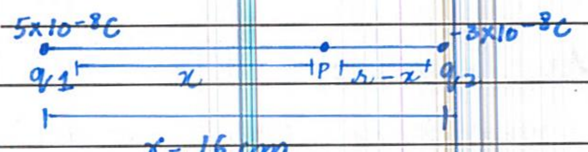
Q. No. 2 (i)

- During a light storm, charges are moving from clouds to ground so there is a chance of electric shock.
- As automobile surface is made of metal and inside metal electric field $E = 0$ because charges rest on the surface of metal.
- Therefore, if we sit inside car, no charges are present inside so chance of electric shock is reduced.

Q. No. 2 (ii)



- Electric potential will be zero at a point P near to smaller charge q_2.
- $r = 16\,cm$, $q_1 = 5\times10^{-8}C$, $q_2 = -3\times10^{-8}C$

As potential is zero $\Delta V = 0 \Rightarrow V_2 - V_1 = 0$

$V_1 = V_2$

$$\frac{Kq_1}{x} = \frac{Kq_2}{(r-x)}$$

$$\frac{5\times10^{-8}}{x} = \frac{3\times10^{-8}}{16-x} \Rightarrow \text{Cross multiply } 5(16-x) = 3x$$

Q. No. 2 (iii)

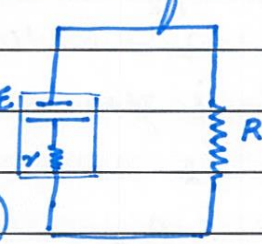
Q. No. 2 (iv)

Maximum Power Transfer Theorem:

In an electric circuit, maximum power is delivered from source to load resistance when load resistance becomes equal to internal resistance of source of emf.

$\mathcal{E} = I R_{eq}$

$I = \frac{\mathcal{E}}{R_{eq}} = \frac{\mathcal{E}}{R+r}$

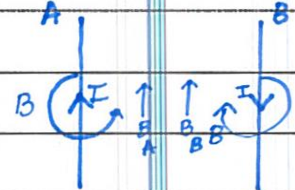


$P_{out} = I^2 R$ (across resistor)

$= \left(\frac{\mathcal{E}}{R+r}\right)^2 R = \frac{\mathcal{E}^2 R}{(R+r)^2}$ $\therefore (R+r)^2 - (R-r)^2 = 4Rr$

$P_{out} = \frac{\mathcal{E}^2 R}{(R-r)^2 + 4Rr}$ Now if $R = r$

Q. No. 2 (v)



A and B are two wires carrying current I in opposite direction. Both wires will repel each other.
Reason: As current carrying wire produces magnetic field around itself. Magnetic fields produced in both wires have opposite direction. But in centre of the two wires both B_A and B_B have same direction. Hence magnetic field is stronger in centre and weaker outside so both wires repel each other.

Q. No. 2 (vi)

Galvanometer: It is a device used for detection and measurements of small currents.

Data: $I_g = 5mA = 5 \times 10^{-3} A$, $R_g = 100\Omega$, $V = 20V$

$R_h = ?$

Solution: $R_h = \frac{V}{I_g} - R_g = \frac{20}{5 \times 10^{-3}} - 100$

$R_h = 3900\ \Omega$

Thus, galvanometer can be converted into voltmeter of required range by connecting a high resistance of 3900Ω in series with galvanometer.
Voltmeter is connected in parallel in the circuit.

Q. No. 2 (vii)

Q. No. 2 (viii)

Bohr second postulate $L = \frac{nh}{2\pi}$

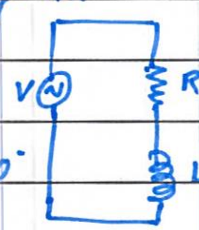
$mvr = \frac{nh}{2\pi}$

It was proved by de, broglie.
as wavelength was

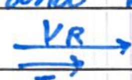
Q. No. 2 (ix)

Q. No. 2 (x)

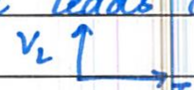
- In R-L series circuit, a resistor R and inductor L is connected in series with an AC supply V.



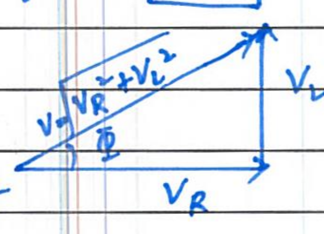
- In resistor, current and voltage are in phase $\Phi = 0^\circ$



- In inductor, voltage leads current by 90°



- If we add both voltage vectors

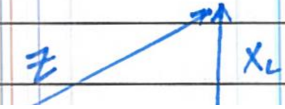


$V^2 = V_R^2 + V_L^2$, $V = \sqrt{V_R^2 + V_L^2}$

$V = \sqrt{I^2R^2 + I^2X_L^2} \Rightarrow V = I\sqrt{R^2 + X_L^2}$

$V = IZ$, Z = impedance.

From phasor diagram, we can see



Q. No. 2 (xi)

Paramagnetic: 1-They are weakly attracted by a strong magnet 2- At high temperature, they become diamagnetic.
3- They have unpaired electrons in valence shells.
4- Magnetic permeability is little greater than unity
5. e.g. Aluminium, antimony

Ferromagnetic: 1. Strongly attracted by magnet
2. High temperature above curie point makes them paramagnetic 3- Have unpaired electrons in shell.
4- High magnetic permeability 5. e.g Iron, copper, nickel

Diamagnetic: 1. Weakly repelled by strong magnet
2- No effect of temperature 3 No unpaired electrons
4- Magnetic permeability less than unity
5- e.g oxygen,

Q. No. 2 (xii)

متعلقہ سوال کا جواب صرف مختص کردہ جگہ پر اور بیرونی نشان کے اندر دیا جائے۔

Q. No. 2 (xiii)

- In magnetic levitation trains, track is made of superconductor electromagnet.
- As train comes in contact with superconductor, due to change in magnetic flux, emf is induced and it opposes the gravitational force such that both are equal, as there is no back emf.
- Therefore train slightly floats on the track.
- This greatly increases the speed of train because there is no energy loss.

Q. No. 2 (xiv)

All configurations CC, CE and CB are used for amplification but transistor with CE configuration is particularly a current amplification devices, as output current I_C is very large as compared to input I_B.

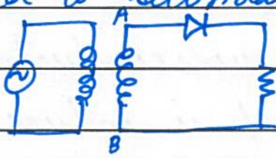
$$\beta = \frac{I_C}{I_B} \Rightarrow I_C = \beta I_B \Rightarrow I_C >> I_B$$

Transistor is a good amplifier because it has:

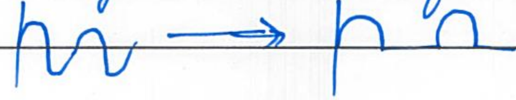
- high current gain
- high voltage gain
- high power gain
- high input resistance and low output resistance.
- produces a very stable output signal.

Q. No. 2 (xv)

- PN junction act as half wave rectifier when it is connected to secondary circuit of transformer along with load resistance.



- In the first half cycle, terminal A becomes positive while B is negative so diode acts as forward biased so current flows and produces signal at load resistance so switch is ON.
- In the next half cycle, terminal A is negative and B becomes positive, diode becomes reverse biased, no current flows and no signal produced at R_L. Switch is OFF. In this way wave is rectified only in one half cycle.



Q. No. 2 (xvi)

- α is current gain in common base configuration.

$$\alpha = \frac{I_c}{I_E}$$

- β is current gain in common emitter configuration

$$\beta = \frac{I_c}{I_B}$$

They are related as

$$\alpha = \frac{I_c}{I_E} = I_c / I_c + I_B \quad \text{or} \quad \beta = \frac{I_c}{I_B} = \frac{I_c}{I_E - I_c}$$

Divide both sides by I_B — Divide both sides by I_E

$$\alpha = \frac{I_c/I_B}{(I_c+I_B)/I_B} \qquad \beta = \frac{I_c/I_E}{(I_E-I_c)/I_E}$$

$$\alpha = \frac{\beta}{I_c/I_B + I_B/I_B} \qquad \beta = \frac{I_c/I_E}{I_E/I_E - I_c/I_E}$$

Q. No. 2 (xvii)

Data: $\Delta t = 10^{-8}\ s$

$\Delta E = ?$

Solution By Heisenberg's uncertainty principle

$$\Delta E \Delta t \approx h$$

$$\Delta E \approx \frac{h}{\Delta t}$$

$$\Delta E \approx \frac{6.626 \times 10^{-34}\ Js}{10^{-8}\ s}$$

$$\Delta E \approx 6.626 \times 10^{-26}\ J$$

Q. No. 2 (xviii)

Data : For second line of Paschen series

$p = 3$, $n = 5$

$\lambda n = ?$

Solution

$$\frac{1}{\lambda n} = R_H \left[\frac{1}{p^2} - \frac{1}{n^2} \right]$$

$$= 1.0974 \times 10^7 \left[\frac{1}{(3)^2} - \frac{1}{(5)^2} \right]$$

$$= 1.0974 \times 10^7 \left[0.11 - 0.04 \right]$$

$$= 1.0974 \times 10^7 (0.07)$$

$$\frac{1}{\lambda n} = 7.68 \times 10^5 \ m^{-1}$$

$$\lambda n = \frac{1}{7.68 \times 10^5}$$

$$\lambda_n = 1.302 \times 10^{-6} m$$

$$= 1.302 \ \mu m.$$

Cutting Line

Q. No. 2 (xix)

For fusion reaction, we require

- High enough plasma densities
- Very high temperature of about 10 million °C
- Energy confinement in core.

At our earth, we cannot fulfil these requirements. It is not impossible to give such a high temperature to overcome the repulsion between two lighter nuclei. Thus fusion reaction is favourable only at environment of stars. We have made fusion possible on earth but controlled fusion reaction still cannot be achieved.

Q. No. 2 (xx)

$^{234}_{90}Th \longrightarrow ^{234}_{91}Pa + ^{0}_{-1}\beta + \bar{\nu} + Q.$

Data

mass of $^{234}_{90}Th$ = 234.0436 u , mass of $^{234}_{91}Pa$ = 234.0428u

mass of $^{0}_{-1}\beta$ = 0.00055 u

Q = ?

Solution By law of conservation of mass-energy

Reactants Products

234.0436 u 234.0428 u

0.00055 u

234.0433

Q = Mass of reactants - Mass of products.

= 234.0436 u − 234.0433 u.

= 0.0003 u

Q = 0.0003 × 931.5 MeV

= 0.2794 MeV

As energy is positive, it shows that reaction is exothermic and energy is released.

Q. No. 3 (Page 1/6)

c. Data: $n = 15/cm = 1500/m$

$A = 2\ cm^2 = 2 \times 10^{-4}\ m^2$

$I_1 = 2A$

$I_2 = 4A$, $\Delta I = I_2 - I_1 = 2A$

$\Delta t = 0.1s$

Required: $\mathcal{E} = ?$

$$\mathcal{E} = \frac{N\Delta\Phi}{\Delta t} = \frac{N\Delta(BA)}{\Delta t} = \frac{NA\Delta B}{\Delta t}$$

From Ampere's law, $\Delta B = \mu_0 n \Delta I$

so, $= 4\pi \times 10^{-7} \times 1500 \times 2$

$= 3.76 \times 10^{-3}$

$\Delta\Phi = A\Delta B = 2 \times 10^{-4} \times 3.76 \times 10^{-3}$

$\Delta\Phi = 7.52 \times 10^{-7}$

$$\mathcal{E} = \frac{\Delta\Phi}{\Delta t} = \frac{7.52 \times 10^{-7}}{0.1} = 7.52 \times 10^{-6}\ V$$

b.

Ampere's Law

It is used to relate magnetic field around a loop of a current carrying wire and current flowing in the wire.

Statement

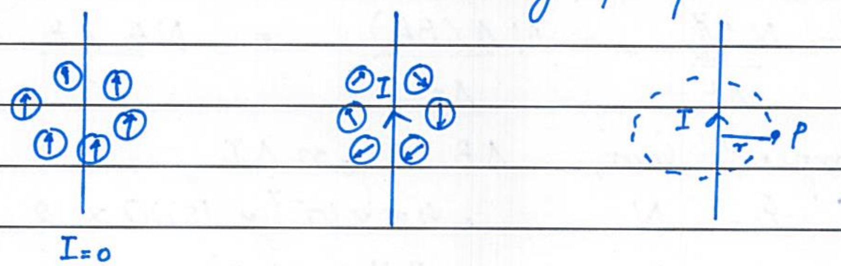
For any closed loop, sum of length elements multiplied by component of magnetic field parallel to each element is directly proportional to current enclosed in the loop.

Mathematical Form $\sum_{r=1} B \cdot \Delta l = \mu_0 I$

Explanation: When no current flows through the wire there is no magnetic field around the wire

Q. No. 3 (Page 2/6)

a current, all compass needles point in direction tangent to circle repesting the direction of magnetic field. Now consider a point P at distance r from wire where magnetic field strength is to be found. At point P, magnetic field is directly proportional to current in wire and inversely proportional to distance



$B \propto \frac{I}{r} \Rightarrow B = \frac{\mu_0}{2\pi} \times \frac{I}{r}$

where μ_0 is permeability of free space $= 4\pi \times 10^{-7} \frac{Tm}{A}$

as sum of length elements = circumference of ampeiian path.

$\Sigma \Delta L = 2\pi r$

$\Sigma B \cdot \Delta L = \mu_0 I$.

Application

Magnetic field due to current carrying solenoid

• A coil wounded in the form of spiral (helix) is called solenoid. As current flows through solenoid, magnetic field is produced which is stronger along the axis of solenoid and weaker outside.

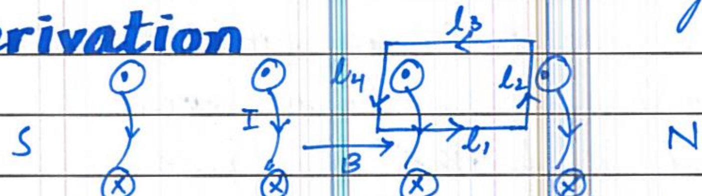
• Magnetic field lines in a loosely bound solenoid are uniform and parallel to each other. For a tightly bound solenoid, magnetic field lines are very close to each other.

Q. No. 3 (Page 3/6)

magnetic field in interior becomes more strong and enterior nearly approaches to zero.

Ideal solenoid: Number of turns of solenoid are greater the radius of solenoid. Internal magnetic field is maximum and external magnetic field = 0.

Derivation



Consider a solenoid, current is flowing in solenoid. Consider an amperian path in the region of solenoid's magnetic field. l_3 is present outside of solenoid.

By Ampere's law $\sum B.\Delta L = \mu_o I$

$B.l_1 + B.l_2 + B.l_3 + B.l_4 = \mu_o I$

$Bl_1 \cos\theta_1 + Bl_2 \cos\theta_2 + Bl_3 \cos\theta_3 + Bl_4 \cos\theta_4 = \mu_o I$

$Bl_1 \cos 0^\circ + Bl_2 \cos 90^\circ + Bl_3 \cos 180^\circ + Bl_4 \cos 90^\circ = \mu_o I$

As external magnetic field = 0, for l_3, B = 0.

$\cos 90^\circ = 0$, $\cos 0^\circ = 1$

$Bl_1(1) + Bl_2(0) + (0)l_3 \cos 180^\circ + Bl_4(0) = \mu_o I$

$Bl_1 + 0 + 0 + 0 = \mu_o I$

$Bl_1 = \mu_o I$

$B.l = \mu_o I$

For N-number of turns $B.l = N\mu_o I$

$B = \frac{N}{l}\mu_o I$

$n = \frac{N}{l}$ = turns per unit length

$B = \mu_o n I$

Direction of magnetic field can be predicted by right

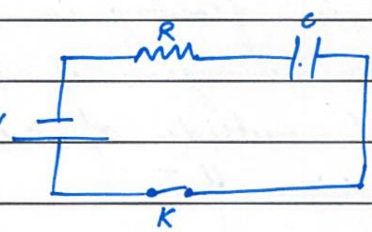
Q. No. 3 (Page 4/6)

in directcion of north pole.

a.

Charging and Discharging

Consider a resistor R and capacitor C connected in series with battery V and key K. When key is open, $I=0$ at $t=0$, so $q=0$ as capacitor is not charged. But as key is closed, charge begins to flow to capacitor and it begins to charge.



Charging

As battery supplies current, charge begins to deposit on one plate of capacitor and opposite charge on other plate. As charging continues, current decreases as charge on capacitor opposes further more charge to deposit on plate. When no more charge can deposit on capacitor, it is said to be charged.

Time Constant For Charging

"Time during with capacitor charges to 63.2% of maximum charge q_0 is called time constant."

or

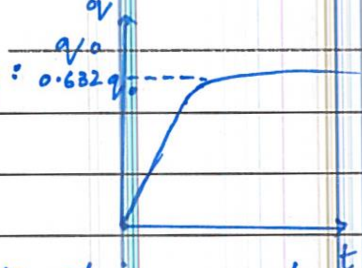
"Product of resistance R and capacitance C".

$$RC = t$$

Capacitor can never be fully charged. It can only be charged up to $0.632\, q_0$ in one time constant.

Q. No. 3 (Page 5/6)

Charging :



* Greater is the time constant, slower is rate of charging or discharging thus if either capacitance or resistance is increased charging becomes slow.
* In order for capacitor to charge completely $q = q_o$ infinite time is required.

Equation $q = q_o(1 - e^{-t/RC})$

$t = 1RC$ $q = 0.632\,q_o$

Practically 5RC are required for capacitor to charge to about 99%.

Discharging

If battery is removed from circuit and key is closed, capacitor starts discharging. Capacitor can only discharge such that 36.8% q_o is left on surface.

Time Constant For Discharging

Time during which capacitor discharges such that $0.368\,q_o$ is left on plates of capacitor.

$RC = t$

Equation $q = q_o e^{-t/RC}$

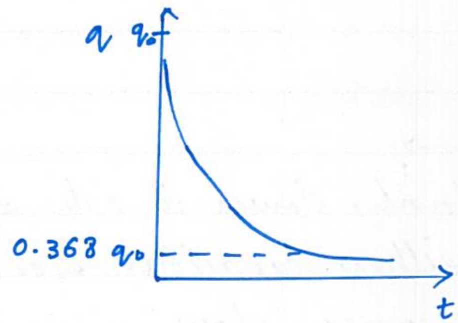
Thus in order to discharge capacitor completely, $q=0$ infinite time is required.

Applications

Charging and discharging has many applications. CDI (capacitor discharge ignition) is used in different machineries. Capacitor discharges to provide enough

Space for diagram/rough work

Q. No. 3 (Page 6/6)



For Discharging

Q. No. 4 (Page 1/6)

c.

- By Kirchoff's Voltage Law

For loop 1 $\mathcal{E}_1 - I_1 R_1 - (I_1 - I_2) R_3 = 0$

For loop 2 $-(I_2 - I_1) R_3 - I_2 R_2 - \mathcal{E}_2 = 0$

loop 1 $\mathcal{E}_1 - I_1 R_1 - (I_1 - I_2) R_3 = 0$

$\Rightarrow 5 - I_1(1) - (I_1 - I_2) 3 = 0$

$5 - I_1 - 3I_1 + 3I_2 = 0$

$5 + 3I_2 - 4I_1 = 0 \quad \rightarrow (1)$

loop 2 $-(I_2 - I_1) R_3 - I_2 R_2 - \mathcal{E}_2 = 0$

$-(I_2 - I_1) 3 - I_2(2) - 10 = 0$

$-3I_2 + 3I_1 - 2I_2 - 10 = 0$

$-5I_2 + 3I_1 = 10$

Q. No. 4 (Page 2/6)

Cutting Line

Q. No. 4 (Page 3/6)

Q. No. 4 (Page 4/6)

Cutting Line

Q. No. 4 (Page 5/6)

Space for diagram/rough work

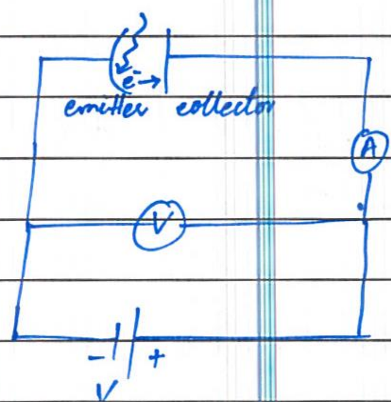
Q. No. 4 (Page 6/6)

Cutting Line

Q. No. 5 (Page 1/6)

a. Photoelectric effect

- When photons interact with metal surface, electrons are emitted from metal surface which is called photoelectric effect and the electrons are called photo electrons.
  Current due to photo electrons is called photoelectric current.
- This process was first observed by Hertz and explained by Einstein.



- When photon strikes on emitter, it emits electrons which are attracted towards collector and ammeter shows current.

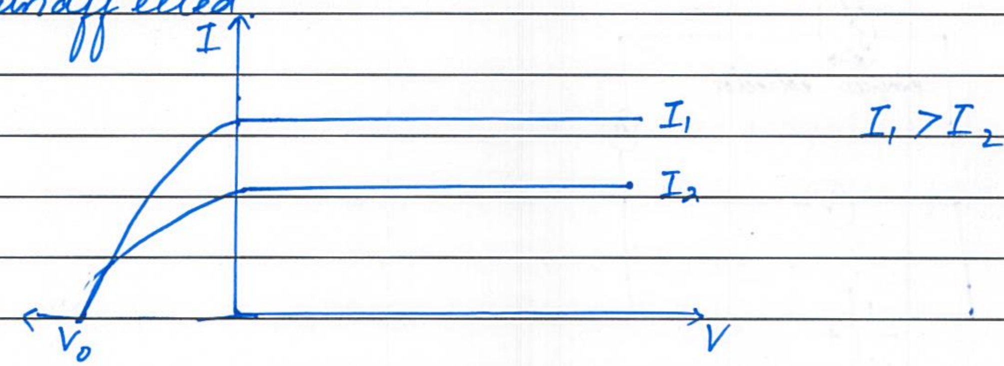
Maximum K.E

If the battery terminals are reversed such that e^- suffers opposition to move to collector, current in the circuit decreases. In order to move in circuit, e^- must have high K.E. As we continue to increase potential at a specific value of V called stopping potential V_0, electrons with max. Kinetic energy cannot pass and thus stop ammeter reading

Q. No. 5 (Page 2/6)

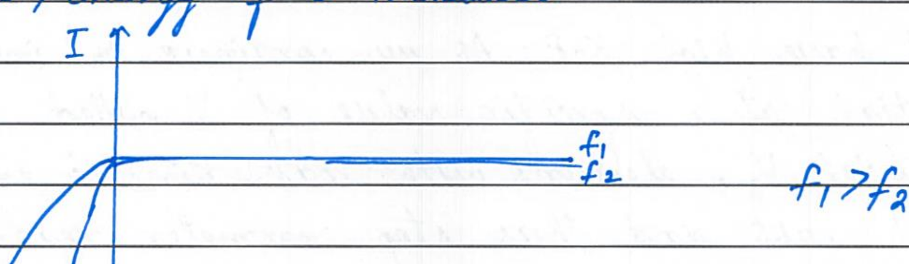
Intensity variation

If beams of photons was made brighter i-e number of photons were increased, it was found that stopping potential still remain same. It was the first puzzle for classical theory, as according to it as intensity increases, energy of electron must increase. But it was not true. Increasing intensity increases the number of electrons so increases photoelectric current but stopping potential is unaffected.



Frequency Variation

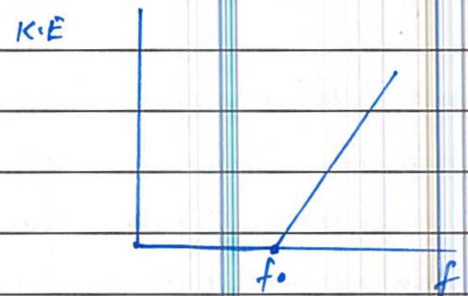
It was found that if frequency of incoming photon was less than threshold frequency f_o, no photoelectric effect occurs. It was second puzzle for classical theory because according to it, energy of $\bar{e}$ does not depend on frequency, but actually if frequency increases, energy of $\bar{e}$ increases



Time Delay

Another puzzle for classical theory was the problem of time delay. According to classical, electrons absorb photons and when they get required energy they get excited. So, there is time delay. But practically there is no time delay as $\bar{e}$ picks up photons of only required energy and is ejected.

Variation of K.E with frequency



It shows that $\bar{e}$ will only ejected if frequency of photon will be equal to threshold frequency.

Einstein's Explanation

Einstein used Plank's model to explain. According to it,
$E = hf$

Thus total energy of photon is used to eject electron as well as its kinetic energy. Every material has a specific work function, which is the minimum energy required for electron to emit.

So total energy of photon $E_{p} = K.E_{max} + \Phi$

So K.E of $\bar{e}$ $K.E = E_p - \Phi$

If energy of photon is just equal to work function there will no K.E

$E = \Phi = hf_0$

Q. No. 5 (Page 4/6)

Thus photoelectric effect will occur only if frequency of photon = fo.

b.

Nuclear Fusion

The process by which two lighter nuclei fuse to form a heavier nucleus is called nuclear fusion.

Energy

The ~~size~~ mass of nucleus formed is always less than the mass of constituent nuclei. This loss of mass appears in the form of energy. Thus, significant amount of energy is released during fusion event which is called thermonuclear energy.
Therefore, fusion reaction are favourable only at the environment of stars like sun because they generate large amount of energy and require high temperature. Controlled nuclear fusion reaction is not possible on Earth.
It occurs in two series of processes.

i- Proton cycle (lower temperatures)
ii- Carbon cycle (higher temperature)

Proton - Proton cycle

Two protons combines together to release beta particle

$${}^{1}_{1}H + {}^{1}_{1}H \longrightarrow {}^{2}_{1}H + {}_{+1}\beta + \nu \qquad E = 1.96\,MeV$$

Another proton combines with deuteron to form ${}^{3}_{2}He$

Q. No. 5 (Page 5/6)

and gamma ray

$^{3}_{2}He + ^{3}_{2}He \longrightarrow ^{4}_{2}He + ^{1}_{1}H + ^{1}_{1}H + \gamma \quad E = 12.85 MeV$

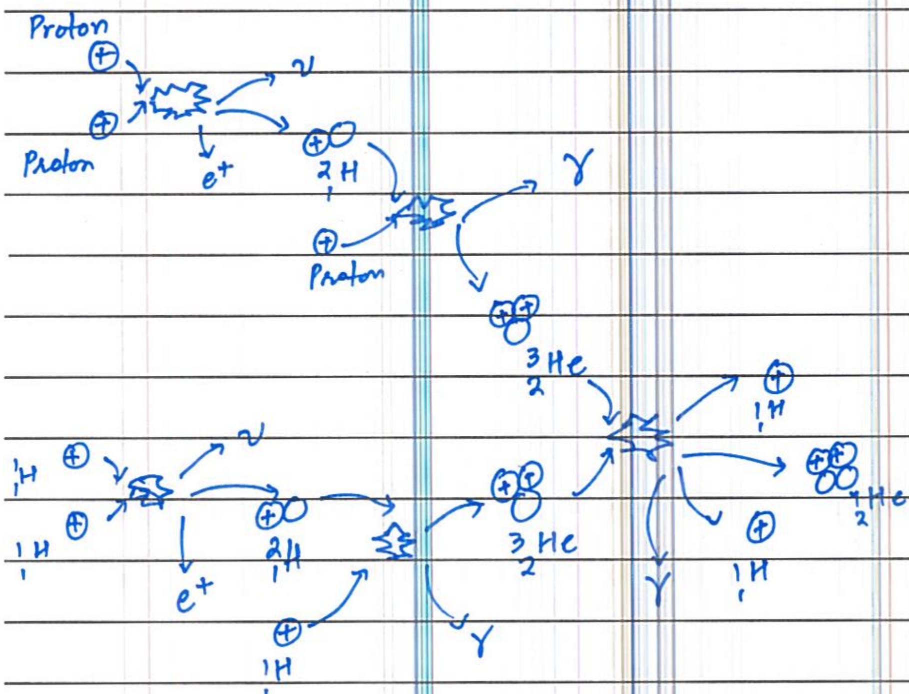
Finally electron and positron combine to form 2 gamma ray photon.

$^{0}_{+1}\beta + ^{0}_{-1}\beta \longrightarrow 2\gamma \quad E = 1.02 MeV$

Sum of these reactions are given as

$4\ ^{1}_{1}H \longrightarrow ^{4}_{2}He + 2\beta^{+} + 2\nu + 7\gamma$

Total energy emitted = 26.71 MeV



So, a large amount of energy is produced in fusion which cannot be handled. Example of fusion is hydrogen bomb.

Space for Diagram/rough work

Q. No. 5 (Page 6/6)

Cutting Line