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 6.63×10^{-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 ($c = \lambda \times v$) to find the frequency, then using Planck's equation to calculate energy.

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

Problem-Solving Strategy

Known				Unknown
Frequency (v)	$E = hv$			Energy (E)
Wavelength (λ)	$v = \dfrac{c}{\lambda}$ → Frequency (v)	$E = hv$		Energy (E)
Energy (E)	$v = \dfrac{E}{h}$ → Frequency (v)	$v = \dfrac{c}{\lambda}$		Wavelength (λ)

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example

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

- find the frequency: $\quad c = \lambda \times \upsilon \qquad v = \dfrac{c}{\lambda} \qquad v = \dfrac{3.00 \times 10^8 \, m/s}{525 \ nm \times \dfrac{1 \ m}{1 \times 10^9 \, nm}} \qquad v = 5.71 \times 10^{14} 1/s$

- find the energy: $\quad E = h \times \upsilon \qquad E = (6.626 \times 10^{-34} \, J \cdot s)(5.71 \times 10^{14} 1/s) \qquad E = 3.78 \times 10^{-19} \, J \, / \, photon$

Use the equations above to answer the following questions.

1. Ultraviolet radiation has a frequency of 6.8×10^{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 7.91×10^{10} 1/s.

3. A sodium vapor lamp emits light photons with a wavelength of 5.89×10^{-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 7.464×10^{-6} m. What amount of energy causes this transition?

5. Find the energy in kJ for an x-ray photon with a frequency of 2.4×10^{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 2.39×10^{-18} J?

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