# Planck's Equation
Chem Worksheet 5-2

Name ________________

Max Planck theorized that energy was transferred in chunks known as **quanta**, equal to *hv*. The variable *h* is a constant equal to $6.63 \times 10^{-34}$ J·s and the variable *v* represents the frequency in 1/s. This equation allows us to calculate the energy of photons, given their frequency. If the wavelength is given, the energy can be determined by first using the wave equation ($c = \lambda \times \nu$) to find the frequency, then using Planck's equation to calculate energy.

| useful equations | |
|---|---|
| $c = \lambda \times \nu$ | $c = 3.00 \times 10^{8}$ m/s |
| $E = h \times \upsilon$ | $h = 6.63 \times 10^{-34}$ J·s |
| $1 \text{ m} = 1 \times 10^{9}$ nm | 1 kJ = 1000 J |

**Problem-Solving Strategy**

| **Known** | | | | **Unknown** |
|---|---|---|---|---|
| Frequency ($\nu$) | | $E = h\nu$ | | Energy (E) |
| Wavelength ($\lambda$) | $\nu = \frac{c}{\lambda}$ | Frequency ($\nu$) | $E = h\nu$ | Energy (E) |
| Energy (E) | $\nu = \frac{E}{h}$ | Frequency ($\nu$) | $\nu = \frac{c}{\lambda}$ | Wavelength ($\lambda$) |

**example**

Light with a wavelength of 525 nm is green. Calculate the energy in joules for a green light photon.

- find the frequency: $c = \lambda \times \upsilon$ $\quad \nu = \frac{c}{\lambda}$ $\quad \nu = \frac{3.00\times10^{8}\, m/s}{525\ nm \times \frac{1\ m}{1\times10^{9}\, nm}}$ $\quad \nu = 5.71\times10^{14}\, 1/s$

- find the energy: $E = h \times \upsilon$ $\quad E = (6.626\times10^{-34}\, J\cdot s)(5.71\times10^{14}\, 1/s)$ $\quad E = 3.78\times10^{-19}\, J/photon$

## Use the equations above to answer the following questions.

1. Ultraviolet radiation has a frequency of $6.8 \times 10^{15}$ 1/s. Calculate the energy, in joules, of the photon.
2. Find the energy, in joules per photon, of microwave radiation with a frequency of $7.91 \times 10^{10}$ 1/s.
3. A sodium vapor lamp emits light photons with a wavelength of $5.89 \times 10^{-7}$ m. What is the energy of these photons?
4. One of the electron transitions in a hydrogen atom produces infrared light with a wavelength of $7.464 \times 10^{-6}$ m. What amount of energy causes this transition?
5. Find the energy in kJ for an x-ray photon with a frequency of $2.4 \times 10^{18}$ 1/s.
6. A ruby laser produces red light that has a wavelength of 500 nm. Calculate its energy in joules.
7. What is the frequency of UV light that has an energy of $2.39 \times 10^{-18}$ J?
8. What is the wavelength and frequency of photons with an energy of $1.4 \times 10^{-21}$ J?