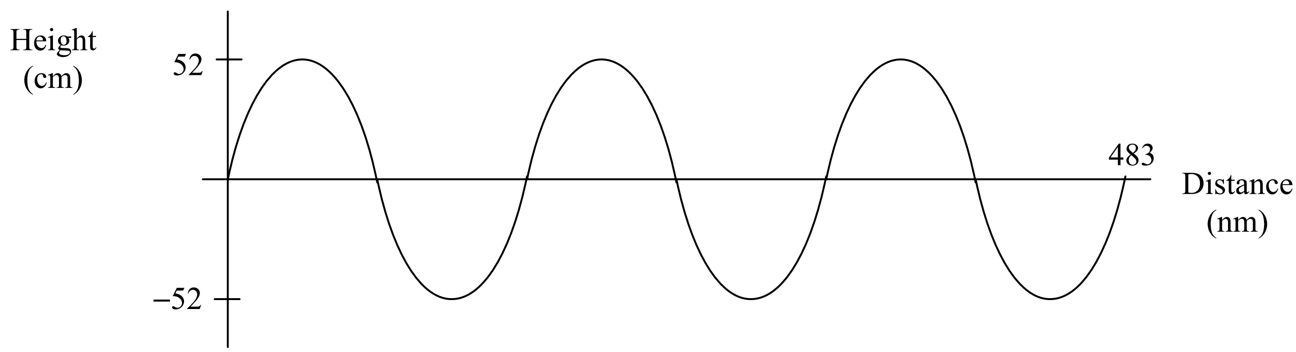
**UNIT 3 REVIEW #2: PHOTON THEORY**

1. a) Convert $3.20 \times 10^{-15}$ J to keV
   b) Convert 67.0 GeV to Joules

2. A photon of EMR has an energy of $2.19 \times 10^{-19}$ J. Would the EMR be visible, infrared, or ultraviolet?

3. Consider the EMR shown below:




Determine the number of photons required to create a total energy of 800 eV.

4. The minimum energy required to remove an electron from a metal is $4.13 \times 10^{-19}$ J. Determine the maximum wavelength of EMR possible to create photocurrent, if this metal is used as a photocathode.

5. The minimum frequency required to emit electrons from a metal is $5.5 \times 10^{14}$ Hz. If 380 nm EMR is shone on the metal, then determine the minimum potential difference required to prevent photocurrent.

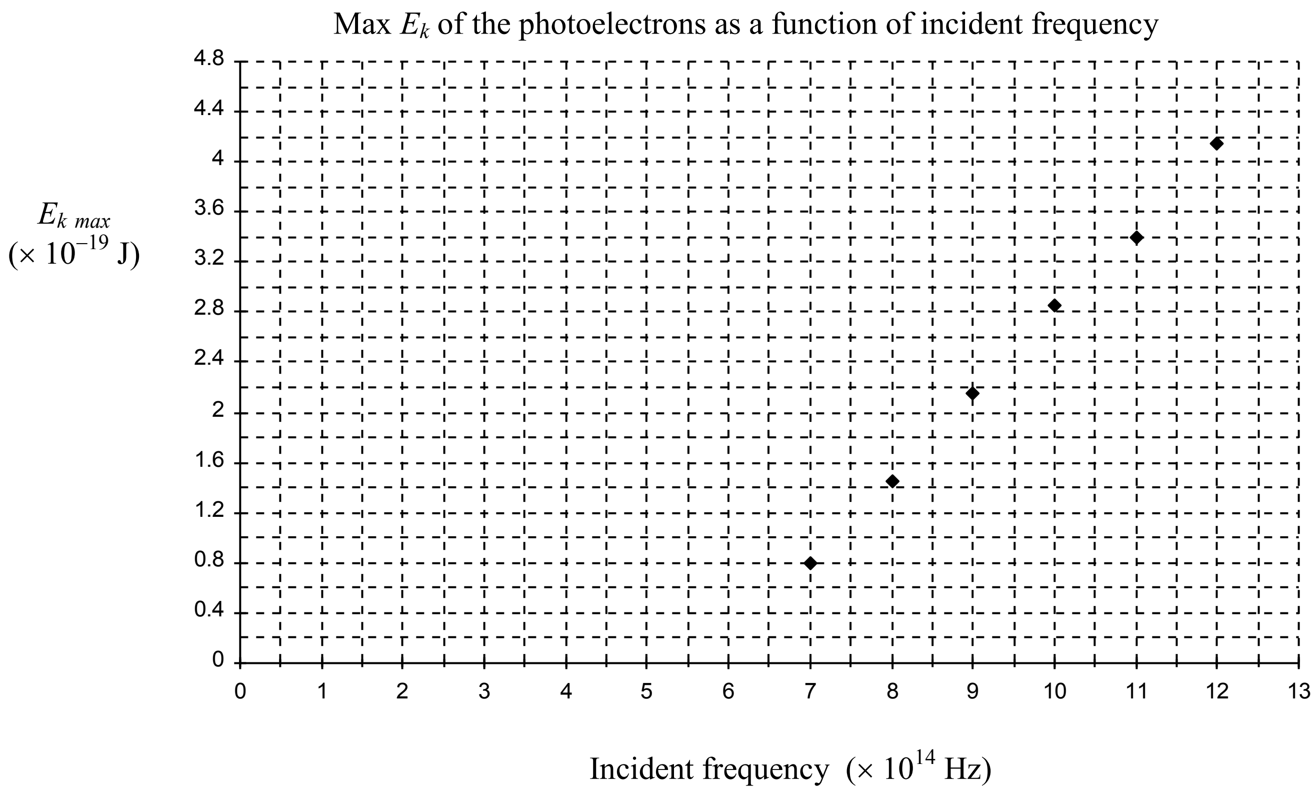
6. White light (400 nm to 700 nm) is shone on a metal surface. If the maximum speed of the emitted photoelectrons is $7.10 \times 10^{5}$ m/s, then determine the work function of the metal used. Answer in eV.

7. When light is shone on a metal, it creates a photocurrent of 620 mA. What is the minimum number of photons striking the metal surface every second?

8. Describe what happens in a photoelectric experiment when the incident EMR is increased in:

   a) intensity  b) frequency

9. A Physics 30 student investigated the relationship between incident frequency and the resulting $E_{k\ max}$ of the photoelectrons. The results are shown in the following graph:

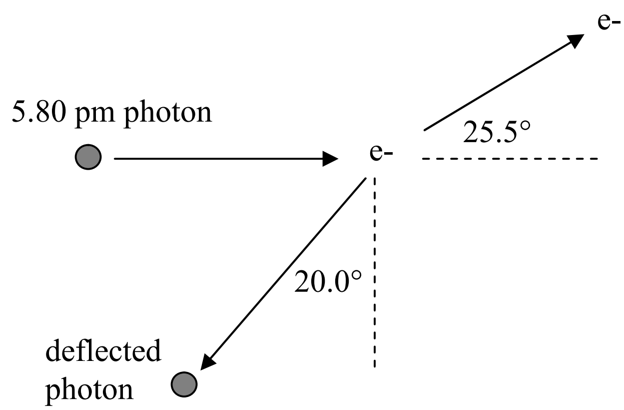



Using the line of best-fit, determine:
a) the threshold frequency
b) Planck's constant
c) the work function

10. Determine the frequency of a photon that has a momentum of $4.41 \times 10^{-26}$ kg·m/s.

11. Determine the speed of an alpha particle if it has the same momentum as a 92.0 MeV photon.

12. A 5.80 pm (i.e. picometer) photon collides with a stationary electron, as shown below:




Determine the wavelength of the deflected photon.

13. When a photon collides with a stationary proton (p+), its wavelength increases by 400 am (attometres). Determine the angle of the photon's deflection.

14. A $4.00 \times 10^{-15}$ m (i.e. 4.00 fm) x-ray photon is moving East and collides with a stationary proton. After the collision, the x-ray photon is travelling due South. Determine:

    a) the frequency of the x-ray photon after the collision

    b) the kinetic energy of the proton after the collision

    c) the proton's angle of deflection and final momentum

15. Compare and contrast the photoelectric effect with the Compton Effect. How are they the same? How are they different?

***SOLUTIONS***

1. a) 20.0 keV b) $1.07 \times 10^{-8}$ J

2. $\lambda = 908$ nm (infrared)

3. $\lambda = 1.61 \times 10^{-7}$ m ; $E_{photon} = 7.714$ eV ; $n = 104$ photons

4. $W = 4.13 \times 10^{-19}$ J ; $f_0 = 6.229 \times 10^{14}$ Hz ; $\lambda_{\max} = 482$ nm

5. $W = 3.6465 \times 10^{-19}$ J ; $E_{photon} = 5.2342 \times 10^{-19}$ J ; $E_{k\,(max)} = 1.5877 \times 10^{-19}$ J
   $V_{stop} = 0.99$ V

6. Use violet light (400 nm): $E_{photon} = 4.9725 \times 10^{-19}$ J ; $E_{k\,(max)} = 2.2962 \times 10^{-19}$ J
   $W = 2.6763 \times 10^{-19}$ J $=$ 1.67 eV

7. It emits $3.88 \times 10^{18}$ electrons every second. Thus, the minimum number of photons would be $3.88 \times 10^{18}$.

8. a) Greater photocurrent
   b) Greater kinetic energy (i.e. speed) of emitted photoelectrons, and thus, grater $V_{stop}$.

9. a) $f_o$ = x-intercept $\approx 5.8 \times 10^{14}$ Hz
   b) $h$ = slope $= 6.8 \times 10^{-34}$ J·s
   c) $W = hf_o = 3.9 \times 10^{-19}$ J

10. $E_{photon} = 1.323 \times 10^{-17}$ J ; $f = 2.00 \times 10^{16}$ Hz

11. $E_{photon} = 1.472 \times 10^{-11}$ J ; $p = 4.9067 \times 10^{-20}$ kg·m/s ; $v = 7.38 \times 10^{6}$ m/s

12. $\theta = 110°$ ; $\Delta\lambda = 3.2556$ pm ; $\lambda_f = 9.06$ pm

13. $\Delta\lambda = +400 \times 10^{-18}$ m ; $\theta = 45.8°$

14. a) $\Delta\lambda = 1.323$ pm ; $\lambda_f = 5.323$ pm ; $f = 5.64 \times 10^{22}$ Hz
    b) Using conservation of energy, $1.24 \times 10^{-11}$ J
    c) Using conservation of momentum, $\vec{p}_{p+} = 2.07 \times 10^{-19}$ kg·m/s at 36.9° above horizontal

15. Photoelectric Effect: The incident photon is fully absorbed by the electron, the electron is emitted, and the electron keeps the rest of the energy as kinetic energy.

    Compton Effect: The incident x-ray photon is only partially absorbed, emitting the electron and giving the electron kinetic energy. The rest of the photon energy is reemitted as an x-ray photon with less energy (lower f, longer λ).