Key

- **Problems:**

Convert the following wavelengths to frequencies:

$c = \lambda \nu$

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

1. λ = 1.098x10⁻⁷m

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

↖ or s^{-1}

2. λ = 3.54x10⁻³ m

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

3. λ = 653 nm → 653×10^{-9} m or 6.53×10^{-7} m

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

4. λ = 2.043 km → 2.043×10^{3} m

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

5. λ = 5.32x10⁻⁷m

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

Convert the following frequencies to wavelengths: $c = \lambda \nu$

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

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

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

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

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

3. $\nu = 5.43$ MHz $\rightarrow 5.43 \times 10^6 \, Hz$

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

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

$\hookrightarrow 2.98 \times 10^3 \, Hz$

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

$\boxed{1.00 \times 10^{14} \, nm}$

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

- **Examples:**

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

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

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

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

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

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

↳ 8.9×10^{-3} Hz

1st determine how much energy each photon has → $E = h\nu$

$E = 6.626 \times 10^{-34}\ J \cdot s \cdot 8.9 \times 10^{-3}\ Hz$

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

Next, multiply by how many photons you have:

1 mole so, 6.02×10^{23}

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

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:

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

Now, find E of 1 Photon:

$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34}\ J \cdot s \cdot 3.00 \times 10^{8}\ m/s}{4.57 \times 10^{-19}\ J}$

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

or 435 nm

- **Problems**

1. **What frequency of light is associated with a photon with an energy of 2.75×10^{-19}J?**

$E = h\nu$

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

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

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

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

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

1 photon → $E = h\nu$

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

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

$1.75 \times 10^{9} \times 4.625 \times 10^{-18} J = 8.09 \times 10^{-9} J$ 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: $E = 4.568 \times 10^{-19} J$

* Now find ν: $E = h\nu$

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

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

$E = h\nu$

$= 6.626\times10^{-34}\ J\cdot s \cdot 6.8\times10^{15}\ \frac{1}{s}$

$E = 4.51\times10^{-18}\ J$

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

$E = h\nu$

$= 6.626\times10^{-34}\ J\cdot s \cdot 7.91\times10^{+10}\ Hz$

$= 5.24\times10^{-23}\ J$

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

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

$= \frac{6.626\times10^{-34}\ J\cdot s \cdot 3.00\times10^{8}\ \frac{m}{s}}{5.89\times10^{-7}\ m}$

$= 3.37\times10^{-19}\ J$

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?

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

$= \frac{6.626\times10^{-34}\ J\cdot s \cdot 3\times10^{8}\ \frac{m}{s}}{7.464\times10^{-6}\ m} = 2.663\times10^{-20}\ J$

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

$E = h\nu$

$= 1.59 \times 10^{-15}$ J

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

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

500×10^{-9} m

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

$= \boxed{3.98 \times 10^{-9} \text{ J}}$

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: $E = hc/\lambda$

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

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

$\lambda = .000142$ m

or 1.42×10^{-4} m

freq: $E = h\nu$

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

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

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