

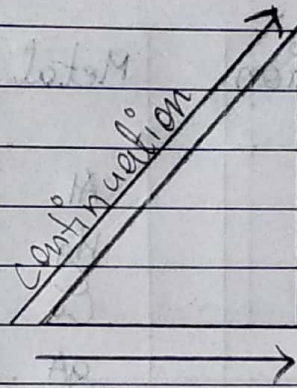
Chp-11: Dual Nature of light and Matter

* Nature of light:

- Two types of nature are:

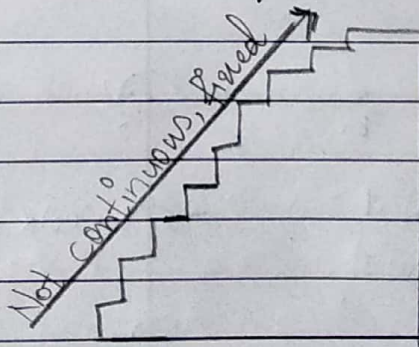
① Wave nature -

Works as wave, energy continuation.
Proves experiment such as diffraction of light, interference pattern, etc.



② Matter -

Finite, energy packets, mass, shape, moves in straight line and finite dimension.



- Planck's idea -

Light travels in terms of energy packets and these are called as quanta. This quanta has specific vibration due to which has different colour and frequency. He says that $E = nhf$, where, h is planck's constant, f is frequency, n is number of

quantum particles.

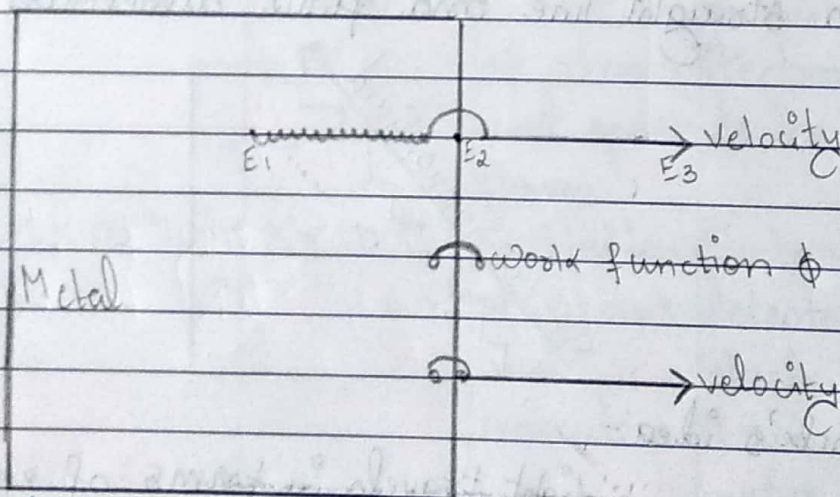
- Equation for Einstein for K.E of e^- ,

$$\Rightarrow K.E = hf - \phi \text{ and } E = h\nu.$$

* Work function:

- Work function is the minimum work required to be done on an electron to eject it out just from the surface of metal without having any velocity.

Metal	Work function ϕ	Metal	Work function ϕ
Cs	2.14	Al	4.28
K	2.30	Hg	4.49
Na	2.75	Cu	4.65
Ca	3.20	Zn	4.70
Mo	4.17	Ni	5.15
Pb	4.25	Pt	5.65



- Thermal electrons -

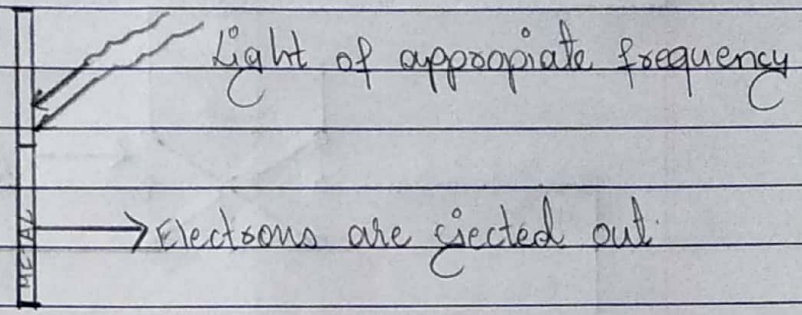
Energy given is thermal energy and they show thermionic emission.

- Field emission-

Electric field is strong enough to give potential energy 'eV' more than binding energy and this electron is called field electrons.

- Photoemission-

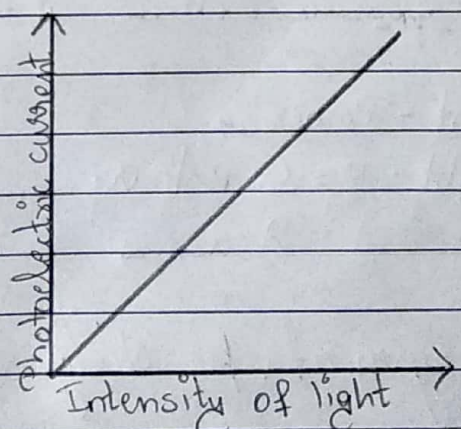
Light of appropriate frequency can eject out electron and those electrons are called photo-electrons.



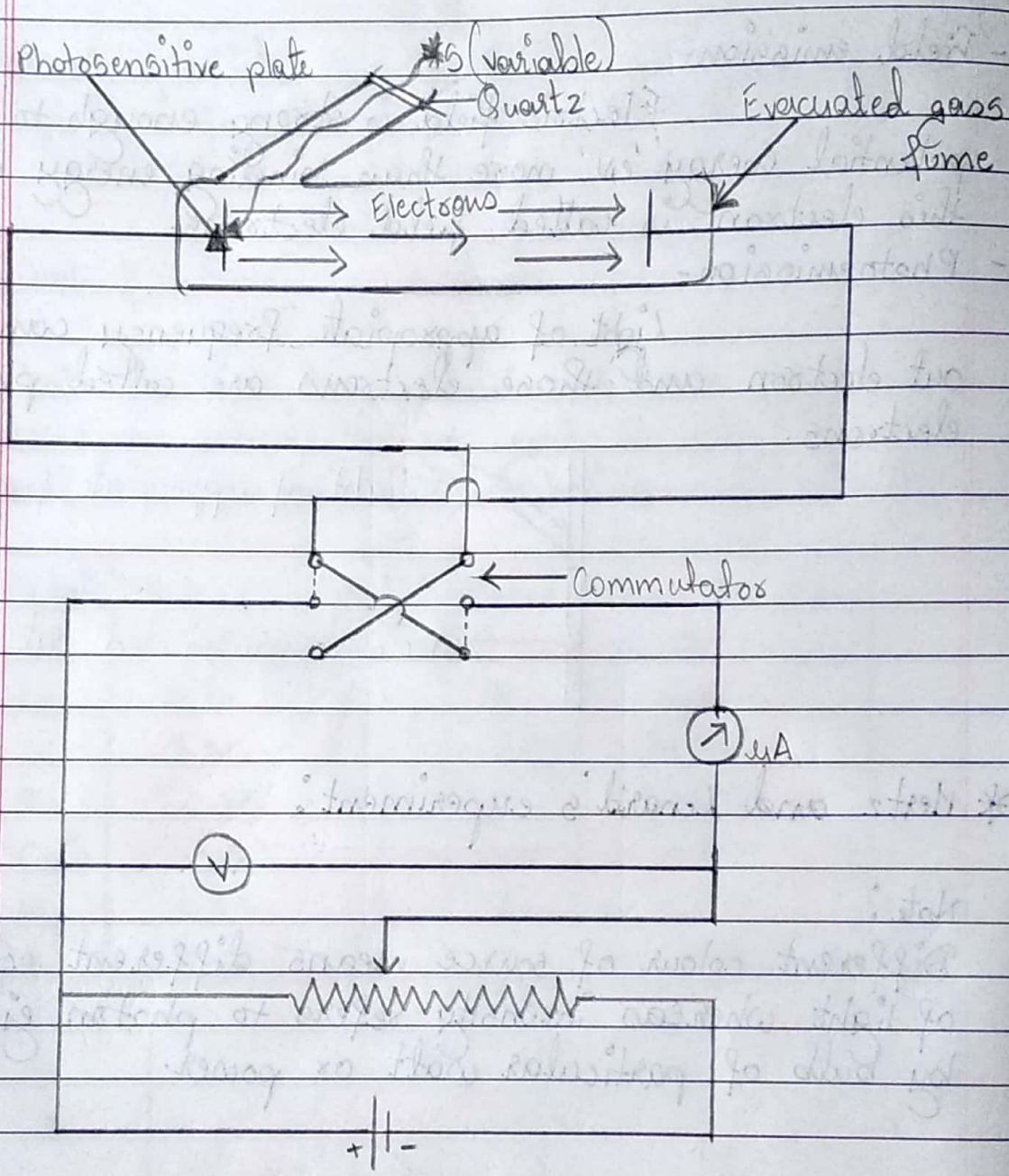
* Hertz and Lenard's experiment:

Note:

Different colour of source means different colour of light whereas intensity refers to photon ejected by bulb of particular watt or power.



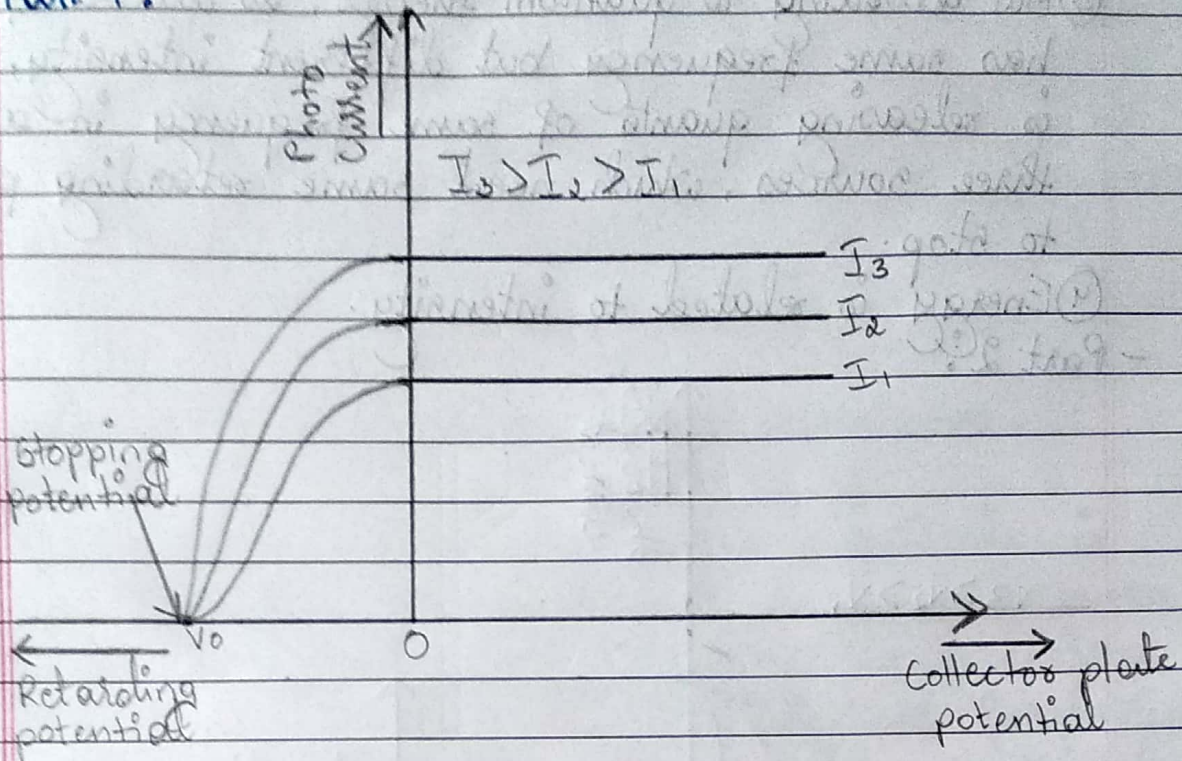
Variation of photoelectric current with intensity of light.



- ① Intensity of light - Power
- ② Frequency of light - $\nu = \frac{c}{\lambda}$ colour.

Experiment arrangement for study of photo-electric effect

- Part 1:

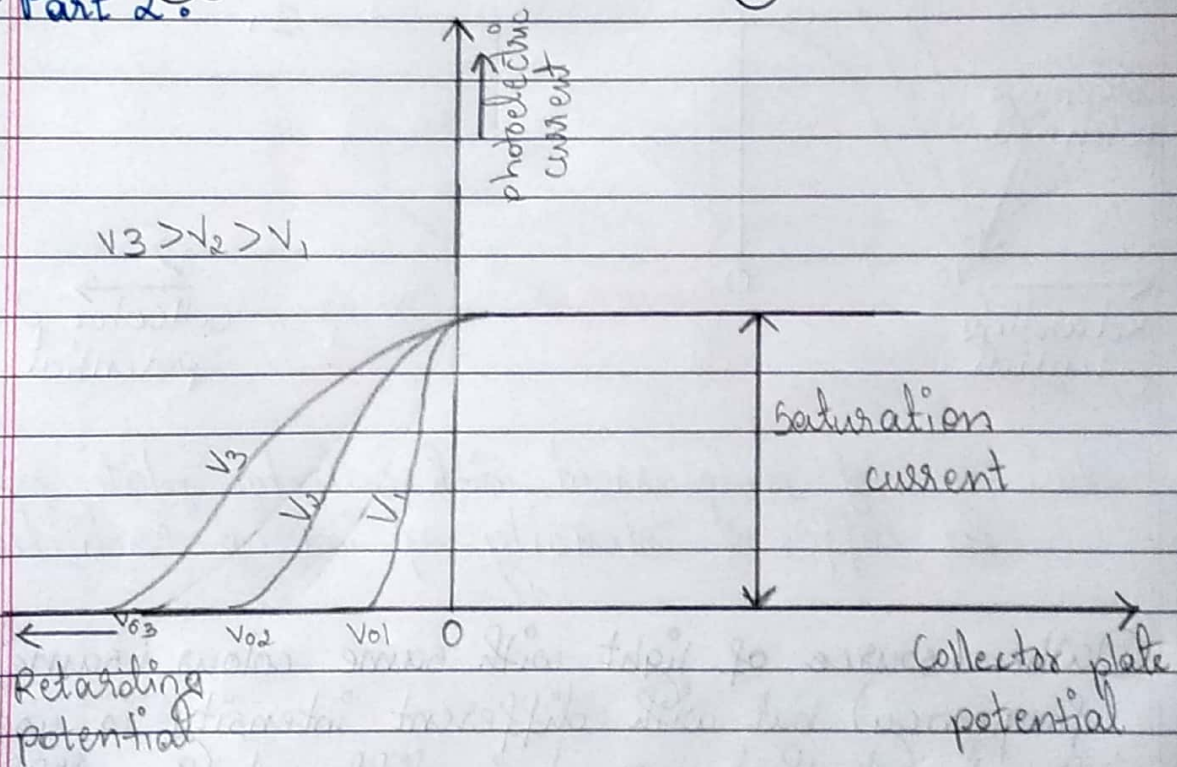


Variation of photocurrent with collector plate potential for different intensity of incident radiation.

- ① When source of light with same colour (same frequency) but with different intensity is used, it's found out that current is different for different intensity of bulb and it increases with increase in its power, but whereas voltage is being retarding all the source is to be found out show 0 current at particular voltage known as stopping voltage.
- ② According to wave theory, we need to have higher value of retarding potential for different intensity of bulb but we find, it all has same and it's not dependent upon intensity and it fails wave theory.

③ But according to quantum theory, as source of light has same frequency but different intensity, source is releasing quanta of same frequency in all the three sources, which need same retarding potential to stop.

④ Energy is related to intensity.
- Part 2.0



Variation of photoelectric current with collector plate potential for different frequencies of incident radiation.

- ① When source has different frequency but with same intensity a different retarding potential is found respectively and same saturation current is found.
- ② Energy of electrons \propto frequency and not intensity.

* Threshold frequency:

- Threshold frequency is that minimum value of frequency that supply sufficient energy to remove electrons from the surface.

$$h\nu_0 = \phi_0$$

* Failure of wave theory in P.E experiment:

- According to wave theory higher amplitude is higher energy but experiment shows that even larger amplitude could not give higher energy.
- The same intensity but ~~for~~ different frequency (colour) by different energy could not be explained. This concept of threshold frequency could not be explained.
- Concept of wavefront, (i) took time to give energy simultaneously to many electrons and (ii) many electrons be ejected together but experiment shows that ejection is instantaneous and not for a long time or large quantity which is contrary of wave theory.