NAME ______________________ DATE ____________ CLASS ____________

Atomic Physics

Problem A

QUANTUM ENERGY

PROBLEM

Find the energy of a photon of red light, having a wavelength of 690 nm.

SOLUTION

Given: $\lambda = 6.90 \times 10^{-7}$ m

Unknown: $f = ?$ $E = ?$

Choose the equation(s) or situation: Use the equation for the energy of a light quantum, given on page 832.

$$E = hf$$

Use the equation relating frequency to wavelength, given on page 522.

$$c = \lambda f$$

Rearrange the equation(s) to isolate the unknown(s): Rearrange the equation to solve for the frequency.

$$f = \frac{c}{\lambda} = \frac{3.0 \times 10^8 \text{ m/s}}{6.90 \times 10^{-7} \text{ m}} = 4.3 \times 10^{14} \text{ Hz}$$

$$E = hf = \frac{(6.63 \times 10^{-34} \text{ J} \bullet \text{s})(4.3 \times 10^{14} \text{ Hz})}{1.60 \times 10^{-19} \text{ J/eV}} = \boxed{1.8 \text{ MeV}}$$

ADDITIONAL PRACTICE

1. Determine the energy of a photon of green light, having a wavelength of 527 nm.
2. What is the energy of a photon of blue light, having a wavelength of 430.8 nm?
3. Calculate the frequency of ultraviolet (UV) light, having the energy of 20.7 eV.
4. Microwave ovens work by vibrating the water molecules in food, causing the food to warm up. Microwaves can reach energies as high as 1.24×10^{-3} eV. At what frequency is this?
5. Calculate the frequency of infrared (IR) light, having the energy of 1.78 eV.
6. An X ray can have an energy of 12.4 MeV. To what wavelength does this correspond?
7. A neutron has 939.57 MeV of energy. If a photon had the same energy as a neutron, what would be the photon's wavelength? The visible part of the spectrum ranges from 700 nm – 400 nm. Would this wavelength lie within the visible spectrum?
8. Calculate the wavelength of a radio wave that has an energy of 3.1×10^{-6} eV.

Atomic Physics

Additional Practice A

Givens	*Solutions*
1. $\lambda = 527 \text{ nm} = 5.27 \times 10^{-7} \text{ m}$	$E = hf = \dfrac{hc}{\lambda} = \dfrac{(6.63 \times 10^{-34} \text{ J•s})(3.00 \times 10^{8} \text{ m/s})}{5.27 \times 10^{-7} \text{ m}} = \boxed{3.77 \times 10^{-19} \text{ J}}$
2. $\lambda = 430.8 \text{ nm}$ $= 4.308 \times 10^{-7} \text{ m}$	$E = hf = \dfrac{hc}{\lambda} = \dfrac{(6.63 \times 10^{-34} \text{ J•s})(3.00 \times 10^{8} \text{ m/s})}{4.308 \times 10^{-7} \text{ m}} = \boxed{4.62 \times 10^{-22} \text{ J}}$
3. $E = 20.7 \text{ eV}$	$f = \dfrac{E}{h} = \dfrac{(20.7 \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})}{6.63 \times 10^{-34} \text{ J•s}} = \boxed{5.00 \times 10^{15} \text{ Hz}}$
4. $E = 1.24 \times 10^{-3} \text{ eV}$	$f = \dfrac{E}{h} = \dfrac{(1.24 \times 10^{-3} \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})}{6.63 \times 10^{-34} \text{ J•s}} = \boxed{2.99 \times 10^{11} \text{ Hz}}$
5. $E = 1.78 \text{ eV}$	$f = \dfrac{E}{h} = \dfrac{(1.78 \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})}{6.63 \times 10^{-34} \text{ J•s}} = \boxed{4.30 \times 10^{14} \text{ Hz}}$
6. $E = 12.4 \text{ MeV}$ $= 1.24 \times 10^{7} \text{ eV}$	$\lambda = \dfrac{hc}{E} = \dfrac{(6.63 \times 10^{-34} \text{ J•s})(3.00 \times 10^{8} \text{ m/s})}{(1.24 \times 10^{7} \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})} = \boxed{1.00 \times 10^{-13} \text{ m}}$
7. $E = 939.57 \text{ MeV}$ $= 9.3957 \times 10^{8} \text{ eV}$	$\lambda = \dfrac{hc}{E} = \dfrac{(6.63 \times 10^{-34} \text{ J•s})(3.00 \times 10^{8} \text{ m/s})}{(9.3957 \times 10^{8} \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})} = \boxed{1.32 \times 10^{-15} \text{ m}}$ $1.32 \times 10^{-15} \text{ m} = 1.32 \times 10^{-6} \text{ nm}$ If a photon were to have this wavelength, it would not lie within the visible part of the spectrum.
8. $E = 3.1 \times 10^{-6} \text{ eV}$	$\lambda = \dfrac{hc}{E} = \dfrac{(6.63 \times 10^{-34} \text{ J•s})(3.00 \times 10^{8} \text{ m/s})}{(3.1 \times 10^{-6} \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})} = \boxed{0.401 \text{ m}}$

Additional Practice B

1. $\lambda = 240 \text{ nm} = 2.4 \times 10^{-7} \text{ m}$ $hf_t = 2.3 \text{ eV}$	$KE_{max} = \dfrac{hc}{\lambda} - hf_t$ $KE_{max} = \dfrac{(6.63 \times 10^{-34} \text{ J•s})(3.00 \times 10^{8} \text{ m/s})}{(2.4 \times 10^{-7} \text{ m})(1.60 \times 10^{-19} \text{ J/eV})} - 2.3 \text{ eV}$ $KE_{max} = 5.2 \text{ eV} - 2.3 \text{ eV} = \boxed{2.9 \text{ eV}}$