AP Physics – Nuclear Stuff – 3 ans

1. What is the energy of a quantum of 475 nm light?

$$E = hf \quad c = f\lambda \quad f = \frac{c}{\lambda} \quad E = \frac{hc}{\lambda} \quad = \frac{1.24 \, x \, 10^3 eV \cdot nm}{475 \, nm} = 0.00261 \, x \, 10^3 eV \quad = \quad \boxed{2.61 \, eV}$$

2. Electrons are ejected from a metal surface with speeds ranging up to 4.60 x 10^5 m/s when light with a wavelength of 625 nm is incident on it. (a) What is the work function? (b) What is the cutoff frequency for this surface?

(a) $K = \frac{1}{2}mv^2 \quad = \frac{1}{2}\left(9.11 \, x \, 10^{-31} kg\right)\left(4.60 \, x \, 10^5 \frac{m}{s}\right)^2 \quad = \quad 96.38 \, x \, 10^{-21} J \quad = 9.638 \, x \, 10^{-20} J$

$$E = hf \quad c = f\lambda \quad f = \frac{c}{\lambda} \quad E = \frac{hc}{\lambda} \qquad K_{Max} = hf - \phi \qquad K_{Max} = \frac{hc}{\lambda} - \phi \qquad \phi = \frac{hc}{\lambda} - K_{Max}$$

$$\phi = \frac{1.24 \, x \, 10^3 eV \cdot nm}{625 \, nm} - 9.638 \, x \, 10^{-20} J \left(\frac{1 \, eV}{1.6 \, x \, 10^{-19} J}\right)$$

$$\phi = 0.001984 \, x \, 10^3 eV - 6.024 \, x \, 10^{-1} eV \quad = 1.984 \, eV - 0.602 \, eV \quad = \quad \boxed{1.38 \, eV}$$

(b) $\quad K_{Max} = hf - \phi \quad 0 = hf - \phi \quad f = \frac{\phi}{h} \quad f = \frac{1.38 \, eV}{4.14 \, x \, 10^{-15} eV \cdot s}$

$$f = 0.333 \, x \, 10^{15} Hz \quad = \quad \boxed{3.33 \, x \, 10^{14} Hz}$$

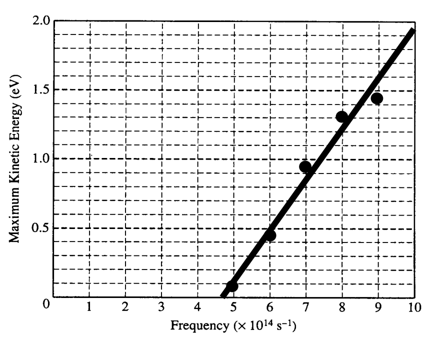
3. Find the minimum film thickness for destructive interference in reflected light for a thin film. Figure on a first minima deal. The film's index of refraction is 1.45. It is illuminated by light that has wavelength of 525 nm.

$$2t = \frac{n\lambda}{n_f} \quad t = \frac{\lambda}{2n_f} \quad = \frac{525 \, nm}{2(1.45)} \quad = \quad \boxed{181 \, nm}$$

4. A series of measurements were taken of the maximum kinetic energy of photoelectrons emitted from a metallic surface when light of various frequencies is incident on the surface.

    a. The table below lists the measurements that were taken. On the axes below, plot the kinetic energy versus light frequency for the five data points given. Draw on the graph the line that is your estimate of the best straight-line fit to the data points.

Light Frequency (10^{14} s^{-1})	Maximum Kinetic Energy (electron volts)
5.00	0.10
6.00	0.45
7.00	0.95
8.00	1.30
9.00	1.45



    a. From this experiment, determine a value of Planck's constant ***h*** in units of electron volt-seconds. Briefly explain how you did this.

$K_{max} = hf - \phi$ ***Equation for a line. h is the slope of the line***

$$h = \frac{K_2 - K_1}{f_2 - f_1} = \frac{1.6 \, eV - 0.1 \, eV}{(9-5) \, x \, 10^{14} \frac{1}{s}} \quad = 0.375 \, x \, x10^{-14} ev \cdot s \quad = \quad \boxed{3.75 \, x \, 10^{-15} eV \cdot s}$$

5. Light of wavelength 350.0 nm in incident on a potassium surface. Electrons are emitted that have a maximum kinetic energy of 1.31 eV. Find (a) the work function of potassium, (b) the cutoff wavelength, (c) the cutoff frequency.

(a) $K_{Max} = \frac{hc}{\lambda} - \phi \quad \phi = \frac{hc}{\lambda} - K_{Max} \quad \phi = \frac{1.24\,x\,10^3 eV \cdot \cancel{nm}}{350\,\cancel{nm}} - 1.31\,eV$

$\phi = 0.00354\,x\,10^3 eV - 1.31\,eV \quad = 3.54\,eV - 1.31\,eV \quad = \boxed{2.23\,eV}$

(b) $K_{Max} = \frac{hc}{\lambda} - \phi \quad 0 = \frac{hc}{\lambda} - \phi \quad \lambda = \frac{hc}{\phi} \quad \lambda = \frac{1.24\,x\,10^3 e\cancel{V} \cdot nm}{2.23\,e\cancel{V}} \quad = 0.556\,x\,10^3 nm \quad = \boxed{556\,nm}$

(c)

$K_{Max} = hf - \phi \quad 0 = hf - \phi \quad f = \frac{\phi}{h} \quad f = \frac{2.23\,e\cancel{V}}{4.14\,x\,10^{-15} e\cancel{V} \cdot s} \quad = 0.539\,x\,10^{-15} Hz \quad = \boxed{5.39\,x\,10^{14}\,Hz}$

6. You have three metals – lithium, aluminum, and mercury. Their work functions are: 2.30 eV, 4.10 eV, and 4.5 eV respectively. Light with a frequency of 1.0 x 10^{15} Hz is incident on all three metals. Determine (a) which metals will emit electrons and (b) the maximum kinetic energy for those that exhibit the effect.

(a) ***E of photon*** $E = hf \quad = \left(4.14\,x\,10^{-15} eV \cdot \cancel{s}\right)\left(1.0\,x\,10^{15} \frac{1}{\cancel{s}}\right) \quad = \quad 4.14\,eV$

E of photon must be greater than work function for emission to take place. Emission is possible for lithium and aluminum

(b) ***Lithium:*** $K_{Max} = hf - \phi \quad = 4.14\,eV - 2.30\,eV \quad = \boxed{1.80\,eV}$

Aluminum: $K_{Max} = hf - \phi \quad = 4.14\,eV - 4.10\,eV \quad = \boxed{0.040\,eV}$

7. What wavelength of light would have to be incident on sodium metal if it is to emit electrons with a maximum speed of 1.00 x 10^6 m/s?

$K = \frac{1}{2}mv^2 = \frac{1}{2}\left(9.11\,x\,10^{-31} kg\right)\left(1.00\,x\,10^6 \frac{m}{s}\right)^2 = 4.555\,x\,10^{-19} \cancel{J}\left(\frac{1\,eV}{1.6\,x\,10^{-19} \cancel{J}}\right) \quad = \quad 2.847\,eV$

$E = hf \quad c = f\lambda \quad f = \frac{c}{\lambda} \quad E = \frac{hc}{\lambda} \quad K_{Max} = hf - \phi \quad K_{Max} = \frac{hc}{\lambda} - \phi \quad K_{Max} + \phi = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{\left(K_{Max} + \phi\right)} \quad \lambda = \frac{1.24\,x\,10^3 e\cancel{V} \cdot nm}{\left(2.847\,e\cancel{V} + 2.46\,e\cancel{V}\right)} \quad = \quad 0.234\,x\,10^3 nm \quad = \quad \boxed{234\,nm}$