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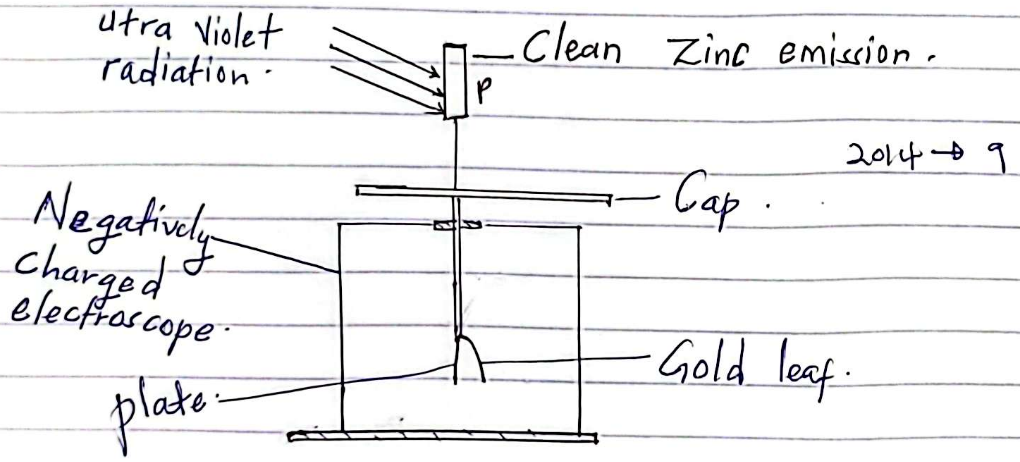
PHOTO ELECTRIC EMISSION. (PHOTO ELECTRIC EFFECT)

Photo electric effect is the process by which electrons are emitted from a metal surface when electromagnetic radiations of high enough frequency fall on it.
The freq. is always greater than the Threshold freq.

Threshold freq.
This is the minimum freq. below which no electrons are emitted from a metal surface.

Examples of electromagnetic radiations.
- ✓ X-rays.
- ✓ Ultra violet.
- ✓ Infra red.

An experiment to demonstrate Photoelectric emission



A well cleaned zinc plate is connected to a negatively charged gold leaf electroscope.
The zinc plate is then illuminated with utra violet radiations from a lamp in a dark room.
The leaf of electroscope will be seen to fall gradually indicating loss of charge due to emission of electrons hence photoelectric effect.

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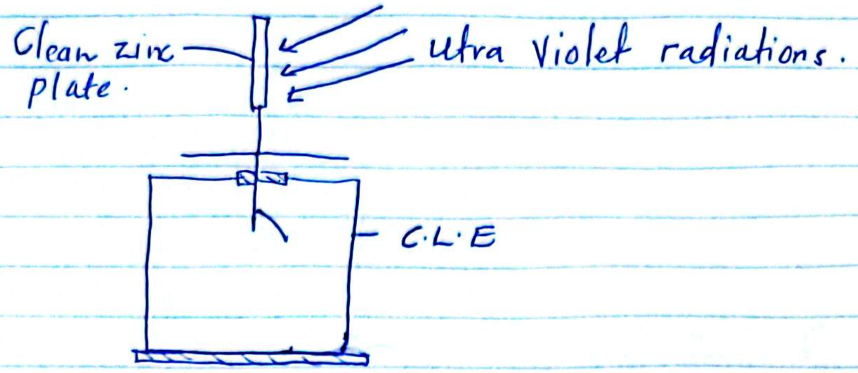
1. A freshly cleaned Zinc plate placed on a cap of a gold leaf electroscope is irradiated with ultra violet radiations as shown in the figure below.



Explain what happen when the gold leaf electroscope is (i) positively charged

(ii) negatively charged.

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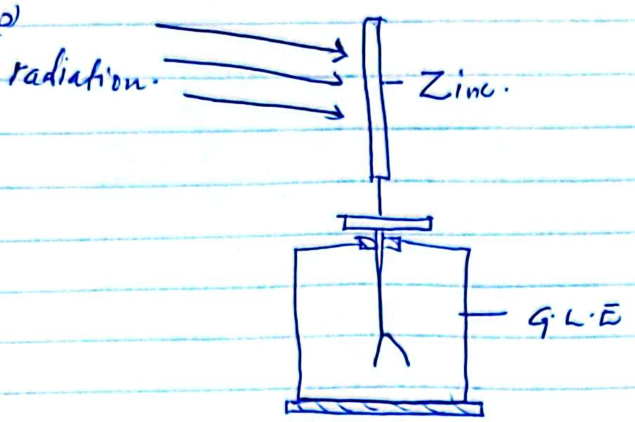
(a) Explain what is meant by photoelectric effect.

(b)



Utraviolet and Infrared radiations are directed in turns into the zinc plate which is attached to G.L.E in the figure above.

Explain what happens when;

i) ~~Of~~ ultraviolet radiations fall on zinc plate.

ii) Infra red falls on zinc plate.

iii)

Properties / laws of photoelectric emission.

1st law.

It states that for a given metal surface there is a minimum freq. of a radiation below which no electrons are emitted irrespective of the intensity of the incident radiation.

2nd law

It states that photoelectrons are emitted with variable k.e which ranges from zero to maximum and is directly proportional to freq. but independent of the intesity of the incident radiations.

3rd. law.

It states that the number of photoelectrons emitted per second is proportional to the ~~intensi~~ intensity of the incident radiation.

4th law.

~~It states that the no of phot~~

It states that there is no time lag between irradiation and emission of the electrons from a metal surface.

Classical Wave theory

Classical Wave theory Considered Electromagnetic radiations as wave like propagation of life.
It states that radiation is emitted with continous energy and this energy is absorbed and accumulated by the electrons.
Failure of the classical wave theory in explaining photo electric emission.

THE QUANTUM THEORY EXPLANATION ON PHOTOELECTRIC EMISSION.

It states that radiation is emitted in packets of energy Called Quanta or photon.
Electrons are emitted from a metal Surface by impact of photons. Each electron requires one photon for its emission.
During this interaction, either all or none of the photon's energy is absorved by the electron.

Explanation provided by quantum theory.

EINSTEINS EQUATION OF PHOTOELECTRIC EMISSION.

It states that;
Energy of incident photon = Work function + KE of photo electrons

$$E = W_0 + K.E_{max}$$

$$hf = W_0 + K.E_{max}$$

$$hf = hf_0 + \frac{1}{2}mV_{max}^2$$

$$h\frac{c}{\lambda} = \frac{hc}{\lambda_0} + \frac{1}{2}mV_{max}^2.$$

$$hf = hf_0 + eV_s.$$

m - mass of electrons
λ - wave length of incident radiation
λ_0 - Threshold wavelength of incident radiation.
f_0 - Threshold freq of incident electromagnetic radiation
c - speed of light in a Vacuum.

W_0 - Work function
V_s - stopping potential.

Work function. This is the ~~max~~ minimum amount of energy necessary to take free electrons out of metal surface against attractive forces of sorrounding positive ions.

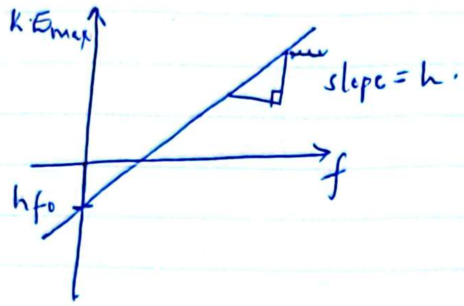
Stopping potential (V_s)
This is the value of retarding potential that is just sufficient to prevent the most energy electrons from being emitted by metal surface.

Sketch graphs under Einstein's eqn.

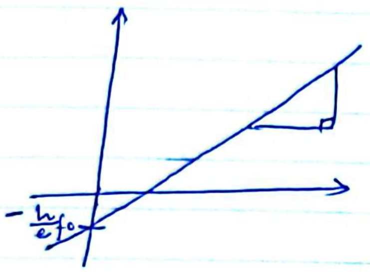
(a) A graph of $k.E_{max}$ against f.

$$hf = hf_0 + k.E_{max}.$$

$$k.E_{max} = hf - hf_0.$$



(b) A graph of V_s against f.



$$hf = hf_0 + eV_s.$$

$$V_s = \left(\frac{h}{e}\right)f - \frac{hf_0}{e}.$$

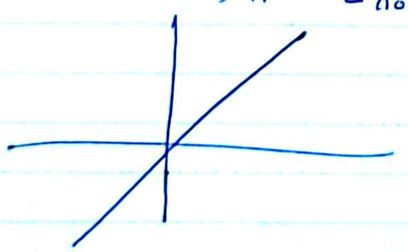
$$\text{Slope} = \frac{h}{e}$$

A sketch graph of V_s against λ

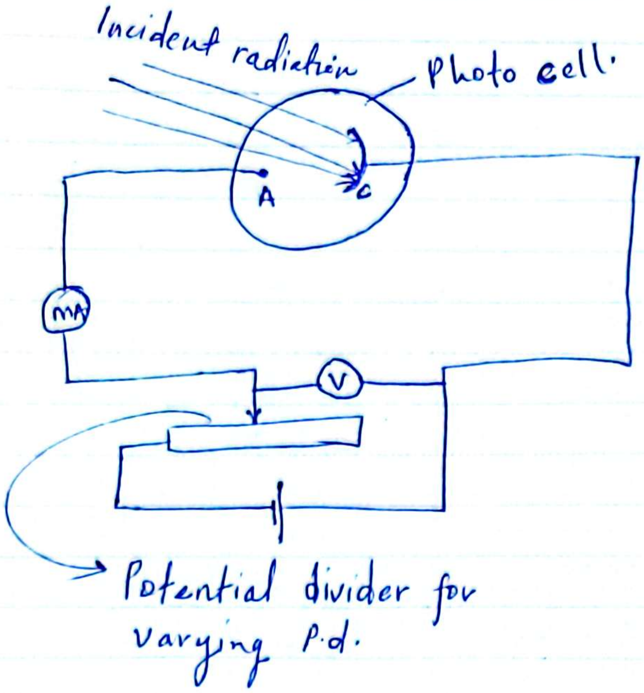
$$hf = hf_0 + eV_s.$$

$$h\left(\frac{c}{\lambda}\right) + h\left(\frac{c}{\lambda_0}\right) + eV_s.$$

$$V_s = \left(\frac{h}{ec}\right)\frac{1}{\lambda} - \frac{hc}{e\lambda_0}.$$



AN EXPERIMENT TO MEASURE THE STOPPING POTENTIAL OF A GIVEN METAL SURFACE. OR PRANK'S CONSTANT.



1. Sodium has a work function of 2.0eV and is illuminated by radiation of wavelength 150nm. Calculate the maximum speed of the emitted electrons.

2 Calculate the stopping potential for a platinum surface irradiated with ultraviolet light of wavelength 1.2×10^{-7}m. The work function of platinum is 6.3eV. [$h = 6.6 \times 10^{-34}$J, $c = 3 \times 10^{8}$ms]
Ans [4.0V]

3. Gold has a work function of 4.9eV.
a) Calculate the maximum kinetic in joules, of the electrons emitted when gold is illuminated with utraviolet radiations of freq. 1.7×10^{15} Hz.
(c) What is the stopping potential for these electrons.
[3.4×10^{-19}J, 2.1eV, 2.1V]
b) What is energy in eV.

4. light of ~~wave~~ freq. 6×10^{14}Hz, incident on a metal surface ejects photoelectrons having a kinetic energy 2×10^{-19}J. Calculate the energy needed to remove an electron from the metal.
[1.96×10^{-19}]

5. light of wavelength 0.5μm incident on a metal surface ejects electrons with k.e up to a maximum value of 2×10^{-19}J. What is the energy required to remove an electron from the metal? If a beam of light causes no electrons to be emitted, however great its intensity what condition must be satisfied by its wavelength Ans [1.96×10^{-19}, 1.01×10^{-6}m]