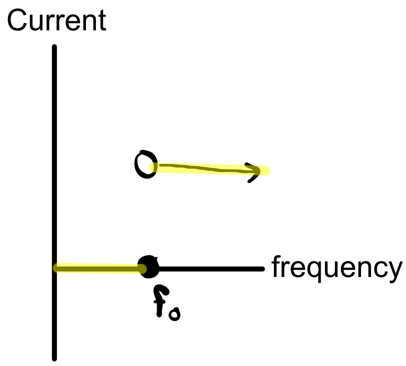
L14 - Photoelectric Effect 1

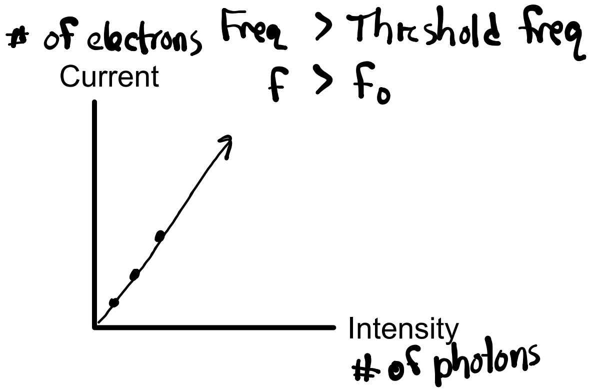
Photoelectric Effect: EMR shining on a piece of metal (photo) can cause electrons to leave the metal (electricity)

Wave Model Expectations:
- Light would slowly give the electrons enough energy to escape (vibrations)
- The brightness would be the key to causing them to escape.

http://phet.colorado.edu/en/simulation/photoelectric

Experimental Results:
- No delay.
- The brightness did not help emit electrons. It only increased the current.
- Minimum threshold frequency





Einstein's Explanation - Conservation of Energy

- Used Planck's Equation E=hf
- Used Conservation of Energy

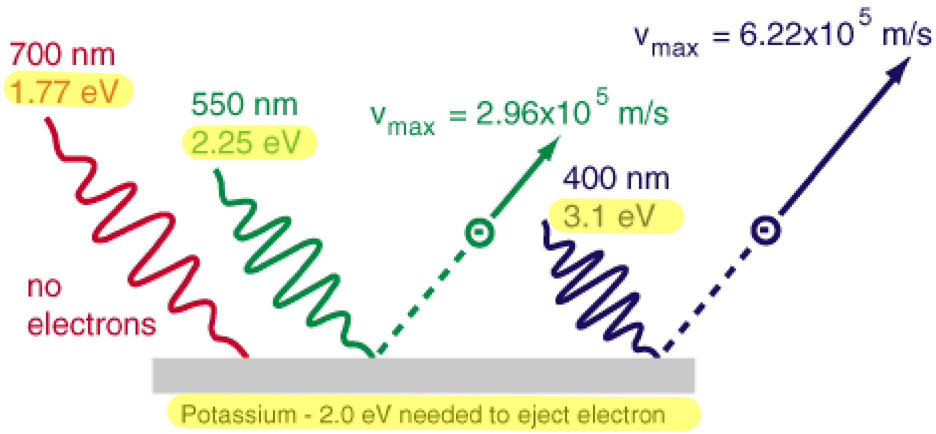
$$E = hf = \frac{hc}{\lambda}$$

Low E — High E

Low Freq. → High Freq.

RMIVUXG

ROYGBIV



Photoelectric effect

Conservation of Energy

$$E_{photon} = W + E_{k\ electrons}$$

$E_{photon} = hf$

$$W = hf_0$$

Work Function = Plank's Constant * Threshold Freq.

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Q1: Experiments show that the work function for cesium metal is 2.10 eV. Determine the threshold frequency and the wavelength for photons capable of producing photoemission from cesium.

$$E_{photon} = W + E_{k\ electrons}$$

Planck's Constant .... $h = 6.63 \times 10^{-34}$ J·s
$h = 4.14 \times 10^{-15}$ eV·s

Work function
"Min required energy"

Low f — ROYGBIV — High f
Large λ — Small λ

750
400
0

$E = hf$

$W = hf_0$

$2.10\,eV = (4.14 \times 10^{-15}\,eV\cdot s) f_0$

$f_0 = 5.07246 \times 10^{14}\,Hz$

$c = f\lambda$

$3.0 \times 10^8 = (5.07\ldots \times 10^{14})\lambda$

$\lambda = 5.91 \times 10^{-7}\,m$

$\approx 591\,nm$

Q2: Use Table 14.1, (Pg 712) determine the maximum speed of electrons emitted from an aluminum surface if it is illuminated with 125 nm ultraviolet light.

$$E_{photon} = W + E_{k\ electrons}$$

Planck's Constant .... $h = 6.63 \times 10^{-34}$ J·s
$h = 4.14 \times 10^{-15}$ eV·s

$6.528 \times 10^{-19}\,J$

Table 14.1 Work Functions of Some Common Metals

Element	Work Function (eV)
Aluminium	4.08
Beryllium	5.00
Cadmium	4.07
Calcium	2.90
Carbon	4.81
Cesium	2.10
Copper	4.70
Magnesium	3.68
Mercury	4.50
Potassium	2.30
Selenium	5.11
Sodium	2.28
Zinc	4.33

$E_{photon} \rightarrow W + E_k$

$\frac{hc}{\lambda} \rightarrow W + \frac{1}{2}mv^2$

$\frac{(6.63 \times 10^{-34})(3.0 \times 10^8)}{(125 \times 10^{-9})} = 6.528 \times 10^{-19} + \frac{1}{2}(9.11 \times 10^{-31})v^2$

$1.5912 \times 10^{-18} = 6.528 \times 10^{-19} + \frac{1}{2}(9.11 \times 10^{-31})v^2$

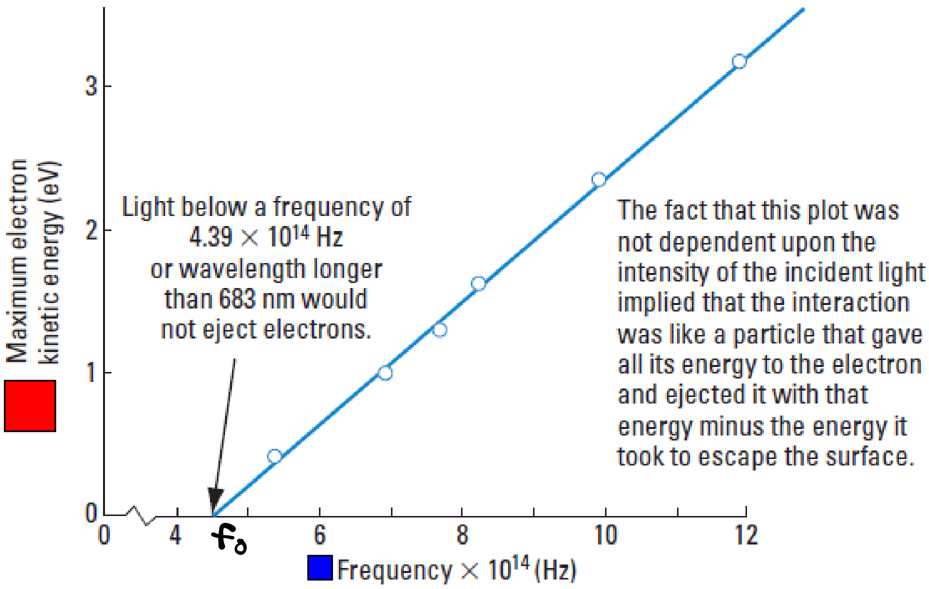
$9.384 \times 10^{-19} = \frac{1}{2}(9.11 \times 10^{-31})v^2$

$v^2 = 2.06015\ldots \times 10^{12}$

$v = 1.4353\ldots \times 10^6\,m/s$

$\boxed{v \approx 1.44 \times 10^6\,m/s}$

How to read a kinetic energy - frequency graph for the photoelectric effect.



x - intercept

y - intercept

Slope

$E_{photon} = W + E_{k\ electrons}$

$E_{k\ electrons} = hf - W$

$y = mx + b$

100% of the time Memorize!