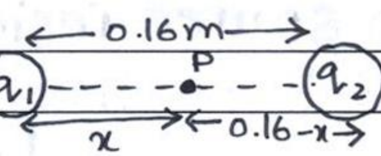
Q. No. 2 (i) It is safe to stay inside an automobile during a light storm. because inside a hollow conductor the **electric field is zero**. According to Guass's law, the **whole charge resides on the surface of conductor** such that electric field inside the conductor is zero. Thus a person remains safe inside the automobile.

Q. No. 2 (ii) • **Data:** $q = 5\times10^{-8}C$, $q_2 = -3\times10^{-8}C$.
$r = 0.16m$., $K = 9\times10^{9}\ Nm^2C^{-2}$

• **To find:** Point at which potential is zero $= x = ?$

• **Sol:-**



Potential due to $q_1 = P_1 = \frac{kq_1}{x}$

$= \frac{450}{x}\ V$

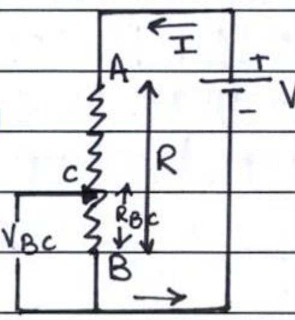
Potential due to $q_2 = P_2 = \frac{kq_2}{0.16-x} = \frac{270}{0.16-x}\ V.$

According to statement, $P_1 - P_2 = 0$

$P_1 = P_2$

450 270

Q. No. 2 (iii) **Potential divider** provides a circuit with a continuously varying potential. The circuit is given as:



If current I flows through wire AC when potential applied is V then

$$V = IR$$

The resistance of wire between points B and C are R_{BC} then, current through BC is I $I = \frac{V_{BC}}{R}$

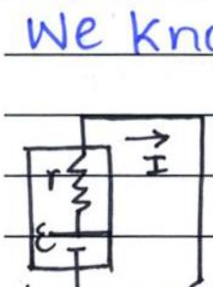
$$V_{BC} = IR_{BC} = \frac{V}{R} R_{BC}.$$

When slider C **moves towards A**, the length and hence **resistance R_{BC} increases**, so V_{BC} increases. When C moves towards B, resistance decreases so V_{BC} also decreases.

Q. No. 2 (iv) Maximum power transfer theorem states that, "maximum power is transferred from the source to load when **load resistance R is equal to source resistance r.**" $\boxed{R = r}$

We know that output power is given as:

$$P_{out} = I^2R$$



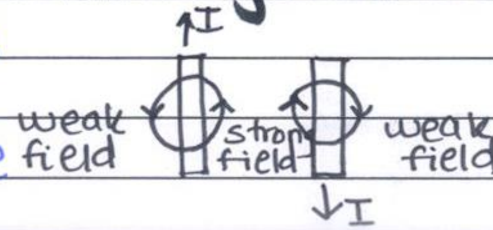
$$= \frac{\varepsilon^2}{(R+r)^2} R \quad \left\{\because I = \frac{\varepsilon}{R+r}\right\}$$

$$= \frac{\varepsilon^2 R}{R^2 + r^2 + 2Rr}$$

We can write $P_{out} = \frac{\varepsilon^2 R}{R^2 + r^2 + 2Rr + 2Rr - 2Rr}$

Thus $P_{out} = \varepsilon^2 R$ ... Now if $R = r$ then by taking

Q. No. 2 (v) Two long straight parallel wires carrying current in opposite direction **repel eachother.** As current is flowing in opposite directions, thus the **magnetic field due to each wire will be directed opposite to the other.** If one wire has magnetic field in clockwise direction, other will have in anti-clockwise direction. In the innerspace, the two fields tend to **support eachother.** Thus, **field in the inner space becomes stronger than on outside.** Force always acts from stronger to weaker field hence the wires will be repelled.



Q. No. 2 (vi) "A Galvanometer is a highly sensitive instrument for **detection and measurement of small electric current.**"

- **Data:** $I_g = 5mA = 5 \times 10^{-3} A.$
  $R_g = 100 \Omega.$
  $V = 20V.$
- **To find:** $R_h = ?$
- **Sol:** As $R_h = \frac{V}{I_g} - R_g$

$$= \frac{20}{5 \times 10^{-3}} - 100$$

$$= 3900 \Omega.$$

Thus a 3900Ω resistance must be conn-

Q. No. 2 (vii)

Q. No. 2 (viii) The **2nd postulate of Bohr Model** states that "electron can revolve only in those orbits for which **angular momentum** of electron is an **integral multiple of h/2π**."

$$mvr = nh/2\pi.$$

This canbe proved by **de-Broglie's wave-length:**

$$\lambda = \frac{h}{p} = \frac{h}{mv} \quad \text{—(1)}$$

Also, $2\pi r = n\lambda$

then, $\lambda = \frac{2\pi r}{n}$ —(2)

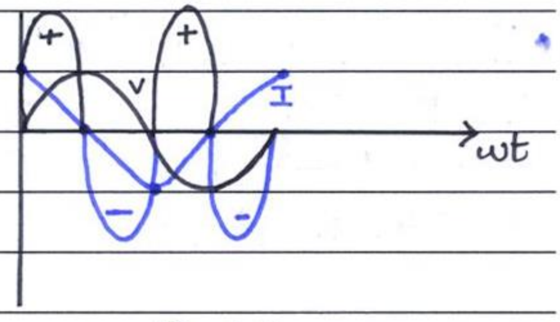
Comparing eq ① and ②:- $\frac{2\pi r}{n} = \frac{h}{mv}$

Q. No. 2 (ix) An ideal capacitor connected to an AC source dissipates **no power**. As in case of capacitor **current leads voltage by 90° or $\frac{\pi}{2}$ radians**. Thus,

$V = V_m \sin\omega t$

$I = I_m(\sin\omega t + 90°)$

$I = I_m \cos\omega t$



Then, Power dissipation is :- $P = \langle V \rangle \langle I \rangle$

$P = \langle V_m \sin\omega t \rangle \langle I_m \cos\omega t \rangle$

$P = V_m I_m \langle \sin\omega t \rangle \langle \cos\omega t \rangle$

$P = V_m I_m (0)$ $\{\because \langle \sin\omega t \rangle \langle \cos\omega t \rangle = 0\}$

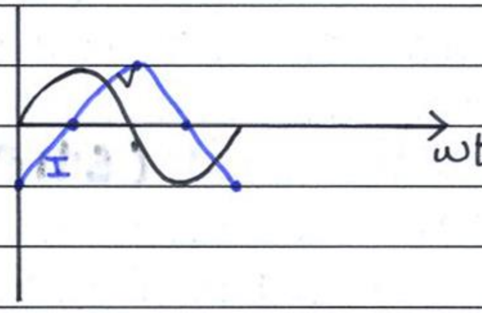
$P = 0$

Positive power is equal to -ve power.

Q. No. 2 (x) In case of an RL series circuit, **current lags voltage by an angle of 90° or π/2 radians**. This is because ~~vol~~ **inductor opposes the change in current** and therefore decreases the rate at which it is changed. This opposition is given as **inductive reactive reactance** :-

$X_L = \frac{V}{I} = \omega L$

$X_L = 2\pi f L.$



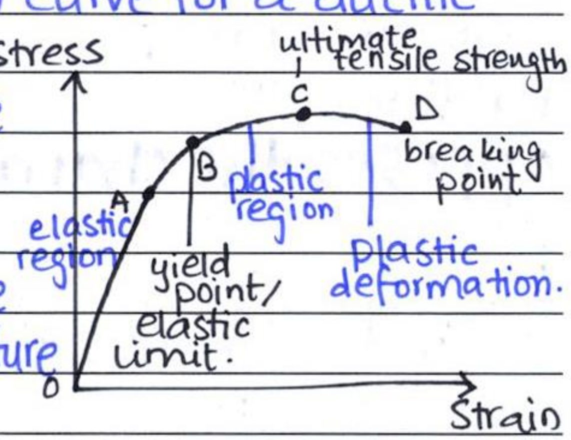
The phasor diagram is:

V

Q. No. 2 (xi)

PARAMAGNETIC	DIAMAGNETIC	FERROMAGNETIC
• These materials are **weakly attracted by magnetic field.**	• They are **weakly repelled by** magnetic field.	• They are **strongly attracted** by magnetic field
• For example, aluminium, antimony.	• e.g. copper, zinc, bismuth	• e.g. Fe, Ni Co.
• Align with magnetic field	• Align opposite to magnetic field.	• Strongly align with field.

Q. No. 2 (xii) The stress strain curve for a ductile material is:-



A ductile material is able to be **drawn into thin wires or threads.** This is because the ultimate Tensile strength and fracture points are far apart.

From the curve, we see that within the **elastic limit (stress ∝ strain)** and body regains its original shape when force is removed. After elastic limit, is the region of **plasticity** where beyound the UTS body

Q. No. 2 (xiii)

Q. No. 2 (xiv)

Q. No. 2 (xv)

Q. No. 2 (xvi) α is the **amplification factor** and is given as the "ratio of I_c to I_E." $\alpha = \frac{I_c}{I_E}$.

β is the **current gain of a transistor** and is given as "ratio of I_c to I_B" $\beta = \frac{I_c}{I_B}$

We know that $I_B = I_E - I_c$

$$\beta = \frac{I_c}{I_E - I_c}$$

Dividing by I_E:- $\beta = \frac{I_c/I_E}{I_E/I_E - I_c/I_E}$

$$\beta = \frac{\alpha}{1-\alpha}.$$

Q. No. 2 (xvii)

- **Data:**

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

$h = 6.626 \times 10^{-34} Js.$

- **To find:**

$\Delta E = ?$

- **Solution:**

$$\Delta E \cdot \Delta t = h$$

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

$$= \frac{6.626 \times 10^{-34}}{10^{-8}}$$

$$= 6.626 \times 10^{-26} J.$$

Q. No. 2 (xviii) Paschen series corresponds to transition from higher energy states to $n = 3$.

Then for second line of Paschen series (Infrared region):

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

$\because$ $R_H = 1.0974 \times 10^7 \, m^{-1}$

$p = 3$

$n = 5$

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

$$\frac{1}{\lambda} = 780.08 \times 10^3$$

$$\lambda = 1.2819 \times 10^{-6} \, m.$$

Q. No. 2 (xix) Fusion process is defined as the "process in which **lighter nuclei combine** to form a **heavier nuclei.**"

Fusion process is difficult to achieve because,

- very high temperature is required which can only be achieved in the **environment of stars.**
- At very high temperature, **ionization occurs.**
- Fusion process takes a very long time.

These factors make it difficult to achieve fusion reaction.

Q. No. 2 (xx) • **Data**: mass of $^{234}_{90}Th$: 234.0436 u.

mass of $^{234}_{91}Pa$ = 234.0428 u

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

• **To find**: $Q = ?$

• **Solution**:

$$^{234}_{90}Th \longrightarrow ^{234}_{91}Pa + B^{-1} + \bar{v} + Q$$

Mass of reactants = 234.0436 u.

Mass of products = 234.0428 + 0.00055

= 234.04335 u

Q = mass of reactants - mass of product

= 2.5×10^{-4} u

= **0.2328 Mev.**

Q. No. 3 (Page 1/6)

Q. No. 3 (Page 2/6)

Q. No. 3 (Page 3/6)

Q. No. 3 (Page 4/6)

Q. No. 3 (Page 5/6)

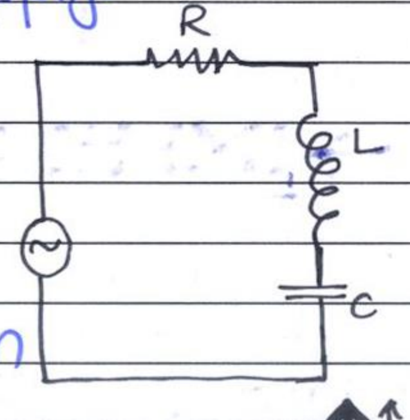
Space for diagram/rough work

Q. No. 3 (Page 6/6)

Q. No. 4 (Page 1/6) **a) RLC SERIES CIRCUIT**

In an RLC series ~~8~~ circuit, a Resistance(R), Inductance(L) and Capacitance (C) is connected in series to an A.C. supply.

Then, the potential in the circuit is equal to the sum of potential drop accross R **($V_R = IR$)**, L **($V_L = IX_L$)** and C **($V_C = IX_C$)**.

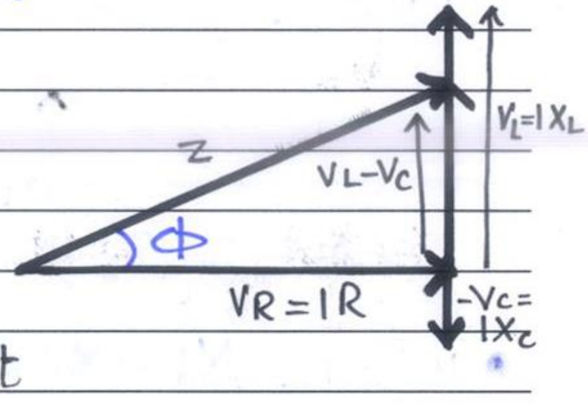


The phasor diagram is given as:-

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V = \sqrt{(IR)^2 + (IX_L - IX_C)^2}$$

$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$



where

$X_L - X_C = X$ = reactance of the circuit

$$\mathbf{V = I\sqrt{R^2 + X^2}}$$

where $\sqrt{R^2 + X^2}$ is the opposition offered by the circuit and is given as **impedence.**

$$\mathbf{Z = \sqrt{R^2 + X^2}}$$

$V = IZ$.

Now, to determine the phase angle,

$$\tan\phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{X_R}$$

The power factor $\cos\phi = V_R$ ... ~~*~~ R

Q. No. 4 (Page 2/6) Then, if Voltage is given as:-

$V = V_m \sin\omega t$

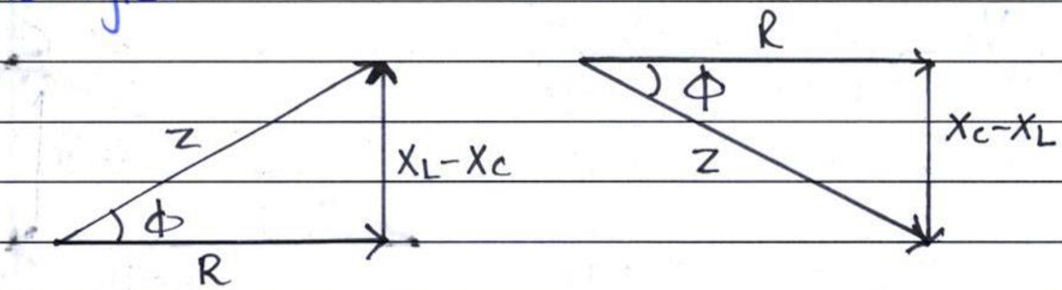
and current as: $I = I_m(\sin\omega t - \varphi)$

The power consumed is given as:-

$P = VI\cos\phi.$

→ IMPEDANCE TRIANGLE:

The triangle created when resistance is added to reactance is called impedence triangle.



- when, $X_L - X_C = +ve$ then $X_L > X_C$ and phase angle is positive. The circuit is inductive.
- when $X_L - X_C = -ve$, then $X_L < X_C$ and phase angle is **negative**, the circuit is ~~resistiv~~ capacitive.
- At resonant frequency, $X_L - X_C = 0$ the circuit **power factor is unity** and circuit is **resistive.**

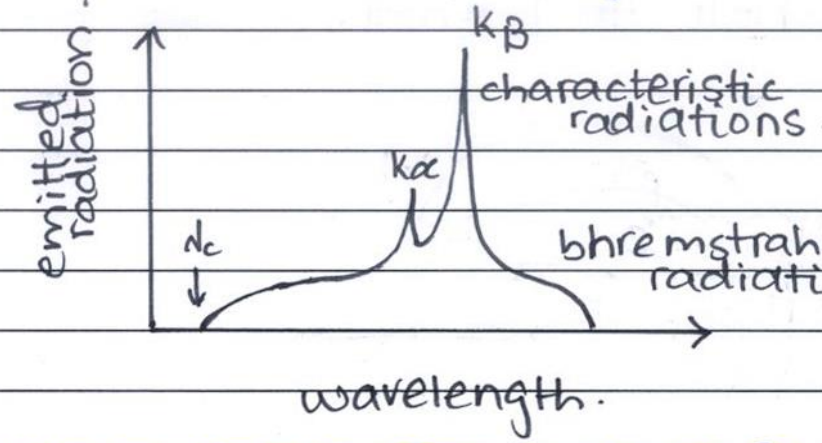
" An AC circuit having resistance and reactive elements is said to be in resonance if

Q. No. 4 (Page 3/6) At resonant frequency, $f_r = \frac{1}{4\pi\sqrt{LC}}$.

At resonance, • $X_C = X_L$
• $Z = R$ minimum resistance.
• $I = max$ current is maximum.

b) X-RAYS:- "X-rays are electromagnetic radiations having wavelength of the order of **angstrom (10^{-10}m)**".

An X-ray spectrum consists of two regions:-
- **Characteristic x-rays.**
- **Continuous x-rays.**



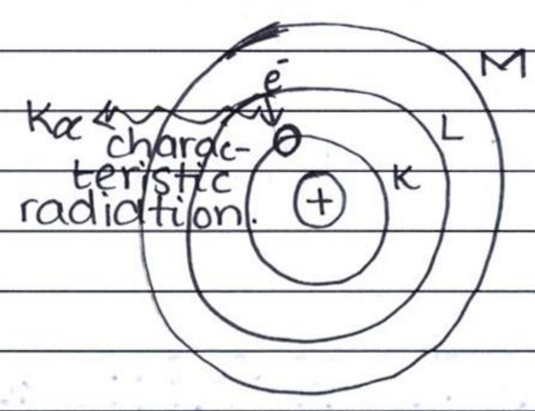
⇒ CHARACTERISTIC X-RAYS:-

Characteristic X-rays are also called **inner-shell transition x-rays.** Atoms in which large number of electrons are present (e.g **molybdenum**), the electrons are present in different energy levels

Q. No. 4 (Page 4/6) An incoming electron may cause transition from an inner shell e.g. k-shell. When this happens, **electron from L, M or N shell** moves to K shell to fill the vacancy emitting photon in this process. Thus,

"X-ray photon is defined as the energy released when an electron makes transition from higher to lower energy state."

Kα, Kβ, ... correspond to transition from higher states to K-shell. Similarly **Lα, Lβ, ...** corresponds to transition from higher shell to L shell.



c)

• Data:

$R_1 = 1\Omega$

$R_2 = 2\Omega$ $E_2 = 10V$

$R_3 = 3\Omega$

Q. No. 4 (Page 5/6)

• **To find:** $I_1 = ?$

$I_2 = ?$

• **Solution:-** By applying kirchoff's law to first loop **abef**:

$$+E_1 - IR_1 - IR_3 = 0$$

$$+5 - (I_1 \times 1) - (I_1 \times 3) = 0$$

$$5 - 1I_1 - 3I_1 = 0$$

$$-4I_1 = -5$$

$$I_1 = \frac{5}{4}$$

$$\mathbf{I_1 = 1.25\,A}$$

In second loop, **bcde**,

$$-E_2 - I_2R_2 - I_2R_3 = 0$$

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

$$-10 - 5I_2 = 0$$

$$-5I_2 = +10$$

$$I_2 = -2A.$$

$$\mathbf{I_2 = -2A.}$$

The negative sign indicates that direction of current is opposite to what we have expected.

Space for diagram/rough work

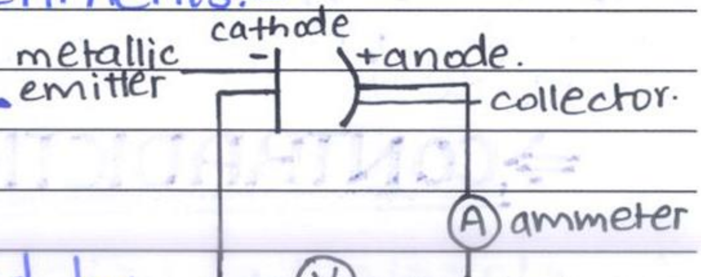
Q. No. 4 (Page 6/6)

Q. No. 5 (Page 1/6) **a) PHOTOELECTRIC EFFECT**

" When a **photon strikes a metal surface**, it causes electrons to be ejected from the surface. The phenomena is known as photo electric effect and electrons are called photoelectrons."

Following arrangement is used to perform photoelectric experiments:-

1St EXPERIMENT:



The voltage is varied by the rheostat until current through the ammeter decreases and **collector becomes -ve** to repel the ejected electrons. The potential is varied until **current drops to 0A**. This potential is known as **stopping potential. (V_0)**

" The reverse potential at which photoelectric current becomes zero is called stopping potential."

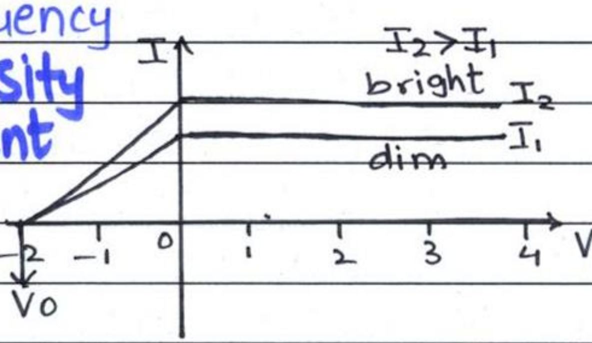
At stopping potential, the most energetic electrons are repelled. then

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

where e is the elimentary charge and V_0 is

Q. No. 5 (Page 2/6) **K.Emax doesnot depend** on the **intensity of light.** For a particular frequency, change in intensity doesnot change the K.E max.

For a particular frequency of light, when **intensity is increased, current increases (no.of photoelectrons increases)** but stopping potential remains constant.



⇒CONTRADICTION

This is a puzzle for **classical physics.** If light is a sinosidially osscillating electromagnetic wave then increasing intensity **should increase KE of ejected electrons.** This is not what happens.

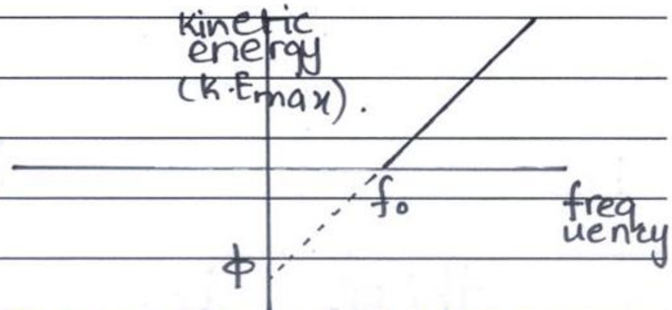
2ND EXPERIMENT:

Now, **frequency is varied** and effect on K.Emax and V_0 is observed. Photoelectric effect doesnot occur below **threshold frequency f_0:**

"the minimum frequency below which no electrons are ejected however intense the light may be."

Q. No. 5 (Page 3/6) **a)** Classical theory suggests **time delay** however the experiments prove that the process is **instantaneous** as photoelectrons are emitted as soon as light is turned on.

b) If light is an electromagnetic wave, then any frequency of light that is intense enough should emit electrons from the surface. This doesnot occur.



PHOTON THEORY OF LIGHT

Einstein used Plank's concept of **Quantization of energy.** According to him the electromagnetic wave's energy is not continuous over entire wavefront. It is **localized in bundles called quantum or photon.** Energy of photon is

$$E = hf.$$

The photon is so localized that it transfers its energy to a single electron then,

$$K.E_{max} = hf - \varphi$$

where φ = work function which is the **characteristic of each metal** and is

Q. No. 5 (Page 4/6) an electron."

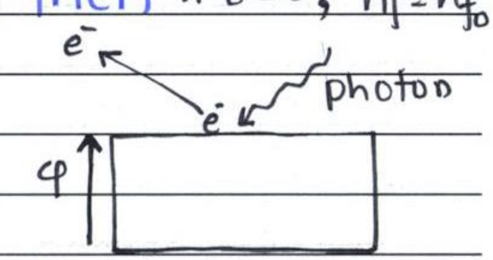
This equation shows **independence of K·E from intensity and shows its dependence on f_0** (threshold frequency).

If a photon has just threshold frequency to knock out an electron then $K \cdot E = 0$, $hf = hf_0$

$$0 = hf_0 - \varphi$$

$$hf_0 = \varphi$$

$$f_0 = \frac{\varphi}{h}$$



As $c = f_0 \lambda_c$ so, $f_0 = \frac{c}{\lambda_c}$

then, $\lambda_c = \frac{c}{f_0}$

$$\lambda_c = \frac{hc}{\varphi}$$

This is the cut off wavelength.

b) NUCLEAR FUSION

"The process in which **lighter nuclei combine to form heavier nuclei** is called nuclear fusion."

Nuclear fusion releases a great deal of energy. The mass of heavy nucleus is less than the sum of masses of individual nuclei. The loss in mass appears as energy. Nuclear fusion can be controlled only in the environment of stars including Sun

Q. No. 5 (Page 5/6) **PROTON CYCLE:**

Proton cycle undergoes following reactions:-

Step 1:- $^1_1H + ^1_1H \longrightarrow ^2_1H + \beta^+ + \nu$ (twice) **0.42 MeV** (twice)

Step 2:- $^2_1H + ^1_1H \longrightarrow ^3_2He + \gamma$ (twice) **5.49 MeV** (twice)

Step 3:- $^3_2He + ^3_2He \longrightarrow ^4_2He + ^1_1H + ^1_1H$ **18.25 MeV**

Step 4:- $^0_{-1}B + ^0_{+1}B \rightarrow 2^2\gamma$ (twice) **1.02 MeV** (twice).

Total: $4\,^1_1H \longrightarrow ^4_2He + 2B^+ + 2\nu + 7\gamma$ **26.71 MeV.**

The energy released in fusion process is known as **thermonuclear energy**, especially if it is achieved on Earth. Efforts are under process to obtain energy from fusion process after first successful thermonuclear bomb **(hydrogen bomb).** Proton cycle is efficient at **low temperature** while **carbon cycle at high temperature.** It release (26.73 MeV) energy.

Proton cycle is drawn on inter leaf page.

Space for Diagram/rough work

Q. No. 5 (Page 6/6)