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Where Minds Pollinate

Class 12

Physics

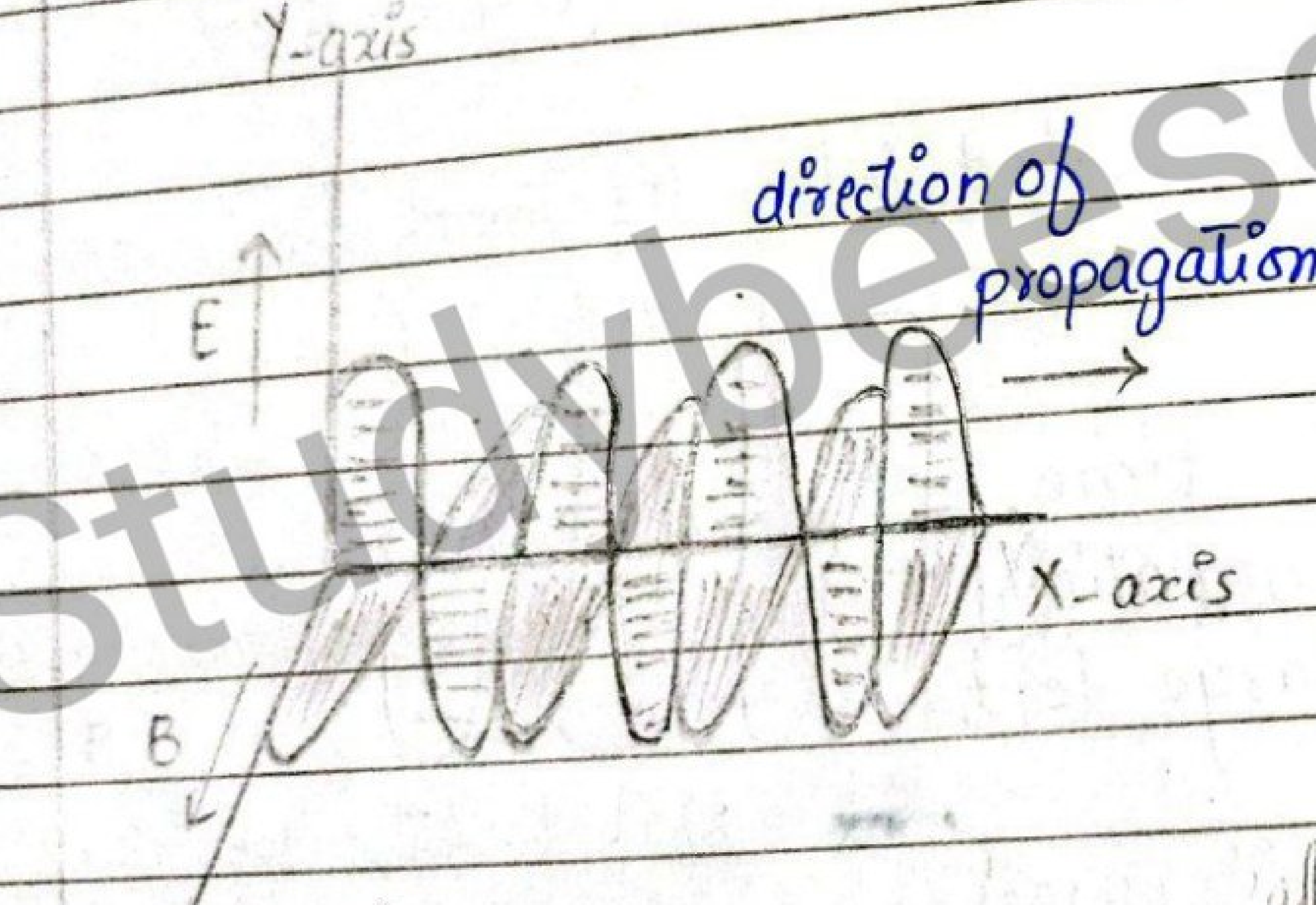
Chapter 21

Handwritten Notes

Chapter 21: (This chapter is related with the particle nature of light).

Quantum Phy:

• Maxwell EM Theory:



According to this theory, light is actually electromagnetic wave which is formed by oscillation of electric and magnetic field that is if electric field is

• Newton (1680's):- air mein light ki speed km holi hai. and light is made up of small particles.

• Huygen (1680's):-

light is wave.
light is longi-tudnal wave.
Light can do interference

• Maxwell (1980's)
• gives Electromagnetic Theo (disturbane)
• light is transverse wave.
• it is confirmed by polarization

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changing along X-axis, it results in the formation of changing magnetic field along Z-axis and the whole package propel (آگے بڑھانا) itself along X-axis.

- Plank's Quantum T:
- Quanta: small packets in form of energy. (Light travel).

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Plank's Quantum Theory:

Light confirmed as:
1) Wave
2) Particle
But it depends on situation.

According to this theory, radiation travels in the form of discrete (الگ) packets of energy called quanta. The energy of these quanta depends upon frequency.

- We will study particle nature of light in this chapter.

$E \propto f$

$E = hf \rightarrow (1)$ h = Plank's constant

$h = 6.63 \times 10^{-34}\ Js$

Quanta: خاص value.

quanta is indivisible.

$$E = \frac{hc}{\lambda} \rightarrow (2)$$

$v = f\lambda$
$c = f\lambda$
$f = c/\lambda$

as $E = mc^2 \longrightarrow (3)$

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(Imp for MCQ's) **Dual Nature of Light :-**

Equalizing eq (2) and (3)

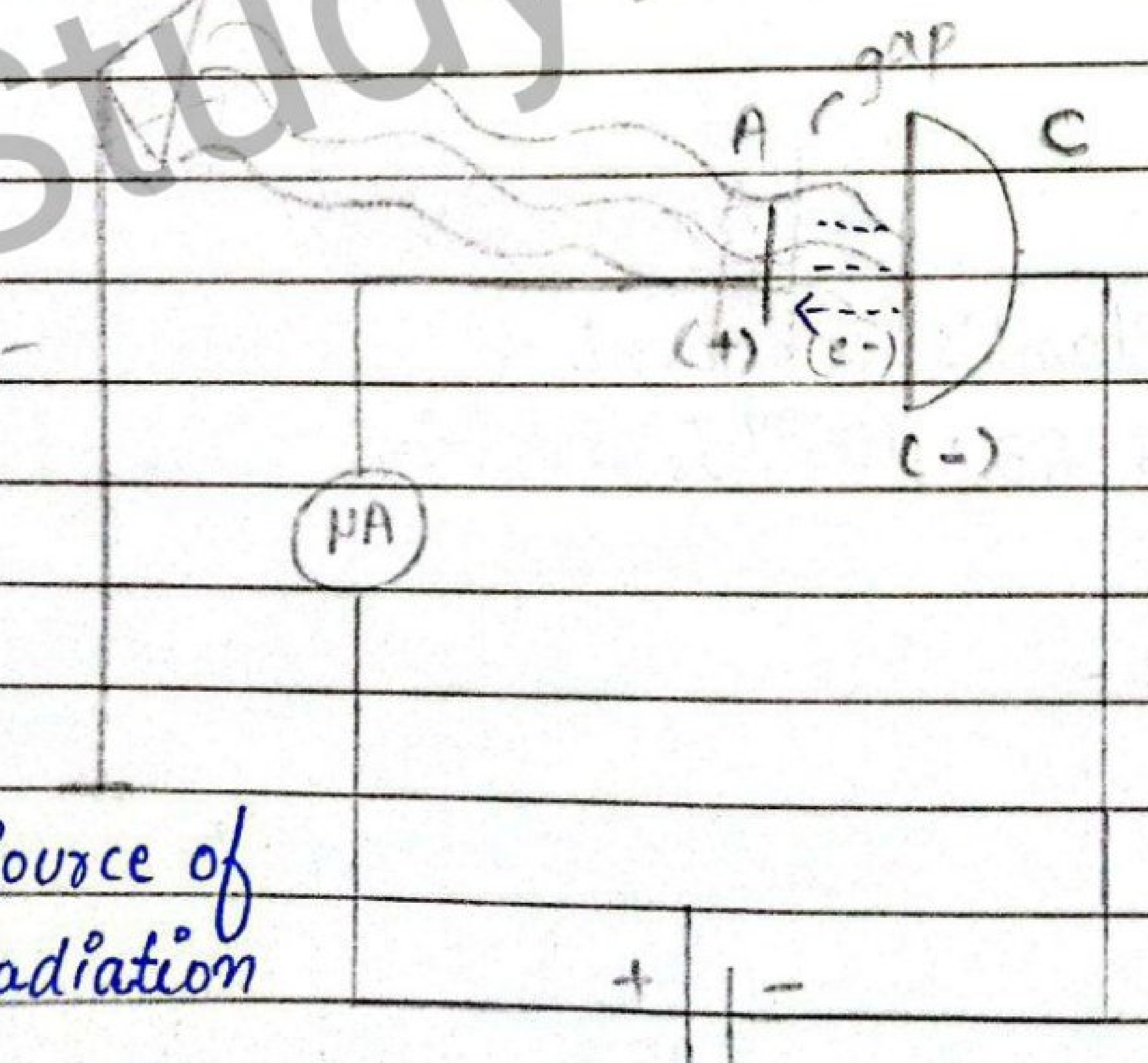
$$mc^2 = \frac{hc}{\lambda}$$

$$\boxed{P = \frac{h}{\lambda}} \rightarrow (4)$$

$$\boxed{E \propto f \propto \frac{1}{\lambda} \propto P}$$

c = constant = 3×10^8 m/s.

• Photo Electric Effect :



Source of Radiation

(Vibgyor :)
- γ-rays
- X-rays
- UV
- Violet
- indigo
- blue
- green
- yellow
- orange
- red
- IR
- microwave
- Radiowave

from :
X-rays → radiowave

F↓ , E↑
P↓ , λ↑ (downward)
- Wave nature ↑
- Particle nature ↓

↳ (Top to bottom)
→ c = constant

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The emission of electron from metallic surface when light of particular frequency is incident is called photoelectric effect. The emitted electrons are called photoelectrons and their emission is called photo emission.

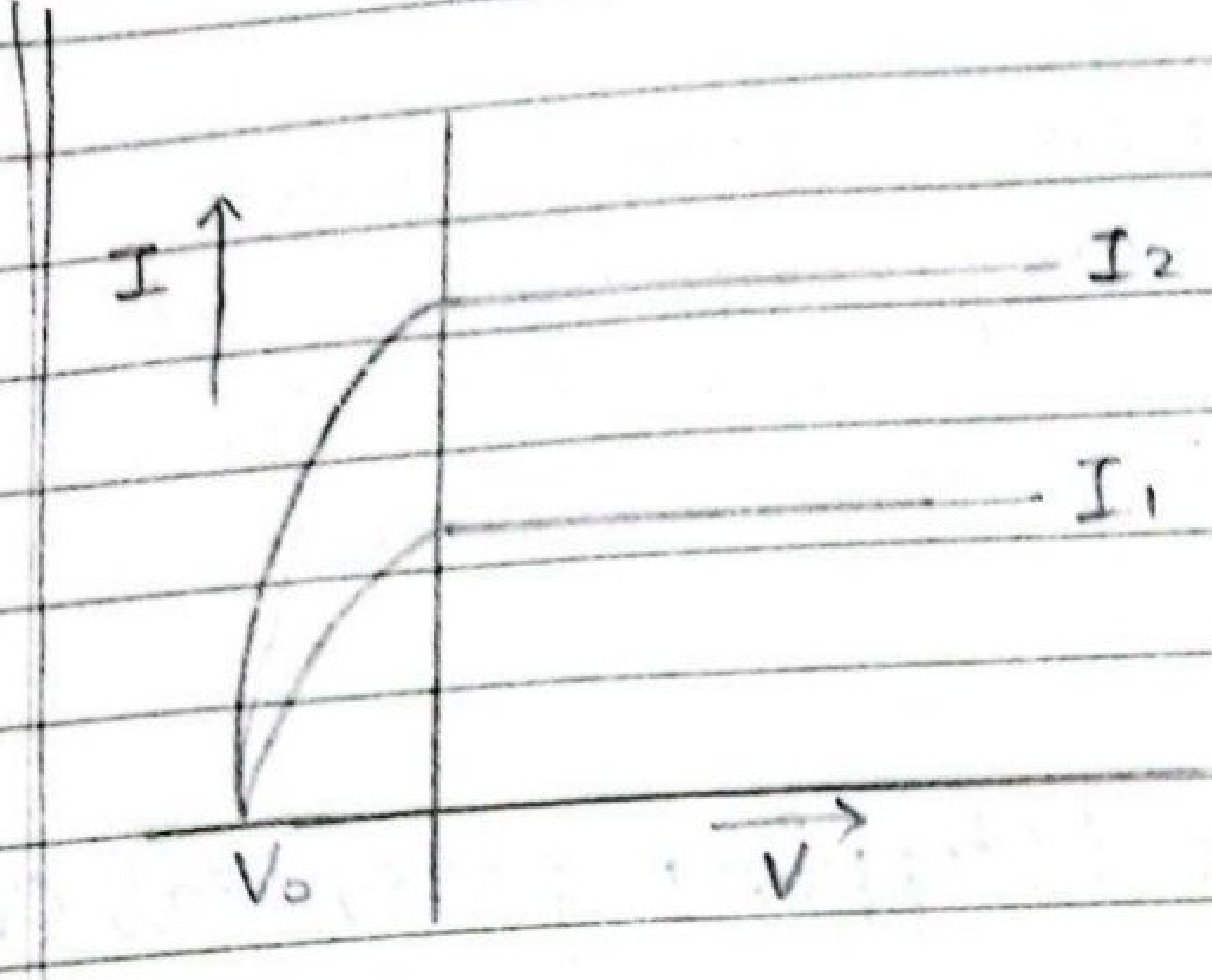
1 Energy of Emitted electrons (Stopping potential (V_0))

To find out the energy of emitted electrons, we apply reverse potential that is connecting plate C with (+) terminal and ptermin A with negative (–) terminal making A more and more (–) would decrease number of electrons until no electron would able to reach end A, such potential is called stopping potential, it tells us maximum energy of electrons.

$$W = \underset{\text{charge}}{Q}\,\underset{\text{p.d}}{V}$$

$$K \cdot E_{max} = eV_0.$$

2 By increasing intensity:



It has been observed that if frequency is kept constant and intensity is increased, then the number of emitted electrons increases. But their energy remains same.

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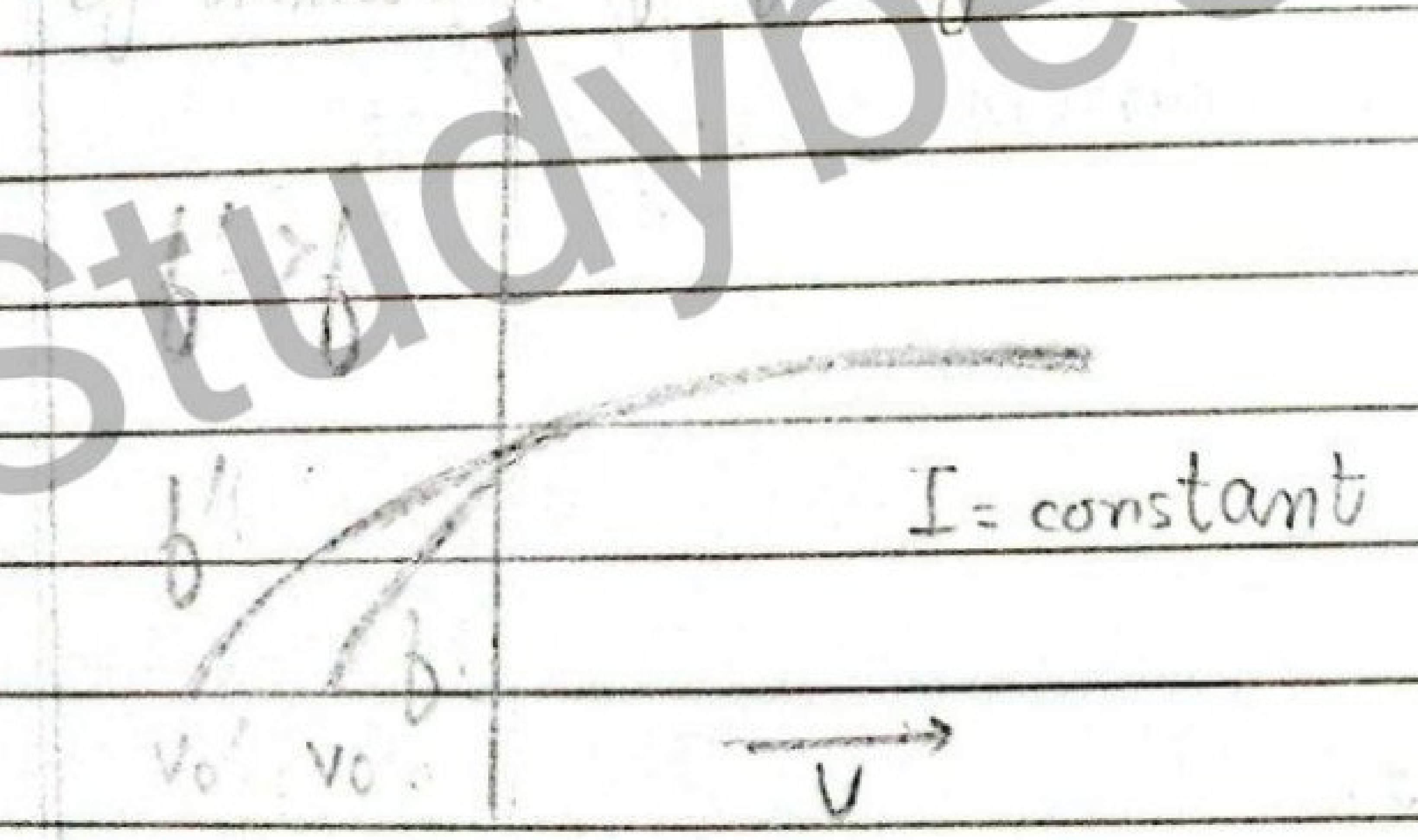
by increasing frequency:

- frequency / Qualit changes energ
- Quantity doesn affect energy



If intensity is kept constant and frequency is increased then, although the number of emitted electrons remains same but their energy increases.

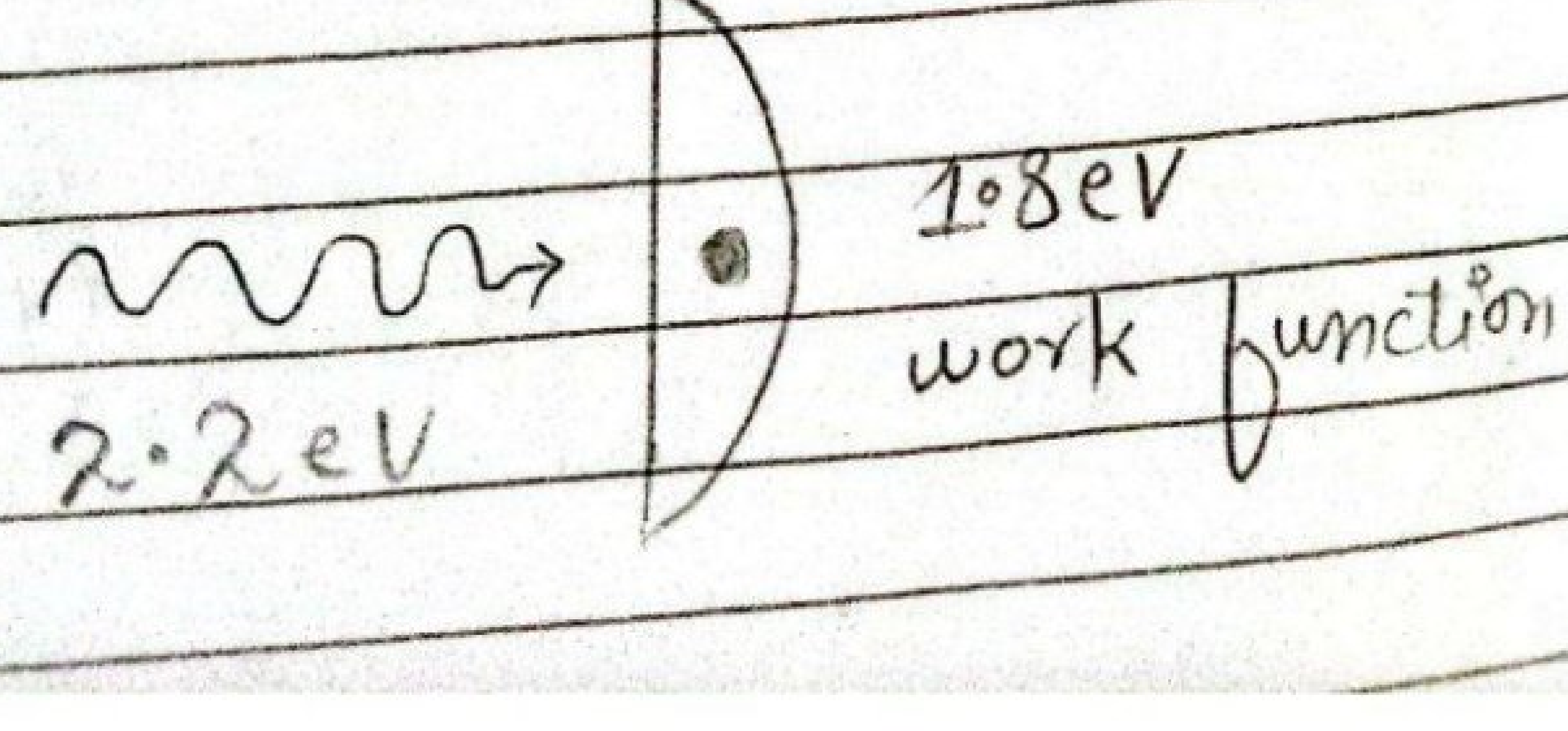
3 Failture of Classical Physics:

According to classical Physics, radiation has wave nature. And if it is true then by increasing intensity, energy of emitted electrons should increase which is not happened.

5 Experimental Results:

- Electrons can only be emitted if light of at least frequency called "Threshold frequency" in incident (f_0).
- The value of threshold frequency depends upon metal surface.
- By increasing intensity, number of emitted electrons increases.
- By increasing frequency, energy of emitted electrons increases.

6 Quantum Explanation:



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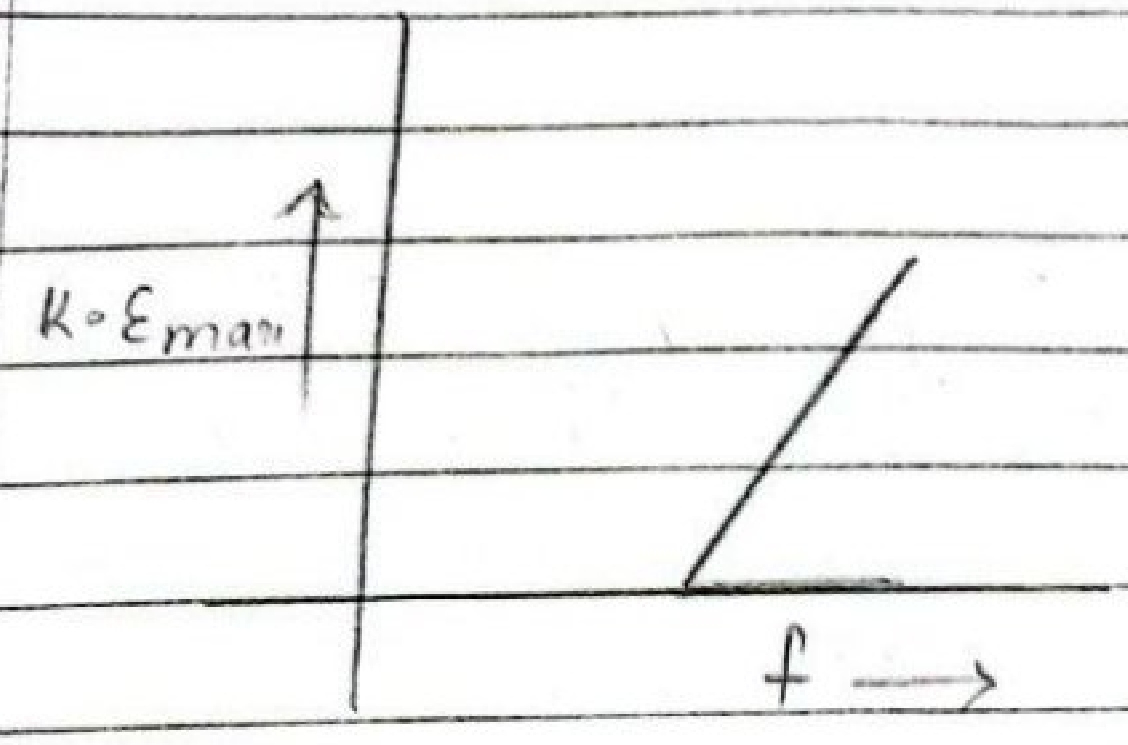


$hf - \underbrace{\Phi}_{\text{(work func)}} = K \cdot E_{max}$

Einstein explained Photo Electric Effect on the basis of Plank's Quantum theory. According to him, electrons consume some amount of energy to leave metal surface called "Work Function" and rest of energy is in the form of kinetic energy maximum ($K \cdot E_{max}$).

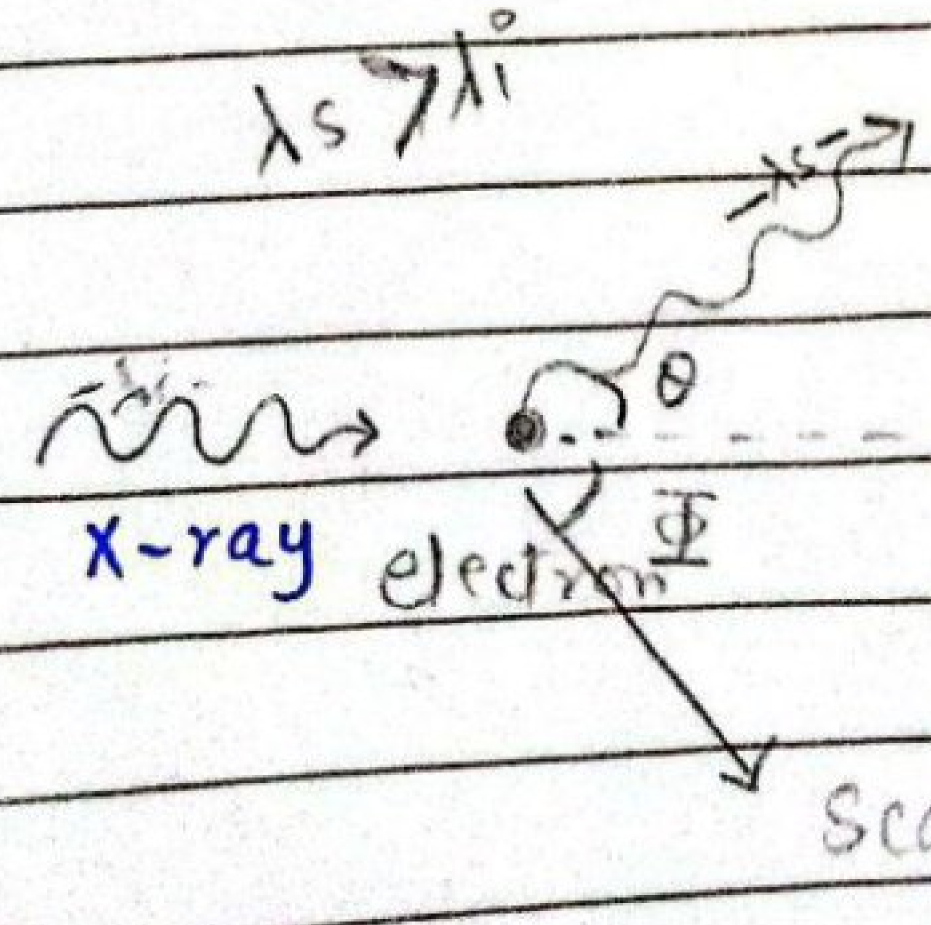
$$hf - \Phi = K \cdot E_{max}$$

$\therefore$ hf = incident photon

$\therefore$ Φ = work function = hf_0

Compton Effect :- (X-rays)

- Best to explain particle nature of light.



quanta (photon).

The increase /shift in wavelenght of X-ray photon on impact with stationary electron is called Compton Effect.

1 Failture of Classical Physics:

According to classical EM theory physics radiation has wave nature. And if it is true then there should be no change in wavelenght.

2 Quantum Explanation:

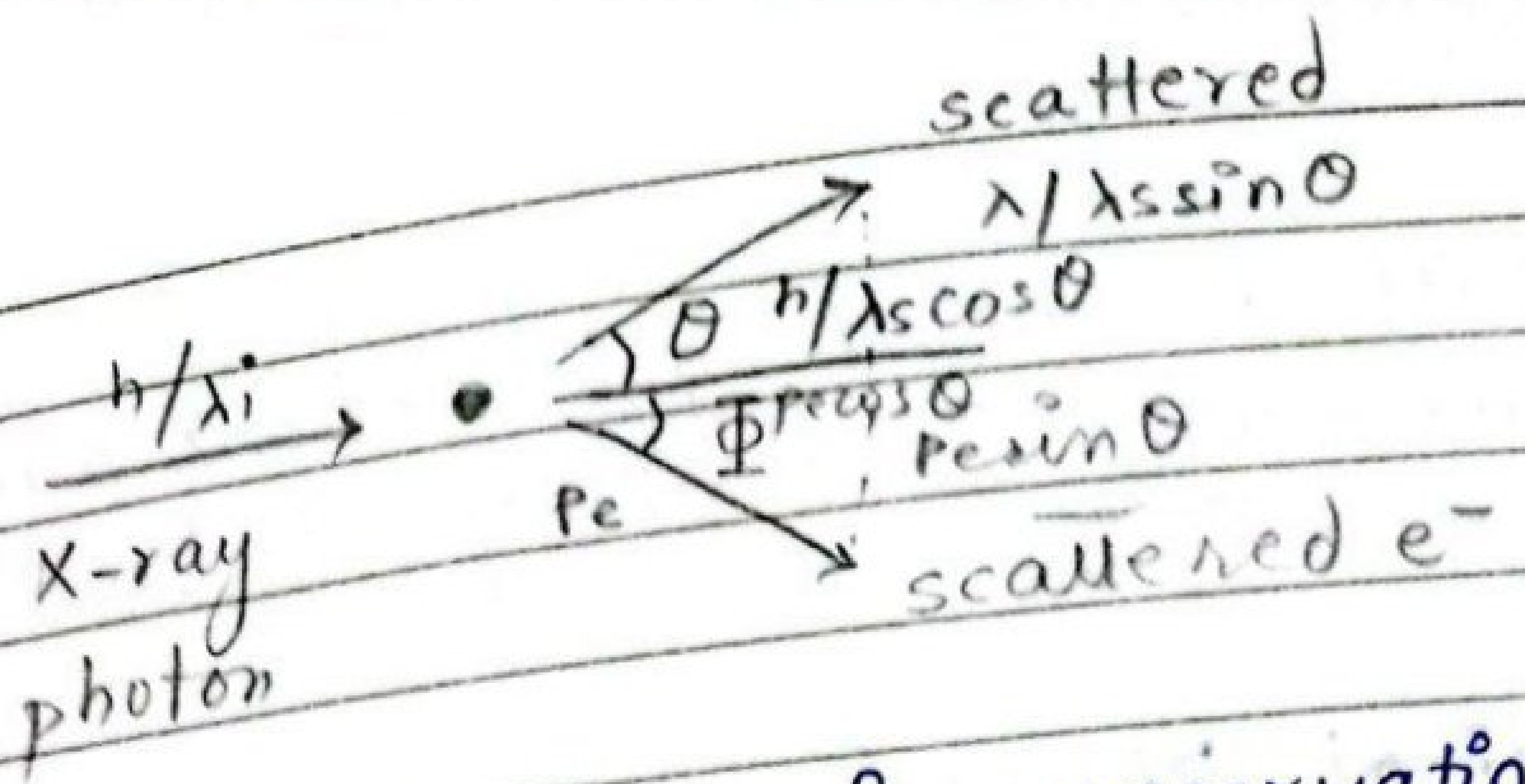
According to Plank's Quantum theory, radiation is in the form of "Quanta" having energy.

$$E = hf$$

$$\downarrow E = \frac{hc}{\lambda \uparrow}$$

On impact with electron, X-ray photon loses its energy and momentum. As a result, wavelength increases.

Compton Effect: "$\Delta\lambda$"



According to law of conservation of energy :

$$hf_i = hf_s + K.E$$

$$\frac{hc}{\lambda_i} = \frac{hc}{\lambda_s} + K.E \longrightarrow (1)$$

According to law of conservation of momentum

- along x-axis :

$$\frac{h}{\lambda_i} = \frac{h\cos\theta}{\lambda_s} + P_e\cos\Phi \longrightarrow (2)$$

- along y-axis :

$$0 = \frac{h}{\lambda_s}\sin\theta - P_e\sin\Phi \longrightarrow (3)$$

By solving eq (1), (2) and (3),

$$\lambda_s - \lambda_i = \frac{h}{m_0 c}(1-\cos\theta)$$

h = Plank's constant

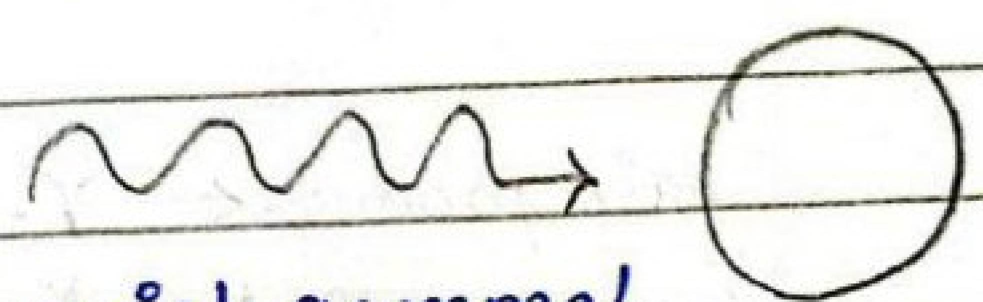
$c = 3 \times 10^8\ ms^{-1}$

Maximum shift is at angle of 180°.

• Pair - Production:

Conversion of energy into mass.

$E_0 = 0.51 MeV$



Electron

$m_0 = 9.1 \times 10^{-31}$ kg

charge = $e^- = -1.6 \times 10^{-19}$ C

Special gamma/ γ-photon

Heavy nucleus

Positron

$m_0 = 9.1 \times 10^{-31}$ kg

$e^- = 1.6 \times 10^{-19}$ C

$E_0 = 0.51 MeV$

$E = 0.51 + 0.51$

$E = 1.02 MeV$

• Law of conservation of charge:

- Production always occurs in pair.
- Impossible to create only electron.

Emission mein eik chez phly sy mojood hoti hai aur phir release/emit hoti hai aur production mein is ka opposite hota hai, koi chez bnti hai.

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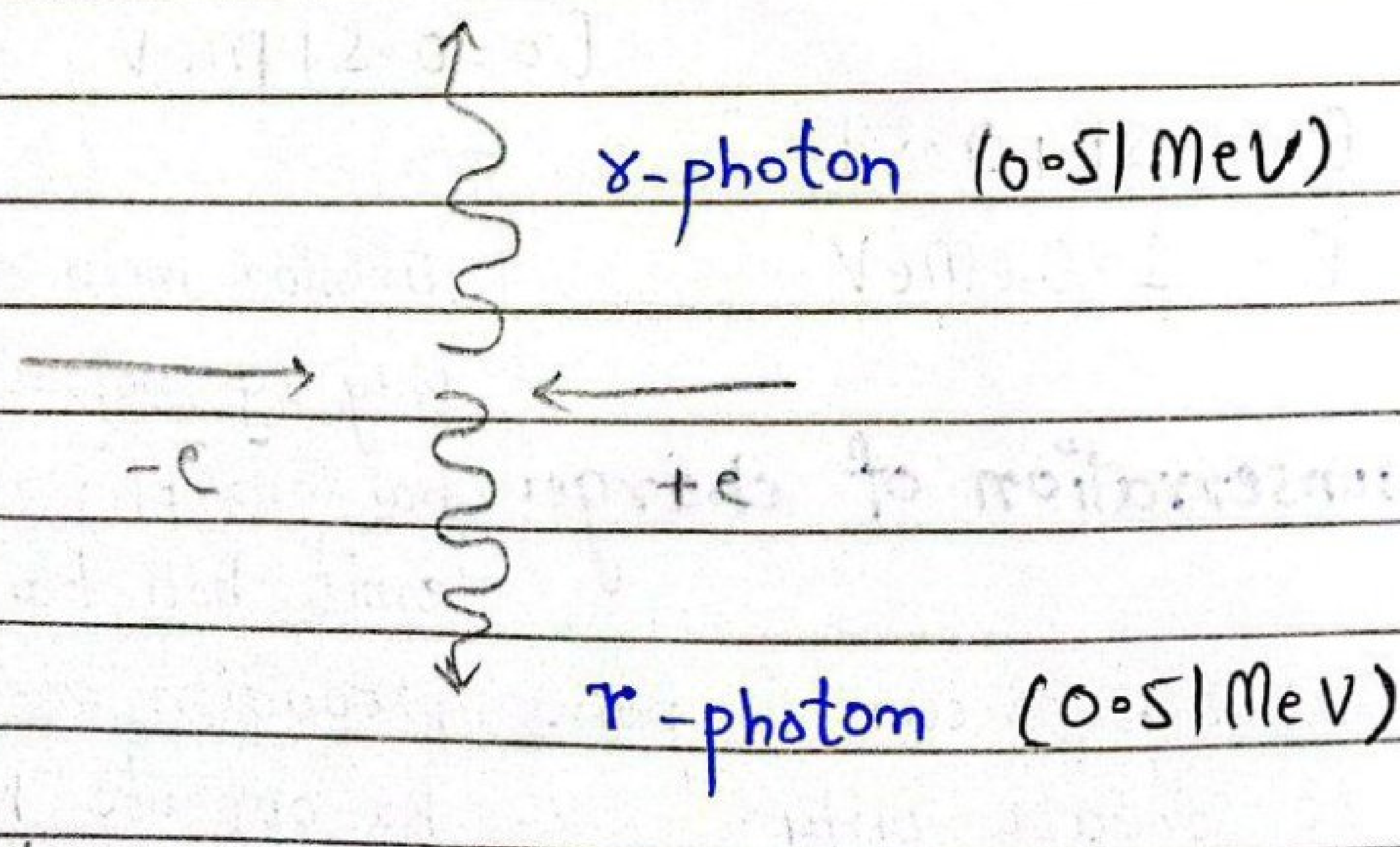
- production always occurs in positive (+) and negative equal charges.
- **Law of conservation of energy:**
- For pair production, we should have atleast 1.02 MeV which is possessed by γ-photon. (special gamma).
- **Law of conservation of momentum:**
- (on book)

(Pg 131)

pair-produc- ← γ-ray
Compton effect ← X-ray
Photoelectric – { UV, Infrared, visible clrs }
donot do anything – { IR, Micro, Radio }

- # Pair Annihilation:

Conversion of mass into energy.



(on book)

• Wave-Particle Duality:

Scientist : De-Borglie

If radiations which are actually wave can behave like particle then particles can also behave like wave. Particles having very small mass but are travelling at very high speed can behave like wave.

If,

m = mass of particle
v = velocity of particle

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

→ if we know momentum of particle, we can find out its wavelength.

• **Ball:**

$m = 100g = 0.1kg$
$v = 10 \ m/s$
$h = 6.63 \times 10^{-3} \ Js$

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

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$$\lambda = \frac{6.63 \times 10^{-34}\ m}{0.2 \times 10}$$

$$\lambda = 6.63 \times 10^{-34}\ m$$

- Electron:

$m = 9.11 \times 10^{-31}\ kg$
$v = 10^6\ m/s$
$h = 6.63 \times 10^{-34}\ Js$

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

$$\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 10^6\ m/s}$$

$$\lambda = 7.27 \times 10^{-10}$$

Q- Is the wavelength can associate with anything?
Ans. No, we can't associate wavenature of ball but we can associate wavenature of electron bcz of relativity small mass.

The wavelength of electron is comparable with x-rays. So, we can say that we can associate wave nature of electrons which is confirmed by diffraction of electrons.

- **Electron Microscope:**

- optical microscope uses light.
- The things we can't observed from normal microscope. for them, we use electron microscope to see.

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· In e⁻ microscope, lens are not used.
· However, electric and magnetic field is used which are also called magnetic and electric lens.

- it is a device that is based upon wave nature of electron. In such device, we use accelerated electrons to observe object in detail upto nano scale. We use high potential sources to excite electrons.

1 **Electron gun:**
It consist of a tungsten which can emit electrons on heating and high potential difference upto 10,000 KV is used to accelerate electrons.

2 **Magnetic coil:**
Magnetic coil is used to focus electron on target.

3 **Advantages:**

It is basically particle use and demonstration of wave nature of electron which is 1000 times shorter than visible light. We can say that visible light of wave-length upto 7000 A° (7000×10^{-10} m) whereas the at potential difference 10,000 KV electron can achieve upto wavelength 0.12 A°. (Angston). ($P.d \propto \frac{1}{\lambda}$)

· wavelenght can vary by varring potential difference.

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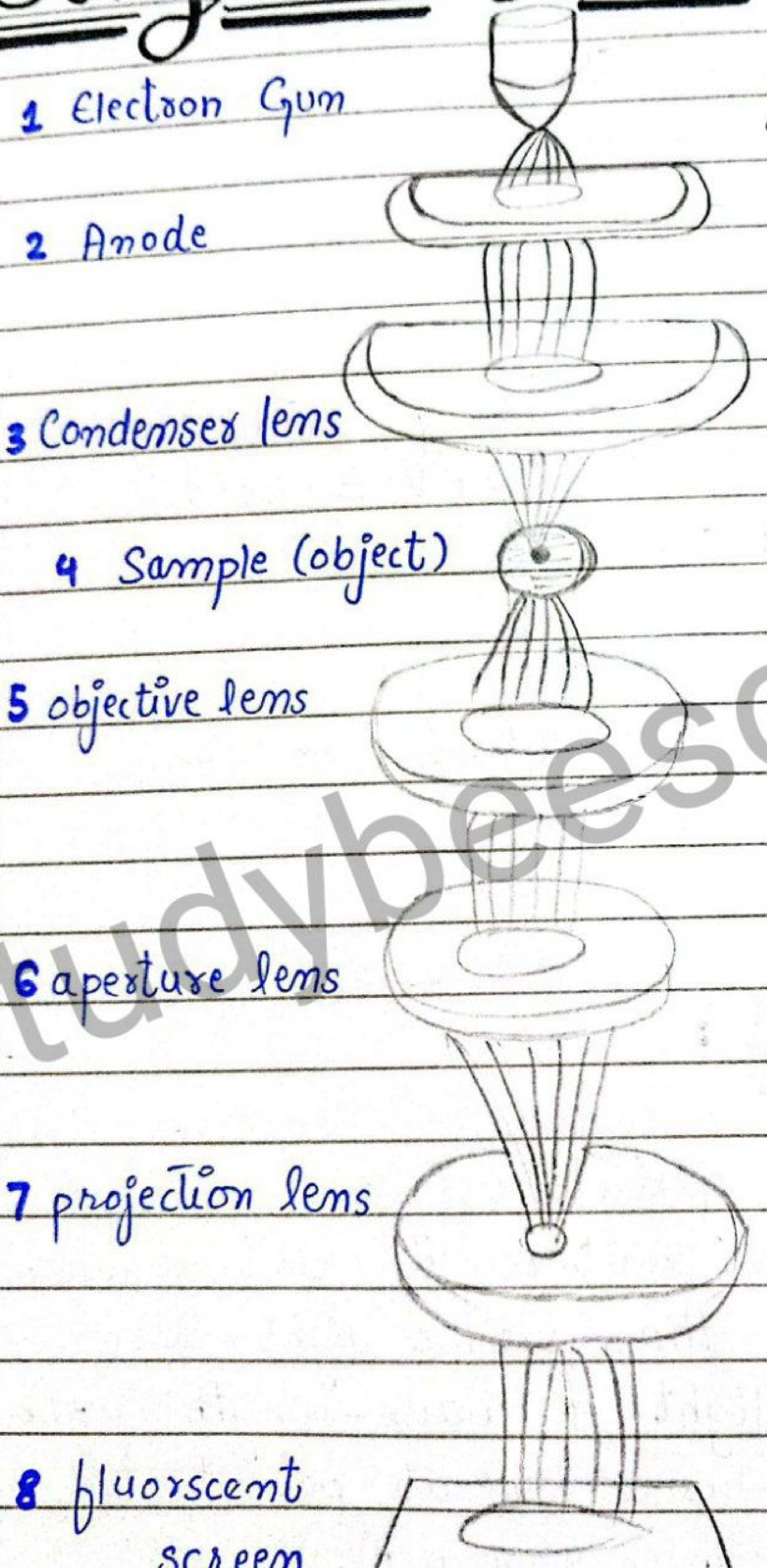
Ray Diagram:



Components:

1 Electron gun
2 Condenser lens
3 Sample stage
4 Objective lens
5 Project lens
6 Screen

Hiesenberg Uncertainity Principle :-

According to this principle, it is impossible to measure position and momentum simultaneously with extreme precision.
i.e: if momentum is measured with extreme precision, there is uncertainity in position Normally, it is happened in case of smaller particles.

Δx = Uncertainity in position

$$\Delta x \approx \lambda \longrightarrow (1)$$

(Shorter the wavelength, less will be uncertainity in position).

P = actual momentum of electron

$$p' \approx P + \frac{h}{\lambda}$$

$$p' - P \approx \frac{h}{\lambda}$$ (momentum when x-rays are used).

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$$\Delta P \approx \frac{h}{\lambda} \longrightarrow (2)$$

Multiplying eq (1) by eq (2)

$$\Delta x \Delta P \approx \cancel{\lambda} \times \frac{h}{\cancel{\lambda}}$$

$$\Delta x \Delta P \approx h$$

$$\boxed{\Delta x \Delta P \geq \frac{h}{4\pi}}$$

$\hbar = \frac{h}{4\pi}$ (Heat)

$E_2 - E_1 = hf$

For energy and time

$$\boxed{\Delta E \Delta t \geq \frac{h}{4\pi}}$$

Absorption and emission Spectrum:

Pg 136 + 137.