(1) $E = hf = (6.63\times10^{-34}\ J\cdot s)(6.8\times10^{15}\ Hz) = \boxed{4.5\times10^{-18}\ J}$

(2) $E = hf = (6.63\times10^{-34}\ J\cdot s)(7.91\times10^{10}\ Hz) = \boxed{5.24\times10^{-23}\ J}$

(3) $\dfrac{3.00\times10^{8}\ m/s}{5.89\times10^{-7}\ m} = (5.09\times10^{14}\ Hz)(6.63\times10^{-34}\ J\cdot s) = \boxed{3.37\times10^{-19}\ J}$

(4) $\dfrac{3.00\times10^{8}\ m/s}{746.4\times10^{-9}\ m} = (4.02\times10^{14}\ Hz)(6.63\times10^{-34}\ J\cdot s) = \boxed{2.66\times10^{-22}\ J}$

(5) $E = hf = (6.63\times10^{-34}\ J\cdot s)(2.4\times10^{18}\ Hz) = \boxed{1.59\times10^{-15}\ J}$

$\downarrow$

$\boxed{1.59\times10^{-12}\ kJ}$

(6) $\dfrac{3.00\times10^{8}\ m/s}{500\times10^{-9}\ m} = (6.00\times10^{14})(6.63\times10^{-34}\ J\cdot s) = \boxed{3.98\times10^{-19}\ J}$

(7) $f = \dfrac{E}{h} = \dfrac{(2.39\times10^{-18}\ J)}{(6.63\times10^{-34}\ J\cdot s)} = \boxed{3.60\times10^{15}\ Hz}$

(8) $f = \dfrac{E}{h} = \dfrac{(1.4\times10^{-21}\ J)}{6.63\times10^{-34}\ J\cdot s} = \boxed{2.11\times10^{12}\ Hz}$

~~$2.11\times10^{12}\ Hz$~~

$\lambda = \dfrac{c}{f} = \dfrac{3.00\times10^{8}\ m}{2.11\times10^{12}\ Hz} = \boxed{1.42\times10^{-4}\ \text{or}\ 0.000142\ J}$

(9) ~~434~~

$f = \dfrac{c}{\lambda} = \dfrac{3.00\times10^{8}\ m/s}{434\times10^{-9}\ m/s} = \boxed{6.91\times10^{14}\ Hz}(6.63\times10^{-34}\ J\cdot s) = \boxed{4.58\times10^{-19}\ J}$

Planck's Constant Worksheet Name Ky Date______________ Period________

Max Planck explained that energy was transferred in chunks known as **quanta**, equal to $h\nu$. The variable h is Planck's constant equal to 6.6262×10^{-34} J·s and the variable ν represents the frequency in 1/s, s^{-1}, or Hz (Hertz). This equation allows the calculation of the energy of photons, given their frequency. If the wavelength is given, the energy can be determined by first using the light equation ($c = \nu\lambda$) to find the frequency, then using Planck's equation to calculate energy.

Problem-Solving Strategy

Known				Unknown
Frequency (ν)		$E = h\nu$ →		Energy (E)
Wavelength (λ)	$\nu = \frac{c}{\lambda}$ →	Frequency (ν)	$E = h\nu$ →	Energy (E)
Energy (E)	$\nu = \frac{E}{h}$ →	Frequency (ν)	$\lambda = \frac{c}{\nu}$ →	Wavelength (λ)

useful equations

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

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

- ***First*** find the frequency: $\nu = \frac{c}{\lambda}$ → $= \frac{3.00 \times 10^8\ m/s}{525\ nm \frac{1 \times 10^{-9}\ m}{1\ nm}} = \nu = 5.71 \times 10^{14}\ s^{-1} = 5.71 \times 10^{14}$ Hz

- **Second** find the energy $E = h\nu$ → $E = (6.6262 \times 10^{-34} J \cdot s)(5.71 \times 10^{14} s^{-1}) = E = 3.78 \times 10^{-19} J/photon$

Use the equations above to answer the following questions.

1. Ultraviolet radiation has a frequency of 6.8×10^{15} Hz. 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} Hz.
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 746.4 nm. What amount of energy causes this transition?
5. Find the energy in kJ for an x-ray photon with a frequency of $2.4 \times 10^{18}\ s^{-1}$.
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?
9. What is the energy of a light that has 434 nm?
10. What is the wavelength of a light that has a frequency of 3.42×10^{11} Hz?

8 $\lambda = \frac{c}{f} = \frac{(3.00 \times 10^8)}{(3.12 \times 10^{14})} = 9.6 \times 10^{-7}$ m