Rao IIT Academy
Symbol of Excellence and Perfection

XII - ISC Baord

Date: 10.03.2015

PHYSICS - SOLUTIONS

PART I (20 Marks)

Answer ALL questions

Question 1:

(A)

(a) (b) Zero

(b) (c) 140Ω

(c) (c) a circle

(d) (b) 9 cm.

(e) (a) $E_k = -\dfrac{E_p}{2}$

(B)

(i) $q = ne$

The total charge is an integral multiple of charge of an electron i.e. $e = 1.6 \times 10^{-19}\ C$

(ii) $e = IR + Ir$

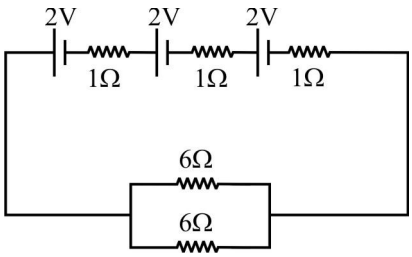
Where , E is EMF of the cell.

V = IR is potential drop across external resistance, R.

Ir is potential drop across internal resistance, r.

$\boxed{e = V + Ir}$

(iii)



Totasl Resistance, $R_T = 1 + 1 + 1 + \dfrac{6 \times 6}{6 + 6}$

$$R_T = 3 + \frac{36}{12} = 6\Omega$$

$V_T = 2 + 2 + 2 = 6\ V$

$$\boxed{I = \frac{V_T}{R_T} = 1\,A}$$

(iv) Diamagnetic material, susceptibility (x) is less then 0. Paramagnetic material, x is more than zero but less than 1.

Ferromagnetic material, it is a very high value in positive.

(v) $|L| = e \times \frac{dt}{dI}$

$$L = 2 \times \frac{0.4}{10} = \frac{0.8}{10} = 0.08\ H.$$

(vi) Electric field $(\vec{E})$, magnetic field vector $(\vec{B})$ and velocity vector $(\vec{C})$ are mutually perpendicular to each other.

$$\frac{E}{B} = C$$

(vii) **Method I** : is by passing unpolarised light through polarizer.

Method II : is by reflection (Brewster's law)

(viii) Angle of incidence = i

Angle of emergence = e

Angle of refracting surface (r) angle of prism = A

Angle of minimum deviation = δ_m

$$i + e = A + \delta_m$$

(ix) Convex or convergent lens is used.

(x) Reflecting telescope remove chrometic and spherical aberration.

(xi) **Moseley's Law:** The law states that the frequency of a spectral line in X-ray spectrum varies as the square of the atomic number of the element emitting it.

(xii) $\lambda_P > \lambda_B > \lambda_L$

(xiii) **Significance of binding energy are nucleon of a nucleus :**

(a) The binding energy per nucleon is very high then they undergo fission reaction i.s. A > 170.

(b) If, it is low if undergoes fussion reaction i.e. A < 30.

(c) It is stable when mass number is between 30 & 170

(xiv) **Nuclear fission:**

$${}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3\,{}^{1}_{0}n$$

(xv) Analogue signals are continous , variations are of current or voltage. Whereas, digital signals are those which can only take discrete values.

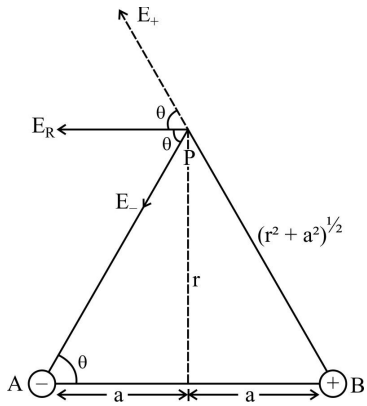
PART II

Section A

Answer any TWO questions from this section.

Question 2:

(a) Electric field at a point, P due to an electric dipole.Due to positive charge, the positive test charge will experience repulsive force whereas due to negative charge test charge will experience attraction. Hence,



$$|E_+| = \frac{1}{4\pi \in_o} \frac{q}{r^2 + a^2}$$

$$|E_-| = \frac{1}{4\pi \in_o} \frac{q}{r^2 + a^2}$$

$$E_R = E_+ \cos\theta + E_- \cos\theta$$

$$= \frac{1}{4\pi \in_o} \frac{2q}{r^2 + a^2} \cdot \cos\theta$$

$$= \frac{1}{4\pi \in_0} \frac{2q}{r^2 + a^2} \cdot \left(\frac{q}{\left(r^2 + a^2\right)^{\frac{1}{2}}} \right)$$

$$E_R = \frac{1}{4\pi \in_o} \frac{2q \times a}{\left(r^2 + a^2\right)^{\frac{3}{2}}} = \frac{1}{4\pi \in_o} \frac{p}{\left(r^2 + a^2\right)^{\frac{3}{2}}}$$

If $r >>>$ a, then

$$\boxed{E_R = \frac{1}{4\pi \in_o} \frac{p}{r^3}}$$

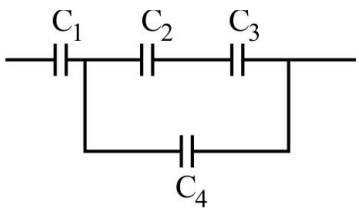
(b) $$U = \frac{1}{4\pi \in_o} \times \frac{q_1 q_2}{a}$$

$$= 9 \times 10^9 \times \frac{10 \times 10}{3}$$

$$= 3 \times 10^{11} J$$

Question 3:

(a) C_2 and C_3 are in series and the resultant is in parallel with C_4.



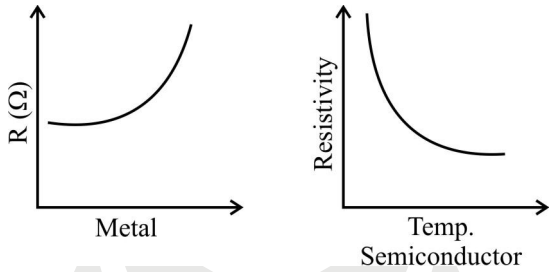
$$\frac{1}{C'} = \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{30} + \frac{1}{20}$$

$$C' = \frac{30 \times 20}{30 + 20} = \frac{600}{50} = 12\,\mu F$$

$$C'' = C' + C_4 = 12 + 28 = 40\,\mu F$$

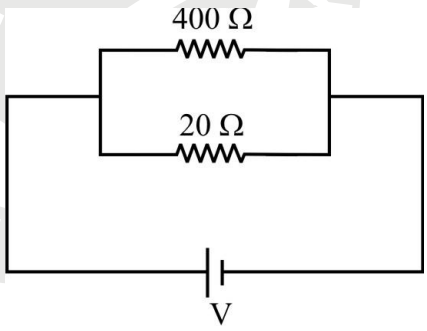
$$C_T = \frac{C'' \times C_1}{C'' + C_1} = \frac{40 \times 10}{40 + 10} = 8\,\mu F$$

(b)



Question 4:

(a) Power across $R_1 = 25$ W



$$P = \frac{V^2}{R}$$

$$25 \times 20 = V^2$$

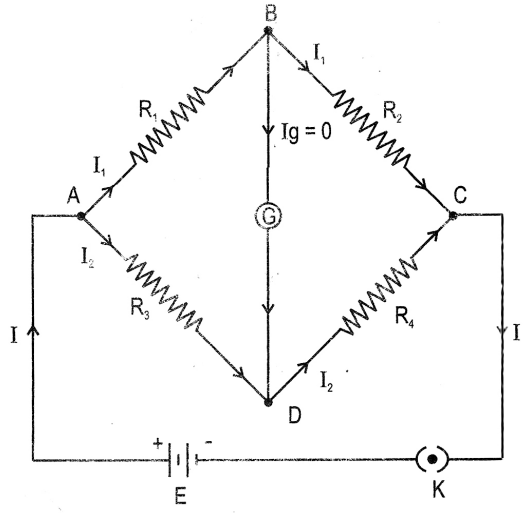
$$V^2 = 500$$

$$V = \sqrt{500}\ V$$

Power across R_2, $P = \frac{V^2}{R} = \frac{500}{400} = 1.2\ W$

$V = \sqrt{500}$, as potential in parallel remains constant.

(b) **Wheatstone's network:**



It consists of four resistances R_1, R_2, R_3 and R_4 which are connected to form a quadrilateral ABCD as shown in figure.

Let I be the current supplied by the cell. At the junction 'A', the current I is divided into two parts; I_1 through R_1 and I_2 through R_3.

$\therefore \quad I = I_1 + I_2$ (Kirchhoff's law)

When network is balanced, $V_B = V_D$ *i.e.* $I_g = 0$ So the current through resistance R_2 along BC is I_1 and the current through resistance R_4 is I_2 along DC.

By applying Kirchhoff's 2nd law to closed loop 'ABGDA', we get

$$-I_1R_1 + 0 \times G + I_2 R_3 = 0$$

$$I_1R_1 = I_2R_3 \qquad .....(1)$$

Similarly, by applying Kirchhoff's 2nd law to the closed loop 'BCDGB', we get

$$-I_1R_2 + I_2R_4 + 0 \times G = 0$$

$$\therefore \quad I_1R_2 = I_2R_4 \qquad .....(2)$$

Dividing equation (1) by equation (2), we get

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad or \quad \frac{R_1}{R_3} = \frac{R_2}{R_4} \qquad .....(3)$$

This is the balancing condition of wheatstone's network.

Question 5:

(a) $l_1 = 10\,m$

$R = 20\ \Omega$

$R_1 = 480\,\Omega$

$V = 5V$

balancing length = $l_2 = 6$ m

(i) Potential gradient = $k = \frac{V}{L} = \frac{5}{6} = 0.83\,V/m$

(ii) $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

$\frac{5}{E_2} = \frac{10}{6}$

$5 \times 6 = E_2 \times 10$

$\frac{5 \times 6}{10} = E_2$

$\therefore E_2 = 3V$

(b) (i) **Hysteresis :** The phenomenon of lagging of flux density (B) behind the magnetising force (H) in a ferromagnetic material subjected to cycles of magnetisation is known as Hysteresis.

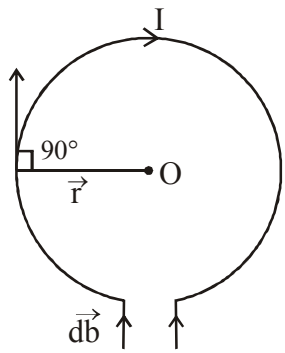
(ii) The elements of earth's magnetic field

(a) Declination (b) Dip (c) Horizontal intensity of earth's magnetic field.

Question 6:

(a) Magnetic flux density B at the centre of a circular coil of radius r having N turns and carrying a current I.

Consider a circular coil of radius r and carrying current I in the direction as shown in figure. Suppose the entire circular coil is divided into a large number of current elements, each of length dl. According to Biot-savart law, the magnetic field $\overrightarrow{dB}$ at the centre O of the coil due to current element $I\overrightarrow{dl}$ is given by,



$$\overrightarrow{dB} = \frac{\mu_o}{4\pi} \frac{I\left(\overrightarrow{dl} \times \vec{r}\right)}{r^3}$$

The magnitude of $\overrightarrow{dB}$ at the centre O is

$$dB = \frac{\mu_o}{4\pi} \frac{I\, dl \times r \sin\theta}{r^3}$$

$$dB = \frac{\mu_o}{4\pi} \frac{I\ dl\ \sin\theta}{r^2}$$

$$\therefore B = \int dB$$

$$= \int \frac{\mu_o}{4\pi} \frac{i\, dl\ \sin\theta}{r^2}$$

$$\theta = 90° \quad \therefore \sin 90° = 1$$

$$\therefore\ B = \frac{\mu_o}{4\pi} \frac{I}{r^2} \int dl$$

$\int dl$ = total length of the coil $= 2\pi r$

$$B = \frac{\mu_o}{4\pi}\frac{I}{r^2}(2\pi r)$$

$$B = \frac{\mu_o I}{2r}$$

If the coil has N turns

$$\therefore\ B = \frac{\mu_o NI}{2r}$$

(b) **Given :**

$L = 2.5\,H$

$R = 20\,\Omega$

$E = 120\ V$

$r = 5\,\Omega$

(i) Time constant, $\tau = \frac{L}{R} = \frac{2.5}{20} = \frac{1}{8} = 0.125\,s.$

(ii) Current, $I = \frac{E}{(R+r)} = \frac{120}{25} = 4.8\,A$

(L will not be consider as the battery is D.C.)

Question 7:

(a) $E_{rms} = 220\ V$

$C = 25\,\mu F$

$L = \left(\frac{4}{\pi^2}\right) H$

$R = 100\,\Omega$

(i) Resonant frequency,

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2 \times 3.14 \times \sqrt{\frac{4}{\pi^2} \times 25 \times 10^{-6}}}$$

$$= \frac{1}{2 \times 3.14 \times \frac{2}{3.14} \times 5 \times 10^{-3}}$$

$= 50 \text{ Hz}$

(ii) Inpedance$(Z) = \sqrt{R^2 + (X_L - X_C)^2}$

$X_L = 127.3\Omega$, $X_C = 127.3\Omega$

$Z = \sqrt{100^2 + (127.3 - 127.3)^2}$

$Z = \sqrt{100^2}$

$Z = 100\Omega$

$I_{rms} = \frac{E_{rms}}{2}$

$= \frac{220}{100}$

$I_{rms} = 2.2\,A$

(iii) Average power consumed by the circuit

$$Power = E_{rms} \times I_{rms} \times \frac{R}{\sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)}}$$

$z = R$

$\therefore \; Power = E_{rms} \times I_{rms}$

$= 220 \times 2.2$

Power = 484 watt

(b) The potential difference across the inductor V_L potential difference across the capacitor phase difference is 180°

Section B

Answer any THREE questions from this section.

Question 8

(a) Suppose that a plane wave front of light is incident at a plane refracting surface MN. Let A_1B_1 and AB be the successive positions of the incident wave front. A_1A and B_1B the correcsponding rays. When the wave front reaches the point A, it becomes a secondary source and emits secondary waves in the same medium. Let c be the speed of light in the medIum If t is the time taken by the incident ray to cover the distance BC, then, BC = c t. During this time, the secondary waves originating at A cover same distance c t in the same medium.Therefore, the secondary spherical wavelet has a radius c t.

With A as the centre, draw a hemisphere of radius ct in the same medium. It represent the secondary wavelet. According to Huygens's principle locus of tangent to all secondary wavelets represent new wave front. Draw a tangent CD to the secondary wavelet. As the points C&D are in the same phase of wave motion, CD represents the corresponding reflected rays. Wavefront in medium. It moves parallel to itself, takling successive positions C_1D_1, C_2D_2 etc. AD_2 and CC_2 represent the corresponding reflected rays.

Proof : i be the angle of incidence and r be the angle of reflection.

From definition, $\angle BAC = i$ & $\angle DCA = r$

From Δ ABC & Δ DCA

BC = AD from construction

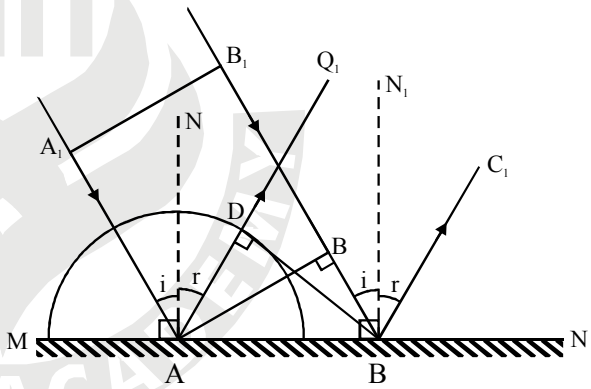
AC = AC common

$\lfloor$ABC = $\lfloor$ADC right angles

Therefore Δ ABC & Δ DCA are congruent

$\therefore \angle BAC = \angle DCA \quad \therefore i = r$

Hence laws of reflection is proved.



(b)

Interference	Diffraction
(1) Interference is result of superposition of different waves	(1) Diffraction is the result of superposition of the light wave of different part of the same wave front.
(2) Interference fringes are of the same width	(2) Diffraction fringes are not of the same width.
(3) All the bright bands of equal intensity.	(3) The intensity of the central maximum is the highest and the secondary maximum are of decreasing intensities.
(4) The regions of minimum intensities are dark.	(4) The region of minimum intensities are not perfectly dark.
(5) Both dark and bright bands are equally spaced.	(5) Dark bands on either side of the central bands are equally spaced but bright bands are not equally spaced
(6) Large numbers of band are obtained	(6) Few bands are obtained.
(7) Resolving power of optical instrument is not related with interference.	(7) Resolving power of optical instrument is related with diffraction.

Question 9

(a) $\lambda = 630\ nm$

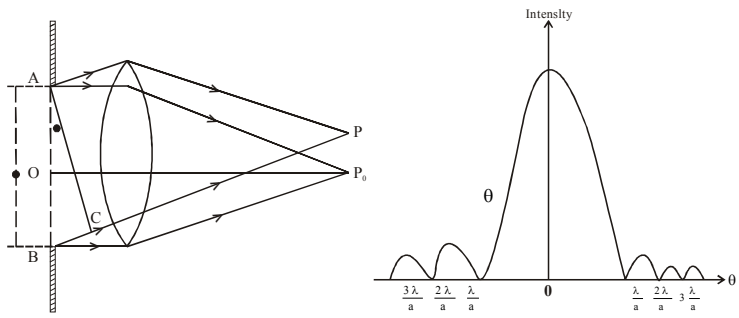
$d = 1.8 \times 10^{-3}\ m$

$D = 0.80\ m$

(i) $\beta = \dfrac{\lambda D}{d} = \dfrac{630 \times 10^{-9} \times 0.8}{1.8 \times 10^{-3}} = 2.8 \times 10^{-4}\ m$

(ii) $x = \dfrac{n\lambda D}{d} = 10 \times 2.8 \times 10^{-4} = 2.8 \times 10^{-3}\ m$

(b) **Fraunhofer diffraction due to a single slit :** Consider a monochromatic parallel beam of light of wavelength `λ` falling on a narrow slit of width `a` as shown in figure. A diffraction pattern is formed on the screen placed in the focal plane of the convex lens. Let `O` be the centre of the slit and `$P_o$` be the central point of the screen. The rays extending from the slit on either side OP_o are at equal optical paths from P_o The maximum intensity is observed at central point P_o. It is called the principal maximum.



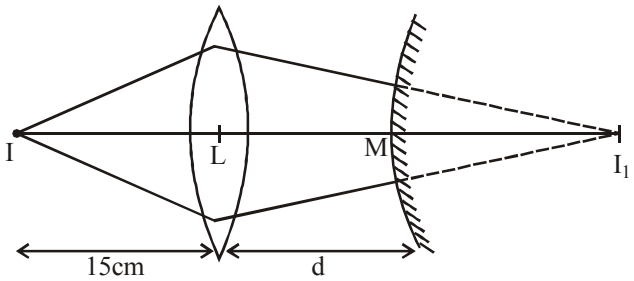
As θ increases, the intensity changes between alternate minima and maxima.

The condition for minima is $a\sin\theta = n\lambda$ where n = 1,2,3,4……

The condition for minima is $a\sin\theta = (2n+1)\lambda/2$ where n = 1,2,3,4……

Question 10

(a)



$u = 15\ cm$

$f = 10\ cm$

$d = f = 10\ cm$

For lens, $\frac{1}{V} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{V} - \frac{1}{(-15)} = \frac{1}{10}$$

$$\frac{1}{V} = \frac{1}{10} - \frac{1}{15} = \frac{3-2}{30} = \frac{1}{30}$$

$$\boxed{V = 30\ cm}$$

$$MI = LI - LM = 30 - 10 = 20\ cm$$

$$\boxed{f = \frac{20}{2} = 10\,cm}$$

(b) **Chromateic Abberation**: It is a type of distortion in whci there is a failure of a lens to focus all colours to the same convergence point.

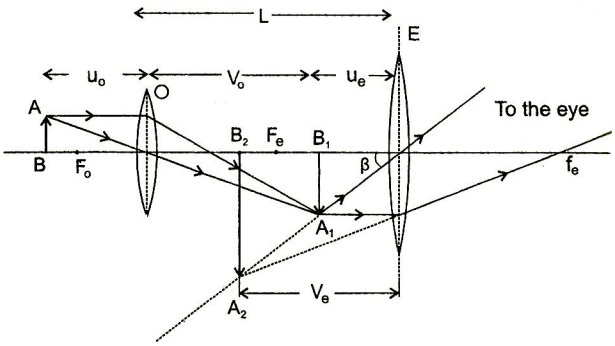
It can be minimise or eleminated by following:

(i) By providing stoppers

(ii) By multiple refraction and reflection

Question 11

(a)



(b) (i) Magnifying power can be increased by increasing focal length of objective or by decreasing focal length of eyepiece.

(ii) Resolving power can be increased by increasing diameter of objective lens.

Section C

Answer any THREE questions from this section.

Question 12

(a) (i) From the graph,

Threshold frequency $= 10 \times 10^{14}\ Hz$

$$\upsilon_o = 10^{15}\ Hz$$

(ii) Work function of the metal

$$w = h\upsilon_o$$

$$= 6.63 \times 10^{-34} \times 10^{15}$$

$$= \frac{6.63 \times 10^{-19}}{1.6 \times 10^{-19}}$$

$$= 4.14\ eV$$

(iii) $E_k = 8\ eV$

Stopping potential $= K.E._{max} - \phi$

$\Rightarrow 8 - 4.14 = 3.86\, eV$

$$\boxed{V = \frac{3.86}{e} \times ev = 3.86\ V}$$

(b) (i) As, $mc^2 = mc \times c$

$\therefore \quad E = pc$

$$P = \frac{E}{C}$$

Since, $E = h\upsilon$

$$P = \frac{h\upsilon}{C}$$

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

(or) $\lambda = \dfrac{h}{P}$

(ii) Diffraction of particles through Davison-Germer experiment which proves wave nature of electrons.

Question 13

(a) Let m and e be the mass and the charge of the electron. If the electron revolves with velocity v in circular orbit of radius r, then according to first Bohr's postulate,

Centripetal force = Electrostatic force

$$\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2} \quad \therefore v^2 = \frac{e^2}{4\pi\varepsilon_0 mr} \quad \text{-----(1)}$$

According to second postulate.

$mvr = \dfrac{nh}{2\pi}$, where n = 1, 2, 3, ... & h is planck's constant.

Squaring this expression we get,

$$m^2v^2r^2 = \frac{n^2h^2}{4\pi^2} \quad \therefore v^2 = \frac{n^2h^2}{4\pi^2m^2r^2} \quad \text{-----(2)}$$

Equating the values of v^2 from eq. 1 & 2

$$\frac{e^2}{4\pi\varepsilon_0 mr} = \frac{n^2h^2}{4\pi^2m^2r^2} \quad \therefore r = \left(\frac{\varepsilon_0 h^2}{\pi m e^2}\right)n^2$$

This expression gives us the radius of the Bohr's orbit. The radius of the successive orbits is given by substituting n = 1, 2, 3, ... etc. since ε_0, h, m, e are all constant, $\therefore r \alpha n^2$.

Thus radius of orbit is proportional to the square of the principle quantum number.

(b) $v = 50\ kV$

Minimum wavelength

$$(f) = \frac{12.27}{\sqrt{v}}\ \mathring{A}$$

$$= 0.054\ \mathring{A}$$

$$= 5.4 \times 10^{-12}\ m$$

Question 14

(a) (i) **Half-life of a radioactive substance :** The time taken by half the number of atoms of the radioactive element, to disintegrate completely, is called half-life period T.

(ii) Relation between half-life (T) and delay constant (λ) of a radioactive substance:

$$N = N_o e^{-\lambda t}$$

when, $t = T$

$$N = \frac{N_o}{2}$$

$$\therefore \frac{N_o}{2} = N_o e^{-\lambda T}$$

$$\frac{1}{2} = e^{-\lambda T}$$

$$\frac{2}{1} = e^{\lambda T}$$

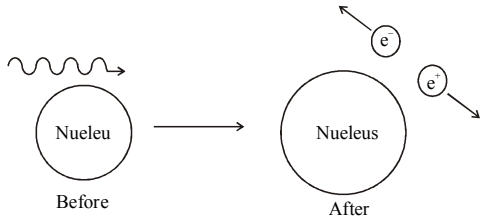
$$Log_e 2 = \lambda T$$

$$T = \frac{\log_e 2}{\lambda}$$

$$T = \frac{0.6931}{\lambda}$$

(b) **Pair Production:**

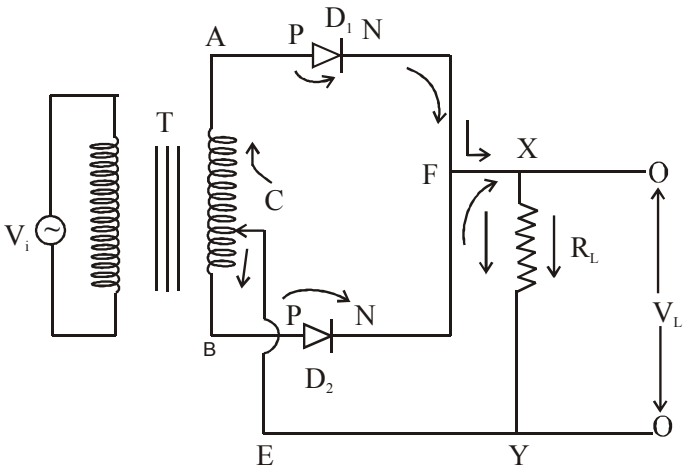
When a photon pusses near a massive particle like an atomic nucleus, the photon disappears by creating an electron-positron pair. This process is called pair production. The energy of the photon should be equal to sum of energy of electron and energy of positron. So a photon must have an energy of at least $2m_o c^2$ to create an electron positron pair. Where m_o is the rest mass of electron.



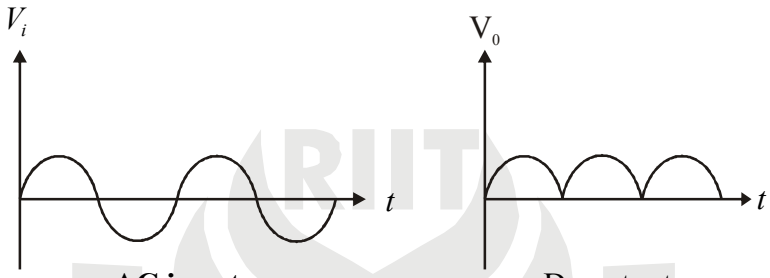
To conserve momentum, the nucleus recoils with very small velocity. Pair production is also known as the motcrialization of radiant energy.

Question 15

(a)



T ----- Transformer
D_1 & D_2 ---- Diode
V_0 ---- output voltage
V ---- input voltage
R_L ---- Load resistance
C ---- Central taps



AC input Dc output

(b)

NAND gate is the combination of AND gate and NOT gate i.e. NAND gate is nothing but it is AND gate with inverted output.

The Logical statement of NAND gate, is if input A is true and B is true then the out put if false otherwise true.

The Boolean equation of NAND gate is $Y = \overline{A.B}$

Input	Output	
A	B	$Y = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0