Modern Physics

→ 1901 - Quantum Theory of Light
Special theory of Rela
Schrödinger, de-Brogl
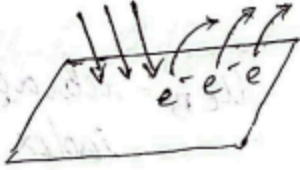Heisenberg's uncertain
principle.

Photoelectric Effect :-

Light

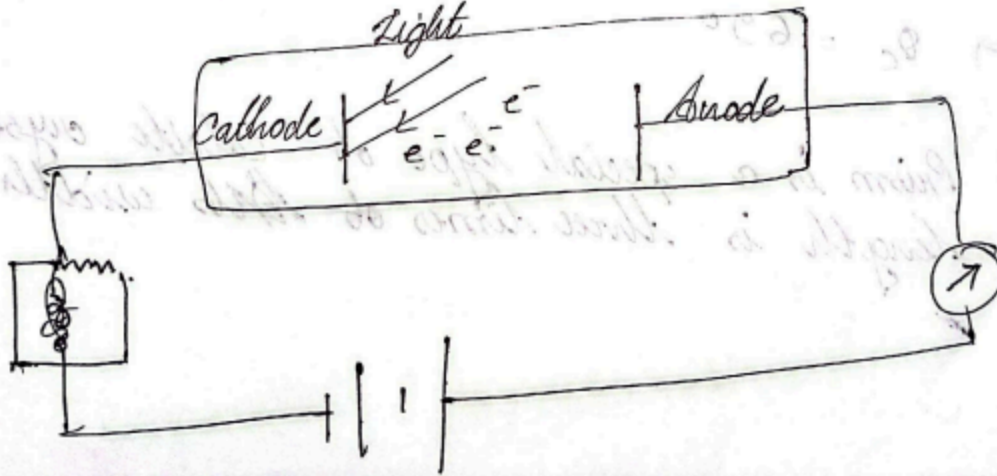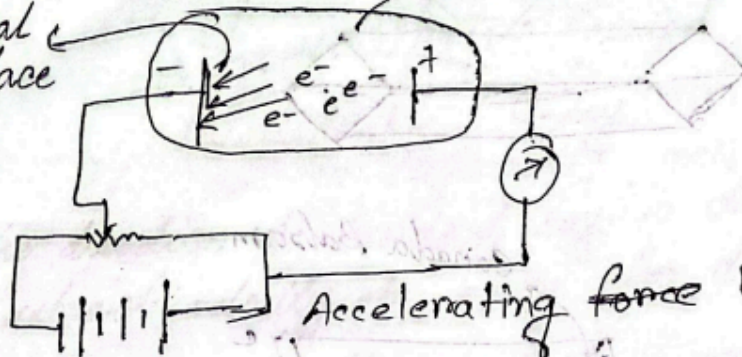Ejection of electrons from metalic surface while illuminated by light or any other radiation of suitable wavelength.

Metal surface

Light

Cathode   e⁻ e⁻   Anode

Photoelectric Effect

→ Vacuum Quartz tube.

Metal surface

circuit diagram.

~~circuit diagram.~~ electric

Accelerating ~~force~~ Potential

Experimental facts (laws) / - Laws of photo electric effect:

যে মুহূর্তে আলী
ধাতুর উপর পরে
মুহূর্তেই e^- নিঃসৃত
হয়।

$t \, (sec)$

$10^{-9} \, sec$
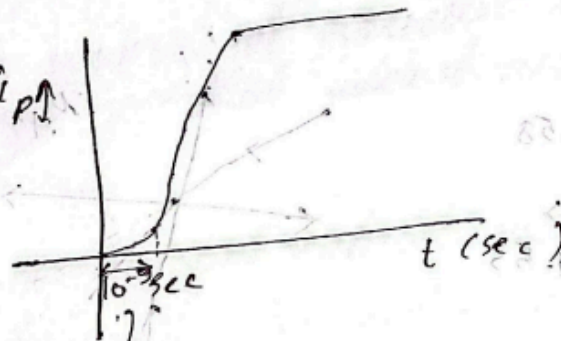
with in the limit of experimental accuracy.
There is no lack

Laws of photoelectric effect

1st law: Electron will be emitted as soon as light rays falls upon the surface

(iii)

যতবেশী. intensity তত বেশী কারেন্
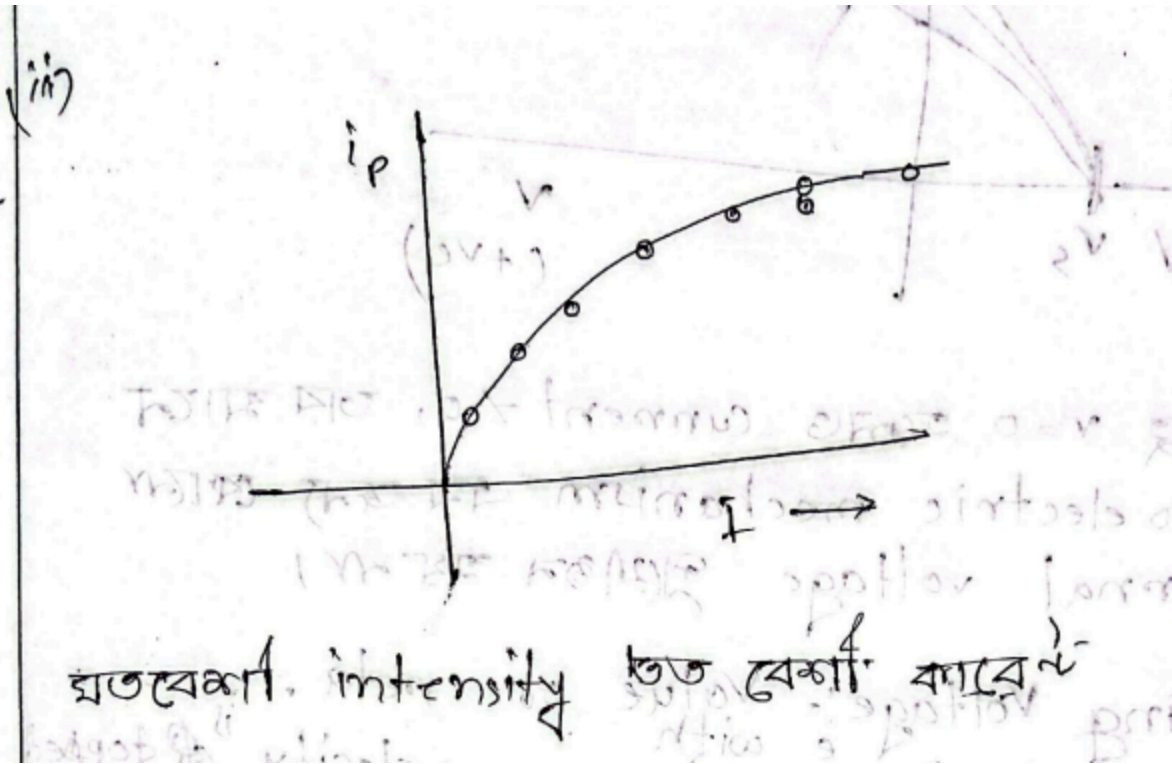
v_o is also called the threshold frequency

(iv)

$\frac{1}{2}mv^2$

Below the threshold frequency, $E_k = 0$, It is directly proportional to frequency.

After reversing the voltage,

Retarding Potential
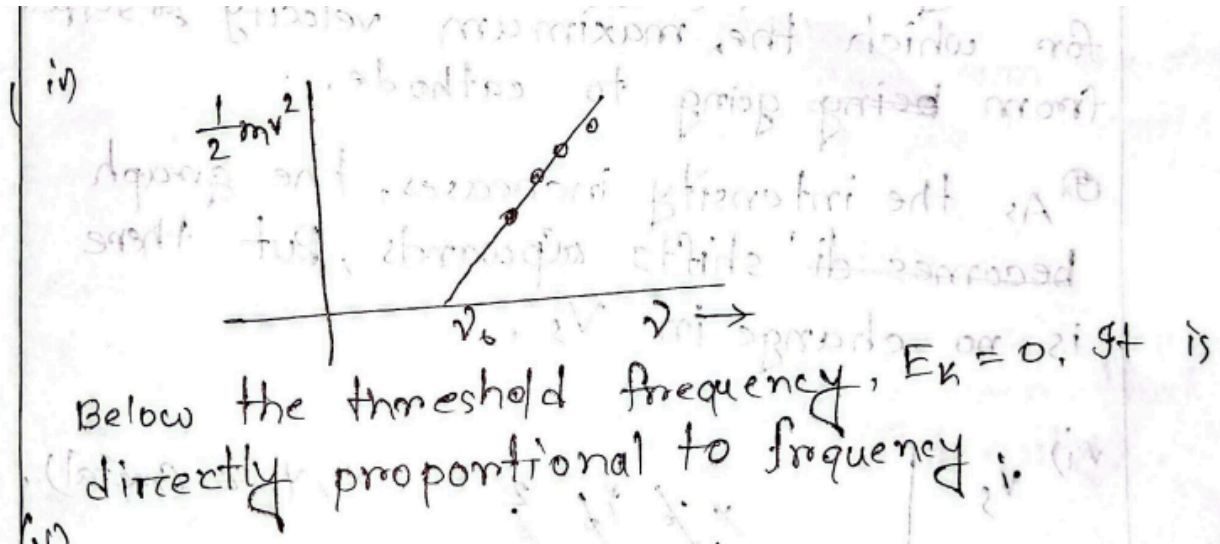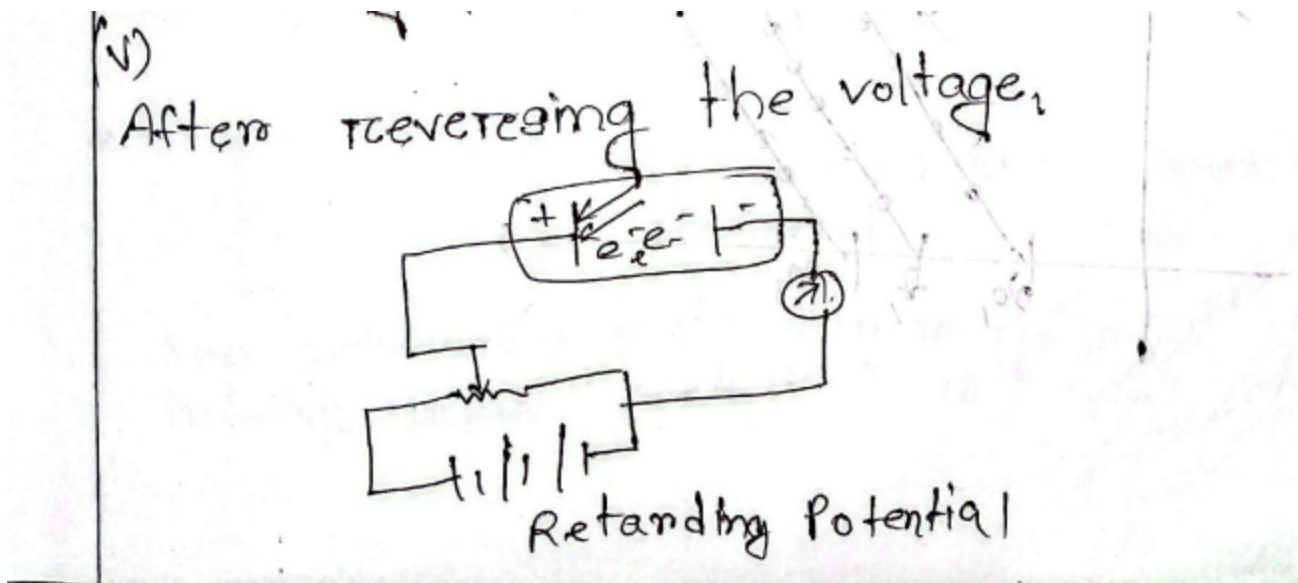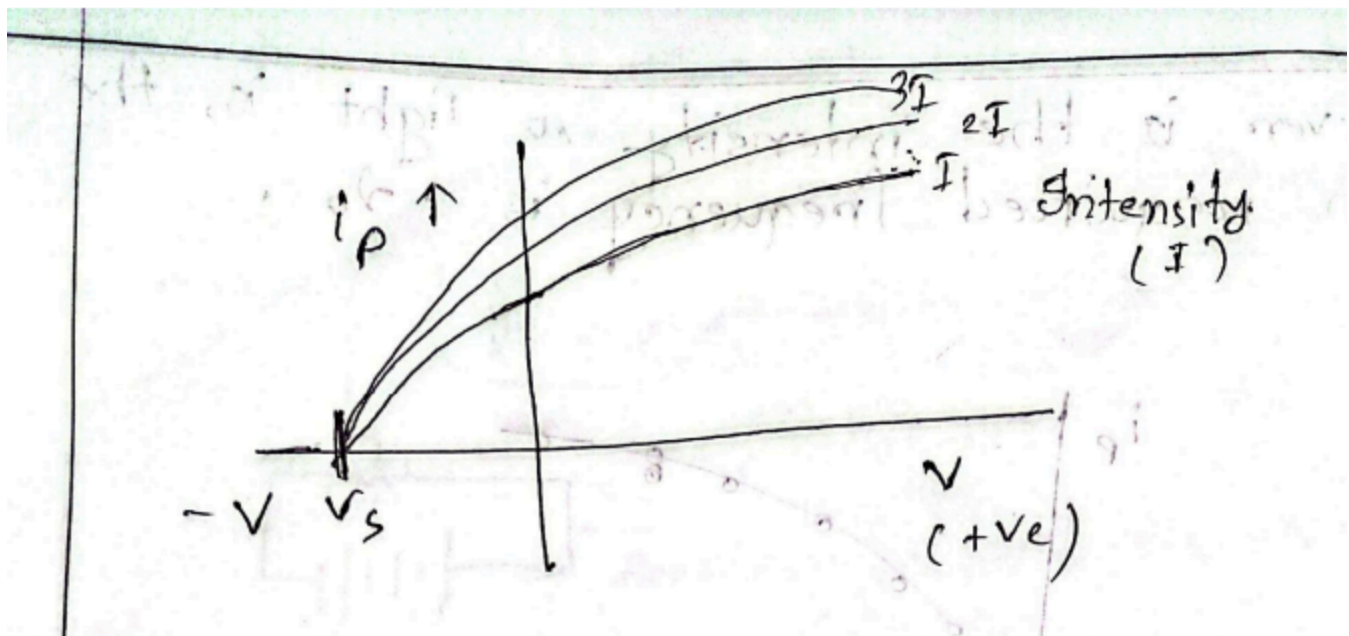
The voltage used to apply voltage in reverse is called the retarding potential

As $v = 0$ but $current \neq 0$ indicating photo electric mechanism does not need external voltage applied.

Stopping voltage(v_s): Minimum value of retarding voltage for which the electron with maximum velocity is stopped from going to cathode

As the intensity increase, the graph shifts upwards, but there is no change in v_s
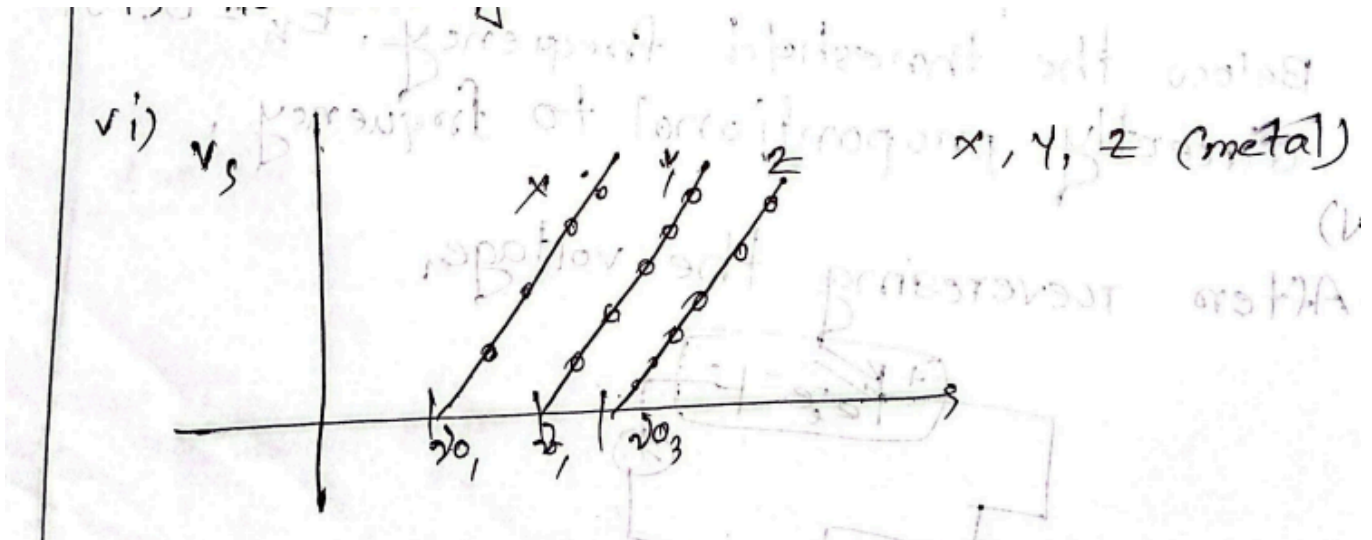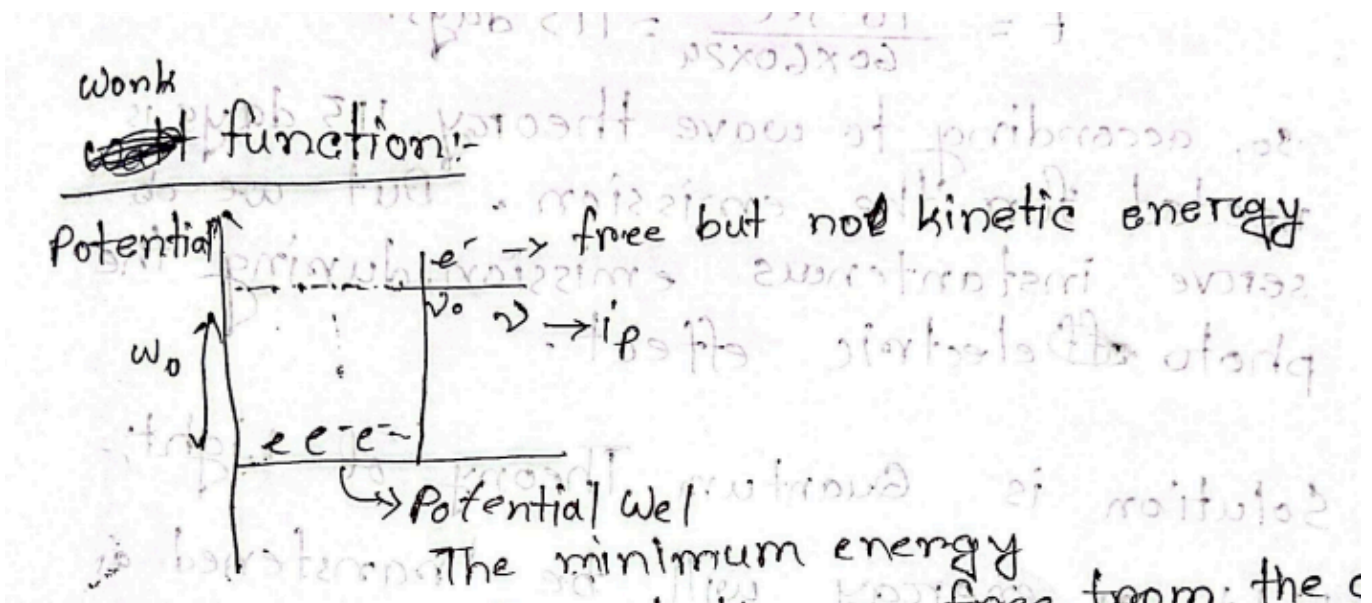

Kinetic energy will very from 0 to max
and,

$$KE_{max} = eV_s$$

$$KE_{min} = 0$$

Work Function:

To get the electron free from and atom and away from the surface is called work function

According to wave theory of light

$$E \propto I \propto A^2$$

But in photoelectric effect is is seen that energy is independent of I(intensity)
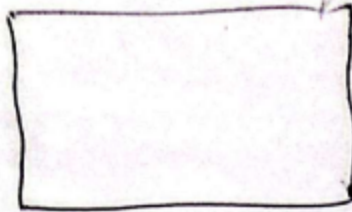
1 m^2 area x 1 Atomic layer thickness of Na metal, 10^9 attoms exists.

For detectable photo current to get, the minimum intensity should heeds is $I = 10^{-6}$ w/m^2

Einstein propose and explanation of photo-electric effect on the basis of Quantum theory of light

Explanation of Einstein.

$\mathcal{E} \begin{cases} \rightarrow h\nu \\ \rightarrow h\nu \end{cases}$
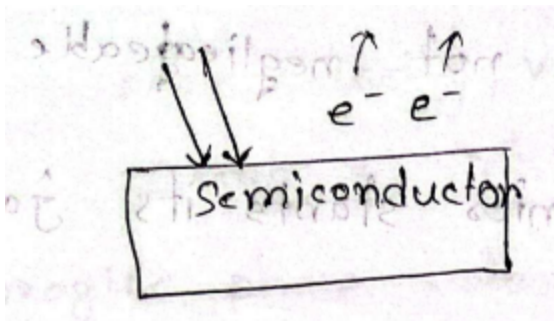
When a single photo falls on the surface, it will get completely absorbed be e^-, it is used for two purpose

Photon energy

$$hf = w_o + \frac{1}{2}mv^2$$

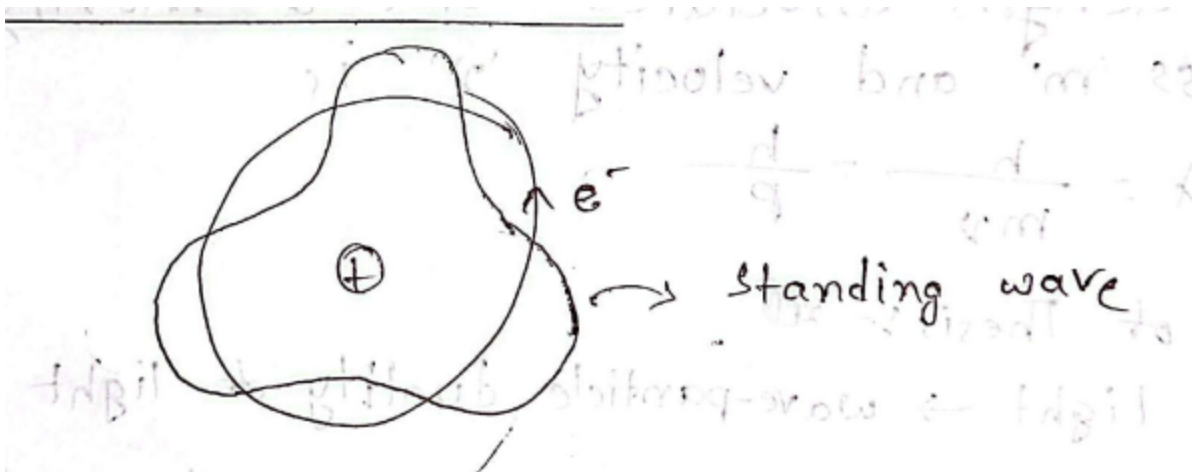where, w_o = work function

Photovoltaic Effect

The wavelength associated with a moving object of mass m and velocity v is

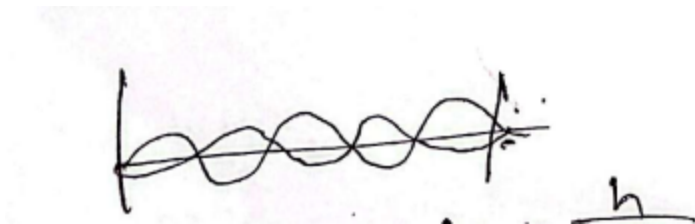$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

For this reason the particles with atomic sizes' wave behaviour is not negligible

So, the wave-mechanics stars its journey from here

Wave Mechanics

Geometrical constraint:

Bohr's Quantization of atomic orbitals

$$mvr = \frac{nh}{2\pi}$$

Matter wave $\rightarrow$ validate Bohr's postulate

For normal wave,

$$y = a\cos(\omega t - kx)$$

Phase velocity,

$$V_p = \frac{\omega}{k} = n\lambda$$

Group velocity,

$$v_g = \frac{d\omega}{dk}$$

De Broglie's phase velocity:
Using usual notion of wave motion

$$V_p = n\lambda = \frac{E}{p} = \frac{mc^2}{mv} = \frac{c^2}{v}$$

Now, $v_p > c$, it violates the special theory of relativity as it is greater than light velocity

For sound velocity, phase velocity is same as wave velocity. So, we can't consider phase velocity here as it is greater than c

Group velocity is the velocity at which the overall shape of wave amplitude known as modulation or envelop propagate through space
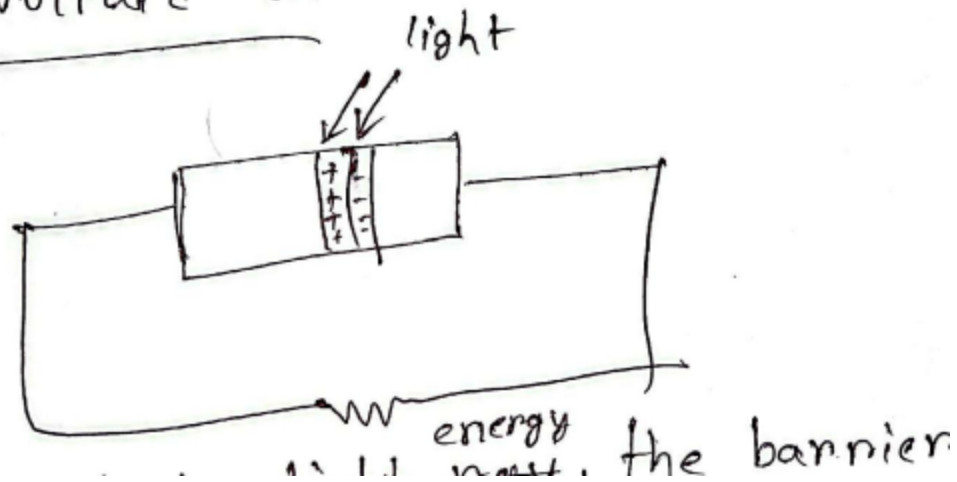
Semiconductor
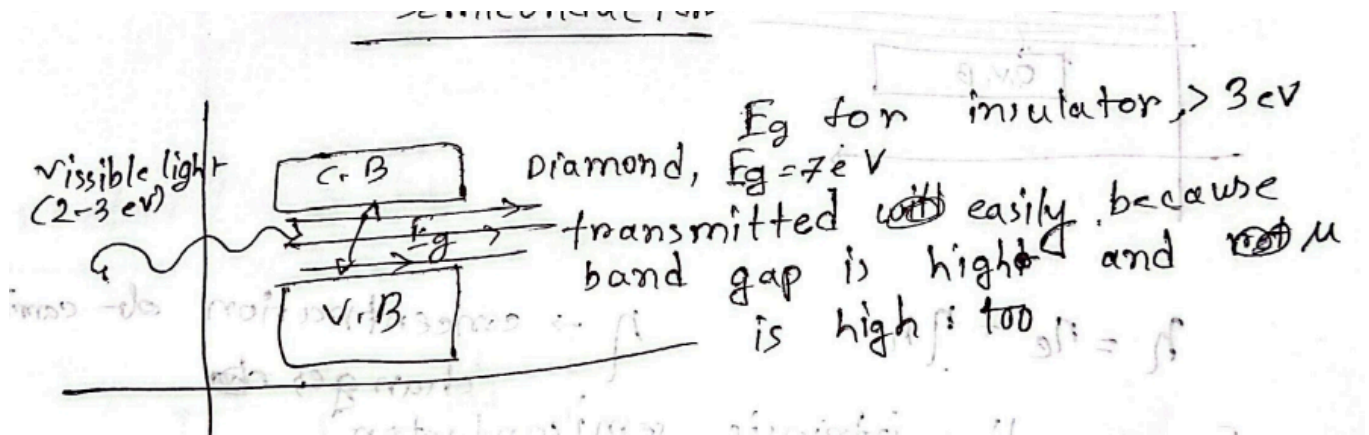
For silicon, band gap is low. As a result, visible light is absorbed. Electron from valence band conducts toward the conduction band

Photovoltaic Cell

1

Photovoltaic Cell :-

light

energy

the barrier

Because of the light energy, the barrier potential decreases and the electron can freely moves from n-type to p-type