1. A photon has two important features: its frequency, f, and its wavelength, lambda.

In a vacuum, the frequency of a photon times its wavelength equals the speed of light, c, $3.00 \times 10^8 \frac{m}{sec}$.

Planck's constant is $6.63 \times 10^{-34}$ joules-seconds. The energy of a photon is Planck's constant times the photon's frequency.

If a photon has a frequency of $4.74 \times 10^{14}$ Hz, what is its wavelength?

(A) $1.42 \times 10^{21}$ m
(B) $1.42 \times 10^{-21}$ m
(C) $1.58 \times 10^{6}$ m
(D) $1.58 \times 10^{-6}$ m
(E) $6.33 \times 10^{-7}$ m

2. Another photon has a wavelength of 625 nm. What is its frequency?

(A) $1.88 \times 10^{14}$ Hz
(B) $2.08 \times 10^{14}$ Hz
(C) $3.00 \times 10^{14}$ Hz
(D) $4.16 \times 10^{14}$ Hz
(E) $4.80 \times 10^{14}$ Hz

3. What is the energy in joules of a wave with a wavelength of 500 nm?

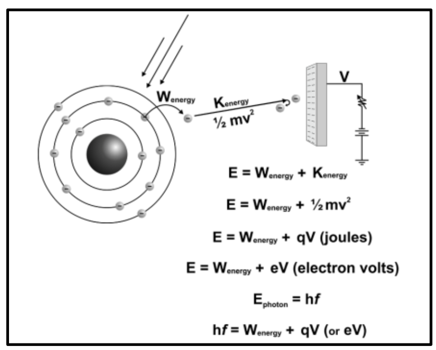
(A) $1.44 \times 10^{-20}$ joules
(B) $1.44 \times 10^{-19}$ joules
(C) $1.38 \times 10^{-19}$ joules
(D) $3.18 \times 10^{-19}$ joules
(E) $3.98 \times 10^{-19}$ joules

4. How long would it take for a photon of any frequency to travel from Venus to Earth, a distance of $28 \times 10^6$ miles? 1 mile = 1.61 km 1 km = 0.62 miles?

(A) 2.0 minute
(B) 2.5 minutes
(C) 3.0 minutes
(D) 3.5 minutes
(E) 4.0 minutes

**Introduction to Question 5**

Einstein realized that when a photon strikes an atom, the energy of the photon is first used to rip the electron from the atom. He called this energy "work energy."



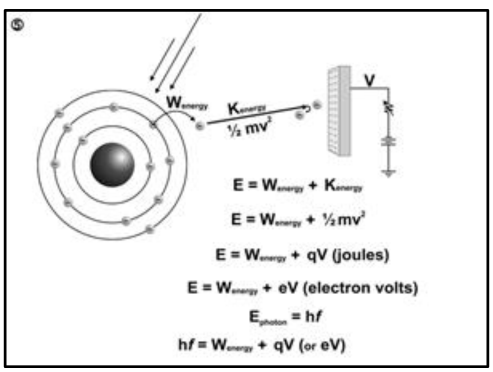

Any extra energy in the photon was then used to provide kinetic energy for the electron in the form of ½ $mv^2$.

Later investigators were able to measure the kinetic energy of the electron by calculating the electrical energy need to stop the electrons from moving. The electrical energy of an electrical charge moving up or down a voltage gradient is the q times V, the electrical charge times the voltage.

This can be measured in joules of energy or electron volts. 1 electron volt is the energy gained by an electron as it travels down a voltage gradient of 1 volt.

The energy of a photon is Planck's constant times its frequency.

So the h f of an electron is divided between the work energy needed to pry the electron loose and the kinetic energy measured in electron volts needed to get the electron moving once it's loose.



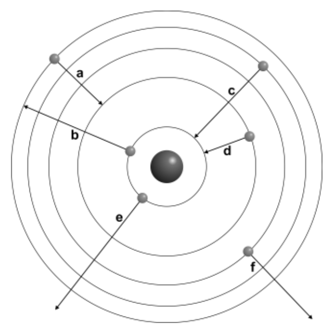

5. Ultraviolet light causes sunburn. How many electron volts of energy are delivered to the skin by a photon of ultraviolet light with a wavelength of 300 nm?

(A) $6.3 \times 10^{-19}$ J
(B) $1.0 \times 10^{-19}$ J
(C) $3.0 \times 10^{-19}$ J
(D) $4.7 \times 10^{-19}$ J
(E) $7.2 \times 10^{-19}$ J

6. A light of wavelength 0.0001 cm strikes a sample inside a closed glass bulb and creates a current. It takes 0.4 volts to stop the current. What is the work function for the atoms in the sample? Each electron has an electrical charge of $1.6 \times 10^{-19}$ coulombs.

(A) $0.64 \times 10^{-19}$ coulombs
(B) $1.34 \times 10^{-19}$ joules
(C) $1.98 \times 10^{-19}$ joules
(D) $2.46 \times 10^{-19}$ joules
(E) $4.92 \times 10^{-19}$ joules

7. Which of the following electron movements produces the shortest wavelength photon?




(A) A
(B) B
(C) C
(D) D
(E) E

8. In 1890, Johannes Rydberg, a Swedish physicist, derived a formula that calculates the energy of a photon emitted from an atom when its electron drops from one energy level to another. The formula states that:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

where R, the Rydberg constant, = 1.097 x $10^7$/m.

N f is the final shell, the shell the electron falls to. N is the initial shell that the electron falls from.

What is the wavelength in nanometers of a photon emitted when an electron drops from the $5^{th}$ shell to the $2^{nd}$ shell?

(A) 226 nm
(B) 354nm
(C) 434 nm
(D) 588 nm
(E) 604 nm

9. The photoelectric effect demonstrated that light could release electrons from metal atoms, but only when the light had a minimal frequency for each different metal. What Einstein's mathematical explanation for the photoelectric effect, h*f* = W + ½$mv^2$, doesn't say is that:

(A) W can be zero
(B) ½$mv^2$ can be zero
(C) h*f* must be greater than ½$mv^2$
(D) h*f* must be greater than W
(E) 1/2 $mv^2$ can be zero and h*f* must be greater than W

10. An isolated electron at rest is struck by a photon with a frequency of 1.5 x $10^{15}$ Hz. If all of the photon's energy is transferred to the electron, how fast will the electron accelerate to?

(A) 1.5 x $10^6 \frac{m}{sec}$
(B) 2.2 x $10^6 \frac{m}{sec}$
(C) 1.5 x $10^{12} \frac{m}{sec}$
(D) 2.2 x $10^{12} \frac{m}{sec}$
(E) 2.2 x $10^8 \frac{m}{sec}$