \text{ m/s}}{5.42 \times 10^{14} \text{ s}^{-1}} = 5.54 \times 10^{-7} \text{ m}$$

3. $\nu = 5.43 \text{ MHz} \rightarrow 5.43 \times 10^6 \text{ Hz}$

$$\lambda = \frac{3.00 \times 10^8 \text{ m/s}}{5.43 \times 10^6 \text{ Hz}} = 55.25 \text{ m}$$

4. $\nu = 2.98 \text{ kHz}$, for this problem, report λ in nm

$$\hookrightarrow 2.98 \times 10^3 \text{ Hz}$$

$$\lambda = \frac{3.00 \times 10^8 \text{ m/s}}{2.98 \times 10^3 \text{ Hz}} = 100671 \text{ m} \left(\frac{1 \text{ nm}}{10^{-9} \text{ m}} \right) =$$

$$1.00 \times 10^{14} \text{ nm}$$

Converting between energy and wavelength (λ) or frequency (ν):

• Examples:

What wavelength of light is associated with a photon with an energy of $2.75 \times 10^{-19} \text{ J}$?

$$E = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E}$$

$$\lambda = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 3.00 \times 10^8 \frac{\text{m}}{\text{s}}}{2.75 \times 10^{-19} \text{ J}}$$

$$\lambda = 7.22 \times 10^{-7} \text{ m}$$

What is the energy of 1.00 mole of photons with a frequency of 8.9 MHz?

→ $E = h\nu$

1st determine how much energy each photon has

$$E = 6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 8.9 \times 10^6 \text{ Hz}$$

$$E = 5.897 \times 10^{-36} \text{ J}$$

$$\rightarrow 8.9 \times 10^6 \text{ Hz}$$

Next, multiply by how many photons you have:

1 mole \Rightarrow , 6.02×10^{23}

$$5.897 \times 10^{-36} \text{ J} \cdot 6.02 \times 10^{23} = 3.55 \times 10^{-12} \text{ J}$$

If a bond has an energy of 275 kJ/mol, what is the wavelength of light that will break the bond?

↑ energy needed to break 1 mol of bonds

1st, we need the energy of 1 bond:

$$\frac{275 \text{ kJ}}{\text{mol}} \left(\frac{1000 \text{ J}}{1 \text{ kJ}} \right) \left(\frac{1 \text{ mol}}{6.02 \times 10^{23}} \right) = 4.57 \times 10^{-19} \text{ J}$$

Now, find E of 1 photon: $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 3.00 \times 10^8 \text{ m/s}}{4.57 \times 10^{-19} \text{ J}}$

$$\lambda = 4.35 \times 10^{-7} \text{ m}$$

or 435 nm

- Problems

1. What frequency of light is associated with a photon with an energy of $2.75 \times 10^{-19} \text{ J}$?

$$E = h\nu$$

$$\nu = \frac{E}{h} = \frac{2.75 \times 10^{-19} \text{ J}}{6.626 \times 10^{-34} \text{ J}\cdot\text{s}} = 4.15 \times 10^{14} \text{ Hz}$$

2. What wavelength (in nm) is associated with a photon with an energy of $5.26 \times 10^{-18} \text{ J}$?

$$E = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 3.00 \times 10^8 \frac{\text{m}}{\text{s}}}{5.26 \times 10^{-18} \text{ J}} = 3.78 \times 10^{-8} \text{ m}$$

3. What is the energy of 1.75×10^9 photons of light with a frequency of $6.98 \times 10^{15} \text{ Hz}$?

1 photon

$$\rightarrow E = h\nu$$

$$= 6.98 \times 10^{15} \text{ Hz} \cdot 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$$

$$= 4.625 \times 10^{-18} \text{ J}$$

$$1.75 \times 10^9 \times 4.625 \times 10^{-18} \text{ J} =$$

$$\boxed{8.09 \times 10^{-9} \text{ J}}$$

total

4. What is the frequency of light that is needed to break a bond of 275 kJ/mol?

* 1st, you need the energy of 1 bond, worked on previous page: $E = 4.568 \times 10^{-19} \text{ J}$

* Now find ν : $E = h\nu$

$$\nu = \frac{E}{h} = \boxed{6.89 \times 10^{14} \text{ Hz}}$$

Mixed Problems:

1. Ultraviolet radiation has a frequency of 6.8×10^{15} 1/s. Calculate the energy, in joules, of the photon.
 have ν need

$$E = h\nu$$
$$= 6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 6.8 \times 10^{15} \frac{1}{\text{s}}$$

$$E = \boxed{4.51 \times 10^{-18} \text{ J}}$$

2. Find the energy, in joules per photon, of microwave radiation with a frequency of 7.91×10^{10} Hz.

$$E = h\nu$$
$$= 6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 7.91 \times 10^{10} \text{ Hz}$$

$$= \boxed{5.24 \times 10^{-23} \text{ J}}$$

3. A sodium vapor lamp emits light photons with a wavelength of 5.89×10^{-7} m. What is the energy of 2.653×10^{22} of these photons?
 λ

$$E = \frac{hc}{\lambda}$$
$$= \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 3.00 \times 10^8 \frac{\text{m}}{\text{s}}}{5.89 \times 10^{-7} \text{ m}}$$

$$= \boxed{3.37 \times 10^{-19} \text{ J}}$$

4. One of the electron transitions in a hydrogen atom produces infrared light with a wavelength of 7.464×10^{-6} m. What amount of energy causes this transition?

$$E = \frac{hc}{\lambda}$$
$$= \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 3 \times 10^8 \frac{\text{m}}{\text{s}}}{7.464 \times 10^{-6} \text{ m}} = \boxed{2.663 \times 10^{-20} \text{ J}}$$

5. Find the energy in kJ for an x-ray photon with a frequency of 2.4×10^{18} Hz.

$$E = h\nu$$
$$= 1.59 \times 10^{-15} \text{ J}$$

$$\text{kJ!} \Rightarrow 1.59 \times 10^{-15} \text{ J} \left(\frac{1 \text{ kJ}}{10^3 \text{ J}} \right) = \boxed{1.59 \times 10^{-18} \text{ kJ}}$$

6. A ruby laser produces red light that has a wavelength of 500 nm. Calculate its energy in joules.

$$E = \frac{hc}{\lambda}$$

$$= \boxed{3.98 \times 10^{-19} \text{ J}}$$

$$600 \times 10^{-9} \text{ m}$$

7. What is the frequency of UV light that has an energy of 2.39×10^{-18} J?

$$E = h\nu$$

$$\nu = \frac{E}{h}$$

$$= \boxed{3.61 \times 10^{15} \text{ Hz}}$$

8. What is the wavelength and frequency of photons with an energy of 1.4×10^{-21} J?

Wavelength: $E = hc/\lambda$

$$\lambda = \frac{hc}{E}$$

$$\lambda = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \cdot 3 \times 10^8 \frac{\text{m}}{\text{s}}}{1.4 \times 10^{-21} \text{ J}}$$

$$\lambda = .000142 \text{ m}$$
$$\text{or } 1.42 \times 10^{-4} \text{ m}$$

Freq: $E = h\nu$

$$\nu = \frac{E}{h}$$

$$\nu = \frac{1.4 \times 10^{-21} \text{ J}}{6.626 \times 10^{-34} \text{ J}\cdot\text{s}}$$

$$\nu = \boxed{2.11 \times 10^{12} \text{ Hz}}$$