B K BIRLA CENTRE FOR EDUCATION

SARALA BIRLA GROUP OF SCHOOLS
SENIOR SECONDARY CO-ED DAY CUM BOYS' RESIDENTIAL SCHOOL
PRE BOARD - II (2024-25)
PHYSICS (042)
MARKING SCHEME

CLASS: XII **TIME: 3 hrs**

Section A

1.

(b) 2
Explanation:
N = $N_B + \frac{N_C}{8} = 1 + \frac{8}{8}$ = 2

2.

(b) 1Ω
Explanation:
1Ω

3.

(b) Full image will be formed but will be less bright
Explanation:
Image will be formed at the same position and same height but intensity of image formed will be less hence its brightness will be less as less number of light rays will form the image. Light rays from the covered portion will not contribute to image formation.

4.

(c) 300A/m, 1.88T
Explanation:
H = nI = 60 × 5 = 300A/m
B = $\mu_o \mu_r H = \mu_m H$
= 5000 × 300 × $4\pi \times 10^{-7}$
= 1.88 T

5.

(b) Zero
Explanation:
Zero

6.

(b) torsional rigidity
Explanation:
torsional rigidity

7.

(b) looking from above, the induced current in the coil will be anti-clockwise.
Explanation:
looking from above, the induced current in the coil will be anti-clockwise.

8.

(b) m and $\frac{M}{2}$
Explanation:
M = m(2l)
M' = ml

$M' = \frac{M}{2}$

So, pole strength will be m and $\frac{M}{2}$.

9.

(b) wavelength and constant phase difference

Explanation:

For coherent sources λ is same and phase is also same or phase diff. is constant.

10.

(b) Giving excess of electrons to it

Explanation:

Giving excess of electrons to it.

11.

(c) 5 Ω

Explanation:

Voltage drop across diode, $V_d = 0.5$ V

Power rate of diode, $P_d = 100$ mW = 0.1 W

Resistance of the diode,

$R_d = \frac{V_d^2}{P_d} = \frac{(0.5)^2}{0.1} = 2.5\Omega$

Maximum current through the diode,

$I_d = \frac{V_d}{R_d} = \frac{0.5}{2.5} = 0.2$ A

Applied voltage, V = 1.5 V

Required total resistance of the circuit,

$R' = \frac{V}{I_d} = \frac{1.5}{0.2} = 7.5\Omega$

Value of the series resistor, $R = R' - R_d = 7.5 - 2.5 = 5\Omega$

12. **(a)** Microscope will decrease but that of telescope will increase.

Explanation:

Microscope will decrease but that of telescope will increase.

13. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation:

$v_{rms} \propto \sqrt{T}$

$\lambda = \frac{h}{mv} \Rightarrow \lambda \propto \frac{1}{v}$

14.

(c) A is true but R is false.

Explanation:

A is true but R is false.

15. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation:

The central spot of Newton's rings is dark when the medium between plano convex lens and plane glass is rarer than the medium of lens and glass. The central spot is dark because the phase change of π is introduced between the rays reflected from surfaces of denser to rarer and rarer to denser media.

16. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation:

A transformer works on the principle of mutual induction. It can step up or step down a changing current like a.c. and not d.c

Section B

17. Ampere circuital law,

$\oint \vec{B} \cdot \overrightarrow{dl} = \mu_0 I$

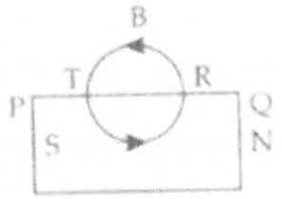
between the plates of the capacitor, I = 0

$\therefore \oint \vec{B} \cdot \overrightarrow{dl} = 0$

Which is impossible, as there is a magnetic field.

Modified ampere circuital law, $\oint \vec{B} \cdot \overrightarrow{dl} = \mu_o (l_C + I_D)$

where I_D = Displacement current = $\varepsilon_0 \frac{d\phi_E}{dt}$.

18. 

Consider an Ampere loop C inside and outside the magnet NS on side PQ of magnet then

$\int_P^Q \vec{H} \cdot \overrightarrow{dl} = \int_Q^P \frac{\vec{B}}{\mu_0} \overrightarrow{dl}$

Where B is magnetic field and m_0 is dipole moment. As angle between B and dl varies from 90°, So

$\int_P^Q \vec{H} \cdot \overrightarrow{dl} = \int_Q^P \frac{\vec{B}}{\mu_0} \cdot \overrightarrow{dl} > 0$ i.e. positive.

Hence, the value of B must be varied from south pole to north pole inside the magnet.

According to Ampere's law, we get $\oint_{PDP} \vec{H} \cdot \overrightarrow{dl} = 0$

$\oint_{PQP} \vec{H} \cdot \overrightarrow{dl} = \int_P^Q \vec{H} \cdot \vec{dl} + \int_Q^P \vec{H} \cdot \overrightarrow{dl} = 0$

As $\int_p^Q \boldsymbol{H} \cdot \boldsymbol{dl} > 0$ (outside the magnet) and $\int_0^P \boldsymbol{H} \cdot \boldsymbol{dl} < 0$ (inside the magnet). It is due to the angle between H and dl is more than 90° inside the magnet so cos θ is negative. It means the lines of H must run from north pole to south pole inside the bar magnet.

19. The resistivity of a semiconductor is given by

$\rho = \frac{1}{\sigma} = \frac{1}{e(n_e\mu_e + n_h\mu_h)}$

As the temperature increases, the mobilities μ_e and μ_h of electrons and holes decrease due to the increase in their collision frequency. But due to the small energy gap of semiconductors, more and more electrons $(n \propto e^{-E_g/k_BT})$ from the valence band cross over to the conduction band. The increase in carrier concentrations, n_e and n_h is so large that decrease in the values of μ_e and μ_h has no influence. The overall effect is that conductivity increases or resistivity decreases with the increase of temperature.

20. Given, Bohr's radius (r_0) = 5.3×10^{-11} m, n = 3

i. Radius of orbit is given by, $r_n = n^2 r_0$

For n = 3, $r_3 = (3)^2 \times 5.3 \times 10^{-11}$

$r_3 = 4.7 \times 10^{-10}$

$r_3 = 4.7$ A^0

ii. Given Total energy of an electron in the first excited state of the hydrogen atom is -3.4 eV

a. Kinetic energy = -Total energy = -(-3.4 eV) = 3.4 eV

b. Potential energy = - 2 × Kinetic energy = -2 × 3.4 = -6.8 eV

21. For the net magnetic field at the point O to be zero, the direction of current in loop L_2 should be opposite to that in loop L_1.

Magnitude of magnetic field due to current I_1 in L_1 = Magnitude of magnetic field due to current I_2 in L_2

or $\frac{\mu_0 I_1 (0.03)^2}{2\left[(0.03)^2+(0.04)^2\right]^{3/2}} = \frac{\mu_0 I_2 (0.04)^2}{2\left[(0.04)^2+(0.03)^2\right]^{3/2}}$

or $I_2 = \frac{(0.03)^2}{(0.04)^2} I_1 = \frac{9}{16} \times 1A = 0.56$ A

OR

Let the $\frac{e}{m}$ of electron be L

Centripetal force = $\frac{mv^2}{r}$ ...(i)

Force provided by the magnetic field = qBv ...(ii)

Equating (i) and (ii),

$\frac{mv^2}{r}$ = Bqv

$\frac{mv}{r}$ = Bq

$\Rightarrow \frac{v}{Br} = \frac{e}{m}$

$\Rightarrow L = \frac{v}{Br} = \frac{10^7}{10^{-2} \times 6 \times 10^{-3}}$

$\Rightarrow L = 1.667 \times 10^{11}\ Ckg^{-1}$

Section C

22. Current, $I = enAv_d$

i. In series, current I is constant. So, $v_d \propto \frac{1}{A}$

$\frac{v_d(X)}{v_d(Y)} = \frac{A_Y}{A_X} = \frac{3}{2}$ = 3 : 2

ii. In parallel, V = IR = constant

$\therefore \quad I \propto \frac{1}{R}$

But $R \propto \frac{l}{A}$

$\therefore \quad I \propto \frac{A}{l}$

or $\frac{I_X}{I_Y} = \frac{A_X}{A_Y} \cdot \frac{l_Y}{l_X} = \frac{2}{3} \times \frac{2}{1} = \frac{4}{3}$

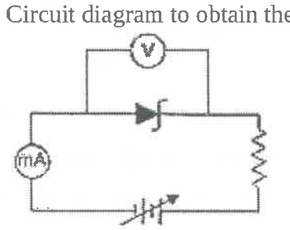
Also, $\frac{I_X}{I_Y} = \frac{enA_X v_d(X)}{enA_Y v_d(Y)} = \frac{2v_d(X)}{3v_d(Y)}$

Hence, $\frac{2v_d(X)}{3v_d(Y)} = \frac{4}{3}$

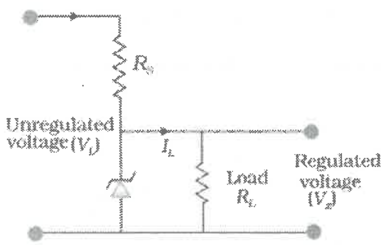
or $\frac{v_d(X)}{v_d(Y)} = \frac{2}{1}$ = 2 : 1

23. i. The semiconductor diode whose V-I characteristic is shown in figure is Zener diode.

ii. Circuit diagram to obtain the given characteristic is shown in figure.



iii. The circuit of Zener diode used as voltage regulator is shown in figure.



The unregulated dc voltage (filtered output of a rectifier) is connected to the Zener diode through a series resistance R_s such that the Zener diode is reverse biased.

If the input voltage increases, the current through R_s and Zener diode also increases. This increases the voltage drop across R_s without any change in the voltage across the Zener diode. This is because in the breakdown region, Zener voltage remains constant even though the current through the Zener diode changes. Similarly, if the input voltage decreases, the current through R_s and Zener diode also decreases. The voltage drop across R_s decreases without any change in the voltage across the Zener diode. Thus any increase/decrease in the input voltage results in, increase/decrease of the voltage drop across R_s without any change in voltage across the Zener diode. Thus the Zener diode acts as a voltage regulator.

24. i. The K.E. of the photoelectron becomes more than double of its original energy. As the work function of the metal is fixed, so incident photon of higher energy will impart more energy to the photoelectron.

ii. The increase in frequency of incident radiation has no effect on photoelectric current. This is because of the incident photon of increased energy cannot eject more than one electron from the metal surface.

iii. With the increase in frequency, the K.E. of the photoelectron increases, so the stopping potential also increases.

25. Half-life of the fuel in the fission reactor = 5 years

= 5 × 365 × 86400 s (∵ 1 day = 86400 seconds)

= 1.576×10^8 sec

∵ 1 gm of Uranium fission gives 200 MeV energy [This can be worked out from the fission equation given below of Uranium].

$${}^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{90}_{36}\mathrm{Kr} + {}^{143}_{56}\mathrm{Ba} + {}^{1}_{0}\mathrm{n} + {}^{1}_{0}\mathrm{n} + {}^{1}_{0}\mathrm{n}$$

∴ 1 gm of Uranium, = $\frac{6.023 \times 10^{23}}{235}$

Energy generated by Uranium fission = $\frac{6.023 \times 10^{23}}{235} \times 200\mathrm{MeV/g}$

= $\frac{6.023 \times 10^{23}}{235} \times 200 \times 10^6 \times 1.6 \times 10^{-19}$ J/g

= 8.2×10^{10} J/gm

∵ The 1000MW reactor operates only 80% of it's time, hence in 5 years amount of uranium consumed

= $\frac{80 \times 1.576 \times 10^8 \times 1000 \times 10^6}{8.2 \times 10^{10} \times 100}$

mass required for producing energy is, m = 1538 kg

∴ This amount is consumed within the half life time.

Hence, the initial amount will be double of this amount = 2 × 1538Kg

= 3076Kg

26. Suppose m be the mass of an electron and v be its speed in nth orbit of radius r. The centripetal force for revolution is produced by electrostatic attraction between electron and nucleus.

or,

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(e)}{r^2} \quad ...(i)$$

$$mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r}$$

So, Kinetic energy [K] = $\frac{1}{2}mv^2$

$$K = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{2r}$$

Potential energy = $\frac{1}{4\pi\varepsilon_0}\frac{(Ze)(-e)}{r} = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r}$

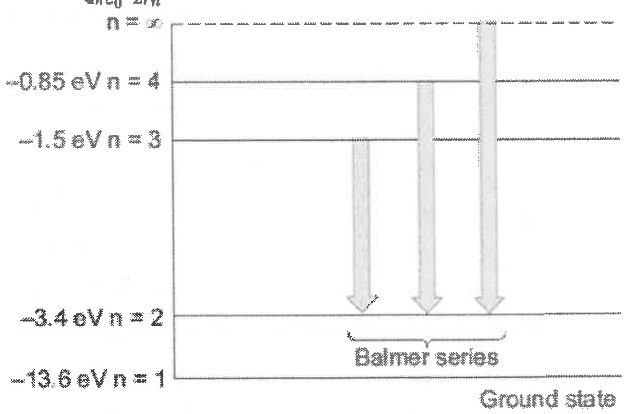
total energy

$$E = KE + PE = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{2r} + \left(-\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r}\right)$$

$$E = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{2r}$$

For n^{th} orbit, E can be written as E_n

$$E_n = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{2r_n} \quad ...(ii)$$



Energy level diagram of Balmer series

27. a. n = 2

distance of second bright fringe = $n\frac{\lambda D}{d}$

= $\frac{2 \times 600 \times 10^{-9} \times 1}{0.6 \times 10^{-3}}$

= 0.002 m

b. Let n^{th} bright of 600nm coincide with $(n + 1)^{th}$ bright of 480nm, by the formula of distance of bright bands we get

$$\frac{n\lambda_1 D}{d} = \frac{(n+1)\lambda_2 D}{d}$$

n × 600 = (n + 1) 480

$$\frac{60}{48} = 1 + \frac{1}{n}$$

$1.25 = 1 + \frac{1}{n}$

$0.25 = \frac{1}{n}$

n = 4

So distance = $\frac{4\times600\times10^{-9}\times1}{0.6\times10^{-3}}$

= 0.004 m

28. i. e = Bvl

P is a positive end

Q is a negative end

ii. Magnetic force is cancelled by the electric force set-up due to the excess charge of opposite nature at both ends of the rod.

There is no net force on the electrons in rod PQ when key K is open and the rod is moving uniformly. This is because the magnetic force is cancelled by the electric force set-up due to the excess charge of opposite nature at both ends of the rods.

iii. Induced emf is zero as a motion of rod not cutting field lines.

In this case, no emf is induced in the coil because the motion of the rod does not cut across the field lines. Or when the permanent magnet is rotated in vertical position the field becomes parallel to rails. The motion of the rod will not cut across the lines of the field. so no emf is produced.

OR

i. Total charge passed through the loop (Q)

Q = area under the I-t graph

= $\frac{1}{2} \times 0.4 \times 1$ coulomb = 0.2 C

ii. Change in magnetic flux

Total charge passing = $\left(\frac{\text{change in magnetic flux}}{R}\right)$

Change in magnetic flux = [R×0.2C]

= [10×0.2] Wb

= 2 Wb

iii. Magnitude of magnetic field applied

Let B be the magnitude of the magnetic field applied

Initial magnetic flux = B×(10Change in magnetic flux10^{-4}) Wb

Final magnetic flux = zero

Change in magnetic flux = $(B\times10^{-3}-0) = 2$

$\Rightarrow B = 2\times10^{3}$ Wb/m^{2}

hence, magnitude of the magnetic field applied is 2×10^{3} Wb/m^{2}.

Section D

29. **Read the text carefully and answer the questions:**

An electromagnetic wave transports linear momentum as it travels through space. If an electromagnetic wave transfers a total energy U to a surface in time t, then total linear momentum delivered to the surface is p = $\frac{U}{c}$. When an electromagnetic wave falls on a surface, it exerts pressure on the surface. In 1903, the American scientists Nichols and Hull succeeded in measuring radiation pressures of visible light where other had failed, by making a detailed empirical analysis of the ubiquitous gas heating and ballistic effects.

(i) **(a)** $\frac{I}{c}$

Explanation:

Pressure exerted by an electromagnetic radiation, $P = \frac{I}{c}$

(ii) **(b)** 6×10^{-4} N/m^{2}

Explanation:

$P_{rad} = \frac{\text{Energy flux}}{\text{Speed of light}} = \frac{18\ W/cm^2}{3\times10^8\ m/s}$

$= \frac{18\times10^4\ W/m^2}{3\times10^8\ m/s} = 6 \times 10^{-4}$ N/m^{2}

(iii) **(c)** 0.166×10^{-8} N m^{-2}

Explanation:

$P = \frac{I}{c} = \frac{0.5}{3\times10^8} = 0.166 \times 10^{-8}$ N m^{-2}

OR

(b) 10^{-6} N/m^2

Explanation:

The radiation pressure of visible light

$= 7 \times 10^{-6}$ N/m^2

(iv) **(d)** 100

Explanation:

Intensity of EM wave is given by $I = \frac{P}{4\pi R^2}$ $V_{av} = \frac{1}{2}\varepsilon_0 E_0^2 \times c$

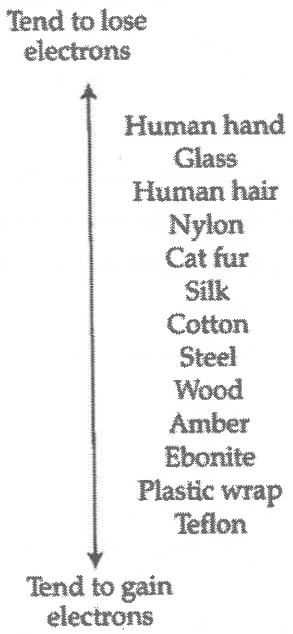
$\Rightarrow E_0 = \sqrt{\frac{P}{2\pi R^2 \varepsilon_0 c}} = \sqrt{\frac{1500}{2\times3.14(3)^2\times8.85\times10^{-12}\times3\times10^8}}$

$= \sqrt{10,000} = 100$ V m^{-1}

30. **Read the text carefully and answer the questions:**

The triboelectric series is a list that ranks materials according to their tendency to gain or lose electrons. The process of electron transfer as a result of two objects coming into contact with one another and then separating is called triboelectric charging. During such an interaction, one of the two objects will always gain electrons (becoming negatively charged) and the other object will lose electrons (becoming positively charged). The relative position of the two objects on the triboelectric series will define which object gains electrons and which object loses electrons.

In triboelectric series, materials are ranked from high to low in terms of the tendency for the material to lose electron. If an object high up on this list (Glass, for example) is rubbed with an object low down on the list (Teflon, for example), the glass will lose electrons to the teflon. The glass will, in this case, become positively charged and the teflon will become negatively charged. Materials in the middle of the list (steel and wood, for example) are items those do not have a strong tendency to give up or accept electrons.



(i) **(c)** high

Explanation:

In triboelectric series, materials are ranked from high to low in terms of the tendency for the material to lose electron i.e., they are ranked high to low tendency of getting positively charged.

(ii) **(a)** Steel, wood

Explanation:

Materials in the middle of the list (steel and wood, for example) are items those do not have a strong tendency to give up or accept electrons.

(iii) **(c)** Hair will be positively charged, Amber will be negatively charged.

Explanation:

Since, human hair is placed at the upper portion of the list, it will leave electron and will be positively charged. Since, amber is placed at the lower portion of the list, it will accept the electron and will be negatively charged.

(iv) **(a)** By contact

Explanation:

The process of electron transfer as a result of two objects corning into contact with one another and then separating is called triboelectric charging.

OR

(d) positively, negatively

Explanation:

During triboelectric charging, one of the two objects always gains electrons and become negatively charged. The other object loses electrons and become positively charged.

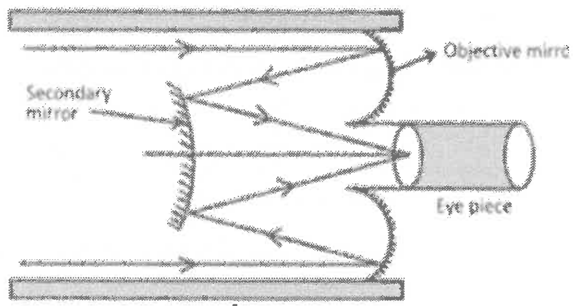
Section E

31. a. The main considerations with an astronomical telescope:

The diameter of the objective on which the brightness of the image and resolving power depend.

The focal length of the objective on which the magnification $\left(m = \frac{f_0}{f_E}\right)$ depends.

b.



Magnifying power $= \frac{f_o}{f_e}$

c. Two advantage

The image formed in a reflecting telescope is brighter than the image formed in a refracting telescope.

Lenses used in large sized refracting telescopes are very heavy and bulky and difficult to manufacture whereas mirrors used in large sized reflecting telescopes can be made thin and light using different techniques

OR

i. Path difference in Young's Double slit experiment at point P is given by the equation:

$\Delta x = S_2P - S_1P$

$S_2P^2 - S_1P^2 = \left[D^2 + \left(x + \frac{d}{2}\right)^2\right] - \left[D^2 + \left(x - \frac{d}{2}\right)^2\right]$

= 2xd

$(S_2P - S_1P)(S_2P + S_1P) = 2xd$

Assuming $S_2P + S_1P \approx 2D$ as x << D and d << D

$\Delta x \approx \frac{xd}{D}$

For constructive interference condition is, $\Delta x = n\lambda$

Position of nth bright fringe is given by: $x_n = \frac{n\lambda D}{d}$

and for destructive interference is given by, $\Delta x = (2n+1)\frac{\lambda}{2}$

Position of nth dark fringe is given by: $x_n = \frac{(2n+1)\lambda D}{2d}$

ii. Let intensity of light sources from slits be I.

Resultant intensity at a point is given by $I' = I + I + 2I\cos\phi$

where ϕ is the phase difference at the point. Path difference is given by:

$\Delta x = \frac{\lambda\phi}{2\pi}$

Hence, $I' = I + I + 2I\cos\left(2\pi\frac{\Delta x}{\lambda}\right)$

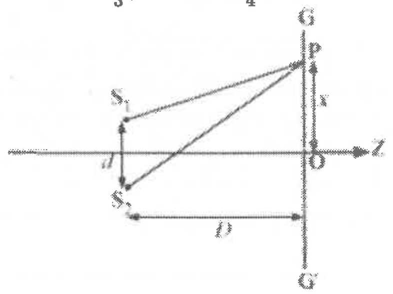
Given intensity at central maximum is I_o

Hence, $I_o = 4I$

At $\Delta x = \frac{\lambda}{6}, I' = 3I = \frac{3}{4}I_o$

At $\Delta x = \frac{\lambda}{4}, I' = 2I = \frac{1}{2}I_0$

At $\Delta x = \frac{\lambda}{3}, I' = I = \frac{1}{4} I_o$



32. a. $q_d = -\frac{1}{3}e$ [charge on down quark]

$q_u = +\frac{2}{3}e$ [charge on up quark]

Potential energy for charges is given by $U = \frac{kq_1q_2}{r}$

$k = \frac{1}{4\pi\varepsilon_0}$

$U = \frac{kq_1q_2}{r} + \frac{kq_1q_3}{r} + \frac{kq_2q_3}{r}$

$\therefore U_n = \frac{1}{4\pi\varepsilon_0} \frac{(-q_d)(-q_d)}{r} + \frac{(-q_d)q_u}{4\pi\varepsilon_0} + \frac{q_u(-q_d)}{4\pi\varepsilon_0 r}$

$= \frac{q_d}{4\pi\varepsilon_0 r}[+q_d - q_u - q_u]$ [Talking sign of charge]

$= \frac{qd}{4\pi\varepsilon_0 r}[q_d - 2q_u] = \frac{9\times10^9 \times \frac{1}{3}e}{10^{-15}}\left[\frac{1}{3}e - 2\cdot\frac{2}{3}e\right]$

[nature sign of charges taken already]

$= \frac{9\times10^9\times e}{3\times10^{-15}} \cdot \frac{e}{3}[1-4]$ Joule

$= \frac{-3\times9\times10^9\times1.6\times10^{-15}}{9\times10^{-15}}$ Joule = -7.68 x10^{-14} J

$\frac{-7.68X10^{-14}}{1.6X10^{-19}}$ = -4.8 × 10^{-14+19} e V = 4.8 × 10^5 e V = -0.48 × 10^6 e V

U = -0.48 MeV

So, charges inside neutron [$1q_u$ and $2q_d$] are attracted by the energy of 0.48 MeV.

The energy released by a neutron when converted into energy is 939 MeV.

$\therefore$ Required ratio $= \frac{1-0.481\text{MeV}}{939\text{MeV}}$ = 0.0005111 = 5.11 × 10^{-4}

b. P.E. Of proton consists of 2 up and 1 down quark

r = 10^{-15} m

$q_d = -\frac{1}{3}e, q_u = \frac{2}{3}e$

$U_p = \frac{1}{4\pi\varepsilon_0}\frac{q_u\times q_u}{r} + \frac{q_u(-q_d)}{4\pi\varepsilon_0 r} + \frac{q_u(-q_d)}{4\pi\varepsilon_0 r}$

$= \frac{q_u}{4\pi\varepsilon_0 r}[q_u - q_d - q_d]$

$= \frac{q_u}{4\pi\varepsilon_0 r}[q_u - 2q_d] = \frac{9\times10^9}{10^{-15}}\frac{2}{3}e\left[\frac{2}{3}e - 2\cdot\frac{1}{3}e\right] = 0$ potential energy is zero for this case.

OR

a. Potential at the mid point of the line joining the two charges is

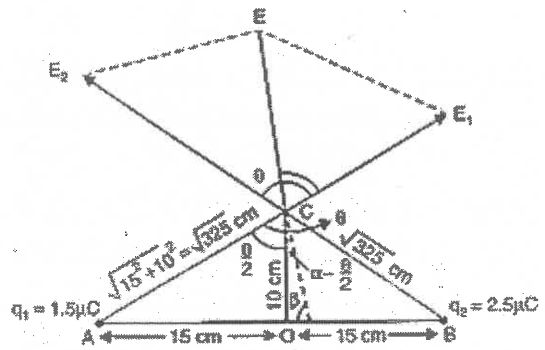
$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r_1} + \frac{q_2}{r_2}\right]$

$= 9\times10^9\left[\frac{15\times10^{-6}}{0.15} + \frac{2.5\times10^{-6}}{0.15}\right]V$

$= 9\times10^9\times10^{-6}\left[10 + \frac{50}{3}\right]$

$= 9\times10^3\times\frac{80}{3}$

Or $V = 2.4\times10^5 V$



Electric field at the mid point O due to charge at A

$= \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_1^2} = 9\times10^9\times\frac{1.5\times10^{-6}}{(0.15)^2}$

$= 6\times10^5 Vm^{-1}$ along OB

Electric field at the mid point O due to charge at B

$= \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_2^2} = 9\times10^9\times\frac{2.5\times10^{-6}}{(0.15)^2}$

$= 10\times10^5 Vm^{-1}$ along OA

Thus, the total electric field at the mid point O is

$E = 10\times10^5 - 6\times10^5$

$= 4\times10^5 Vm^{-1}$ (along BA)

b. Potential at the point C due to the two charges is

$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r_1}+\frac{q_2}{r_2}\right]$

$= 9\times10^9\left[\frac{1.5\times10^{-6}}{\sqrt{3.25}\times10^{-2}}+\frac{2.5\times10^{-6}}{\sqrt{325}\times10^{-2}}\right]V$

$= \frac{9\times10^9\times10^{-6}}{10^{-2}}\cdot\frac{4.0}{\sqrt{325}}V$

$= \frac{9\times4}{18.02}\times10^5 V = 2\times10^5 V$

Electric field at C due to charge at A

$E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_1^2}$

$= 9\times10^9\times\frac{1.5\times10^{-6}}{(\sqrt{325}\times10^{-2})^2}Vm^{-1}$

$= \frac{9\times1.5}{325}\times10^7 Vm^{-1}$

$= 4.15\times10^5 Vm^{-1}$

Electric field at C due to charge at B

$E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_2^2}$

$= 9\times10^9\times\frac{2.5\times10^{-6}}{325\times10^{-4}} = 6.92\times10^5 Vm^{-1}$

If the angle between E_1 and E_2 be θ then

$\tan\frac{\theta}{2} = \frac{0.15}{0.10} = 1.5$

$\frac{\theta}{2} = 56.3^\circ \theta = 112.6^\circ$

Thus, magnitude of resultant field at C is

$E = \sqrt{E_1^2+E_2^2+2E_1E_2\cos\theta}$

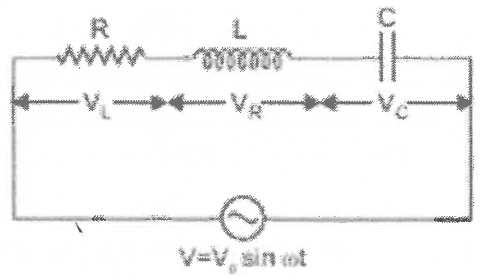
$= \sqrt{(4.15\times10^5)^2+(6.92\times10^5)^2+2\times4.15\times10^5\times6.92\times10^5\cos112.6^\circ}$

$= 10^5\sqrt{17.2+47.8-2\times4.15\times6.92\cos67.4^\circ}$

$(\because \cos(180-\theta) = -\cos\theta)$

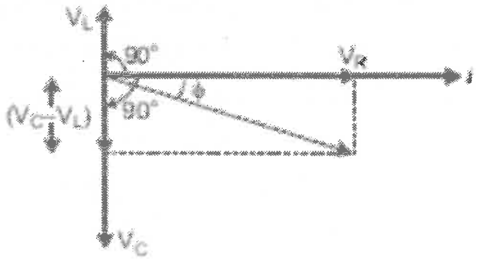
$= 10^5\sqrt{43} = 6.56\times10^5 Vm^{-1}$

33. a. Suppose a resistance R, inductance L and capacitance C are connected to series and an alternating voltage V = $V = V_0 sin wt$ is applied across it.



Since L, C and R are connected in series, current flowing through them is the same. The voltage across R is V_R, inductance across L is V_L and across capacitance is V_C.

The voltage V_R and current i are in the same phase, the voltage V_L will lead the current by angle 90^o while the voltage V_C will lag behind the current by 90^o.



Thus, V_R and (V_C - V_L) are mutually perpendicular and the phase difference between them is 90^o. As seen in the fig, we can say that, as the applied voltage across the circuit is V, the resultant of V_R and V_C - V_L) will also be V.

So,

$$V^2 = V_R^2 + (V_c - V_L)^2$$

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

But, V_R = Ri, V_c = X_ci and V_L = X_Li

where, X_c = $\frac{1}{\omega C}$ and X_L = ωL

So, V = $\sqrt{(Ri)^2 + (X_c i - X_L i)^2}$,

Therefore, impendance of the circuit is given by,

Z = $\frac{V}{i}$ = $\sqrt{(R)^2 + (X_c - X_L)^2}$

Z = $\sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$

This is the impedance of the LCR series circuit.

b. A radio or a TV set has an LC circuit capacitor of variable capacitance C. The circuit remains connected with an aerial coil through the phenomenon of mutual inductance. Suppose a radio or TV station has transmitted a program at frequency f, then waves produce an alternating voltage of frequency in area, due to which an emf of the same frequency is induced in LC circuit. When capacitor C is in circuit is varied then for a particular value of capacitance, C, f = $\frac{1}{2\pi\sqrt{LC}}$, the resonance occurs and maximum current flows in the circuit; so the radio or TV gets tuned.

OR

i. When a source of AC is connected to a capacitor of capacitance C, the charge on it grows from zero to maximum steady value Q_0 .

The energy stored in a capacitor is, $E = \frac{1}{2}CV_0^2$ where, V_0 is maximum potential difference across the plates of the capacitor.

The alternating voltage applied is

$$V = V_0 \sin\omega t$$

and the current leads the emf by a phase angle of $\pi/2$

$$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right) = I_0 \cos\omega t$$

$\therefore$ Work done over a complete cycle is,

$$W = \int_0^T VIdt = \int_0^T (V_0 \sin\omega t)(I_0 \cos\omega t)dt$$

$$= \frac{V_0 I_0}{2}\int_0^T 2\sin\omega t\cos\omega t dt$$

$$\therefore W = \frac{V_0 I_0}{2}\int_0^T \sin 2\omega t dt$$