Name ______________________ Section __________ Date __________

11B Electrons in Atoms

Extra Practice Problems

Wavelength, Frequency, and Energy

Light, a form of electromagnetic radiation, behaves like waves. These waves travel through a vacuum at a constant speed of 3.00×10^{10} cm/s. The symbol c represents the speed of light. Like other wave forms (ocean waves, for example), light has specific frequencies and wavelengths. The frequency is the number of waves passing a given point in a given period of time. The wavelength is, as its name implies, the length of a wave, measured from one point on a wave to the same point on the next wave. Wavelengths are measured typically from crest to crest. The two variables, frequency ν and wavelength λ, are inversely related. As one increases, the other must decrease. The equation relating the two is $c = \lambda \times \nu$.

The frequency of a wave is directly related to the energy of that wave. The faster a wave vibrates, the higher its energy. The equation relating frequency and energy is $E = h \times \nu$, where h is called Planck's constant and has a value of 6.626×10^{-34} J $\times$ s. This worksheet will give you practice in solving problems involving these three variables.

Example A

Calculate the frequency of a wave whose wavelength is 6.0×10^{-5} cm. In what region of the spectrum is this radiation found? *11·6*

Solution Use the equation $c = \lambda \times \nu$ to solve. Rearrange the terms to isolate the variable for which you must solve. Then substitute and solve.

$$c = \lambda \times \nu$$

$$\nu = \frac{c}{\lambda} = \frac{3.0 \times 10^{10}\ \cancel{\text{cm}}/\text{s}}{6.0 \times 10^{-5}\ \cancel{\text{cm}}} = 5.0 \times 10^{14}\ \text{s}^{-1}$$

Note that the unit for frequency is s^{-1}, called reciprocal seconds. This is because the term "cycle" is assumed to be understood in the problem. Radiation of this frequency and wavelength is found (in Figure 11 · 15 on page 256) to fall in the visible region of the spectrum. Reference to Example 2 on page 257 shows that this frequency is very close to that of the sodium lamp emission in the yellow region. The light is probably yellow.

You Try It

1. Calculate the frequency of an x-ray having a wavelength of 2.5×10^{-7} cm. *11·6*

Your Solution

Example B

Calculate the energy associated with a microwave having a frequency of $7.5 \times 10^{10}\ s^{-1}$. *11·7*

Solution Use the equation $E = h \times \nu$ to solve this problem.

$$E = h \times \nu$$

$$E = 6.626 \times 10^{-34}\ \text{J} \times \text{s} \times 7.5 \times 10^{10}\ \text{s}^{-1} = 5.0 \times 10^{-23}\ \text{J}$$

You Try It

2. What energy is associated with a photon in the infrared region of the spectrum having a frequency of $4.5 \times 10^{13}\ s^{-1}$? *11·7*

Your Solution

Example C

Calculate the energy associated with a photon whose wavelength is 4.0×10^{-8} cm. *II·6–7*

Solution Energy is directly related to frequency. Since frequency is not given in this problem, the energy equation must include the wavelength. This can be done by isolating ν in the frequency-wavelength equation and the substituting the value equivalent for ν, $\frac{c}{\lambda}$, into the energy-frequency equation as follows.

$$c = \lambda \times \nu$$

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

$$E = h \times \nu = h \times \frac{c}{\lambda}$$

Now substitute given values into this equation.

$$E = h \times \frac{c}{\lambda} = 6.626 \times 10^{-34}\ \mathrm{J} \times \cancel{\mathrm{s}} \times \frac{3.0 \times 10^{10}\ \cancel{\mathrm{cm}}/\cancel{\mathrm{s}}}{4.0 \times 10^{-8}\ \cancel{\mathrm{cm}}} = 5.0 \times 10^{-16}\ \mathrm{J}$$

You Try It

3. Calculate the energy of a photon having a wavelength of 6.6×10^{-5} cm. *II·6–7*

Your Solution

Problems For You To Try

4. Calculate the wavelength of a photon of blue light whose frequency is $6.3 \times 10^{14}\ \mathrm{s}^{-1}$. *II·6*

5. Calculate the frequency of a photon of orange light whose wavelength is 6.2×10^{5} cm. *II·6*

6. How much energy is associated with a photon in the ultraviolet region of the spectrum with a frequency of $6.6 \times 10^{15}\ \mathrm{s}^{-1}$? *II·7*

7. Calculate the energy involved with radiation having a wavelength of 3.0 m. In what region of the spectrum is this located? *II·6–7*

~~CHAPTER 5~~ WORKSHEET NAME____

LIGHT ~~(pgs 135-142)~~ DATE______________________PERIOD_________

The relationship between the wavelenth of light and its frequency is:

wavelenghth x requency = speed of light or $\lambda \times f = c$

where: λ = wavelength
f = frequency
c = speed of light (3.00×10^8 m/sec)

1. Calculate the frequency of red light which has a wavelength of 7.00×10^{-7} meter. (include units in your work and answer)

2. Yellow light has a wavelength of 5800 A. An angstrom (A) is 1×10^{10} meters. What is the frequency of yellow light? (Include units.)

3. A radar wave has a frequency of 1×10^{10}. What is the wavelength of this type of light?

4. WSHE FM radio station broadcasts on a frequency of 102 magacycles or 102×10^6/sec. What is the wwavelength of these radio waves?

5. Gamma rays are given off during a nuclear reaction and have a wavelength 1×10^{-13}. What is the frequaency of these gamma rays?

The energy that light (radiant energy) contains is a function of its frequency. To convert frequency of light to energy you multiply by Planck's constant which is 6.63×10^{-34} joules-sec. The formula is:

$E = h f$ where E = energy of a photon of light
h = Planck's constant (6.63×10^{-34} joul-sec)
f = frequency of the light

6. What is the energy of light with frequency of 5.00×10^{15}/sec ? (Include units in work and in answer)

7. (a) Calculate the energy of green light ($f = 5.80 \times 10^{14}$/sec) and compare with violet light (7.10×10^{14}/sec).

(b) Which of the two frequencies of light has more energy?

8. (a) If a photon of light has energy of 8.00×10^{-19} joules, what is its frequency?

(b) What is its wavelength?

9. A microwave has a wavelength of 3×10^{-2} meters.
(a) What is its frequency?

(b) What is its energy?