L15 – Photoelectric Effect 2

$W = hf_0$ $E = hf$ $W = hf_0$

$E_{photon} = W + E_{k\,electron}$

$hf \rightarrow hf_0 + \frac{1}{2}mv_e^2$

E_k

$m = h$

f_0 f

$-W$

$W = hf$

Photoelectric Effect – Milikan/ Hertz Experiment

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

Regular Setup
Determining Threshold Freq.

incoming photons

collector

electron-emitting
metal surface

evacuated tube

ammeter

power supply
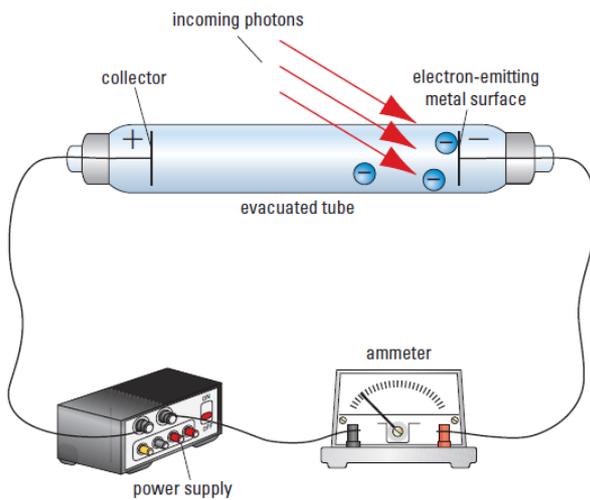
Milikan Hertz Setup
Determining Stopping Potential (Voltage)

The electric force
opposes the motion
of the electron.

incoming
photons

collector

F_e

The electron is repelled by the
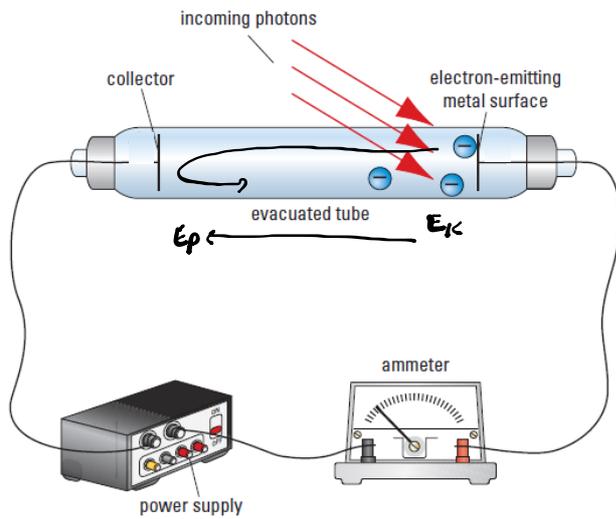collector and attracted to the
positively charged plate.

All
Potential
Energy

All Kinetic
Energy
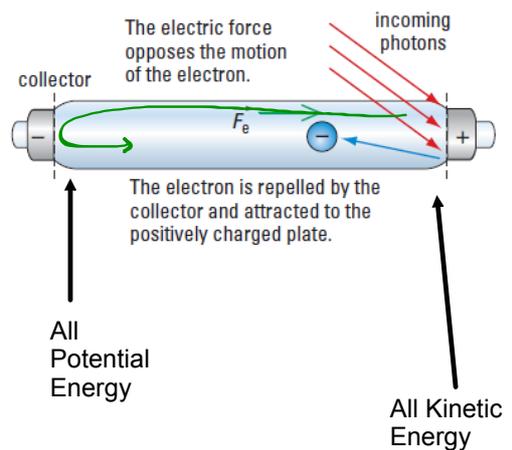
$Ek_{final} = Ek_{initial} - \Delta E$

$E_{k_{max}} = qV_{stopping}$

Q1: Blue light shines on the metal surface shown below and causes photoemission of electrons. If a stopping potential of 2.6V is required to completely prevent electrons from reaching the collector, determine the maximum kinetic energy of the electrons.

Express your answer in units of joules and electron volts.

incoming photons

collector

electron-emitting
metal surface

evacuated tube

$E_p \leftarrow$ _____ E_k

ammeter

power supply

$W = hf_o$

$E_{photon} = W + E_{k \, electron}$

$\boxed{E_{k_{max}} = qV_{stopping}}$

$\boxed{E_K \rightarrow E_p}$
$E_K \rightarrow q\Delta V$
$E_K \rightarrow qV_{stopping}$

$E_{photon} \rightarrow W + \boxed{E_k}$

$E_k \rightarrow E_p$
$E_K = q\Delta V$
$E_K = (1.60 \times 10^{-19})(2.6V)$
$\boxed{E_k = 4.16 \times 10^{-19} \text{ J}}$

$\overset{or}{"="}$

$E_K = (1e)(2.6V)$
$\boxed{E_K = 2.6 \text{ eV}}$

Can only use S.I. units
if then using
$E_k = \frac{1}{2}mv^2$
to find speed.

Q2 (Hard): Use Table 14.1 (Pg 712) , determine the stopping voltage needed to stop electrons emitted from an aluminum surface if it is illuminated with 125 nm ultraviolet light.
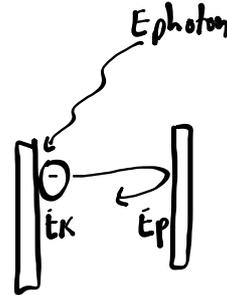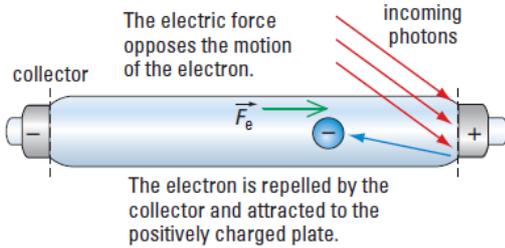
Use S.I. Units (Joules, Coulombs)

Element	Work Function (eV)
Aluminium	4.08eV

$$\frac{4.08 \, eV}{1} \times \frac{1.60 \times 10^{-19} \, J}{1 \, eV} = 6.528 \times 10^{-19} \, J$$

$W = hf_o$

$E_{photon} = W + E_{k \, electron}$

$$E_{k_{max}} = qV_{stopping}$$

collector — The electric force opposes the motion of the electron. — incoming photons

$\vec{F}_e$

The electron is repelled by the collector and attracted to the positively charged plate.
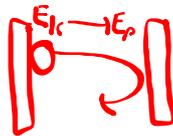
E_{photon}

E_K E_P

$$E_{photon} \rightarrow W + E_K$$

$$\frac{hc}{\lambda} \rightarrow W + E_K$$

$$\frac{(6.63 \times 10^{-34})(3.0 \times 10^8)}{(125 \times 10^{-9})} = 6.528 \times 10^{-19} \, J + E_K$$

$$1.5912 \times 10^{-18} = 6.528 \times 10^{-19} \, J + E_K$$

$$\boxed{E_K = 9.384 \times 10^{-19} \, J}$$

$E_K \rightarrow E_P$

$$E_K \rightarrow E_P$$
$$9.384 \times 10^{-19} = q \Delta V$$
$$\boxed{\Delta V = 5.865 V}$$

Q2 (Easy): Use Table 14.1 (Pg 712) , determine the stopping voltage needed to stop electrons emitted from an aluminum surface if it is illuminated with 125 nm ultraviolet light.
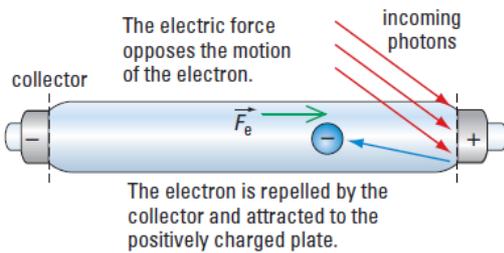
Use easy units (elementary charge units, eV)

Element	Work Function (eV)
Aluminium	4.08

$W = hf_o$

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

$E_{k_{max}} = qV_{stopping}$

The electric force opposes the motion of the electron.

collector

incoming photons

$\vec{F_e}$

The electron is repelled by the collector and attracted to the positively charged plate.

eV

In physics, the **electron volt** (symbol **eV**; also written electronvolt) is a unit of energy equal to approximately 1.6×10^{-19} joule (symbol J). By **definition**, it is the amount of energy gained (or lost) by the charge of a single electron moved across an electric potential difference of one volt.

$$E_{photon} \rightarrow W + E_k$$

$$\frac{hc}{\lambda} \rightarrow W + E_k$$

$$\frac{(4.14 \times 10^{-15})(3.0 \times 10^8)}{(125 \times 10^{-9})} = 4.08eV + E_k$$

$$9.936eV = 4.08eV + E_k$$

$$\boxed{E_k = 5.856 eV}$$

$$E_k \rightarrow E_p$$

$$5.856eV = q\Delta V$$

$$5.856eV = (1e)(\Delta V)$$

$$\boxed{\Delta V = 5.856 V}$$

$$h(J) \approx h(eV)$$

$$6.63 \times 10^{-34} Js \approx 4.14 \times 10^{-15} eVs$$

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