2013

Part: I

Question: 1 [5]

Answer all questions

1. Choose the correct alternatives A,B, C or D for each of the questions given below:

a. Relative permittivity of water is 81. IF ϵ_w and ϵ_0 are permittivities of water and vacuum respectively, then :

O $\epsilon_0 = 9\,\epsilon_w$

O $\epsilon_0 = 81\,\epsilon_w$

O $\epsilon_w = 9\,\epsilon_0$

O $\epsilon_w = 81\,\epsilon_0$

Answer:
$\epsilon_w = 81\,\epsilon_0$

b. Five resistors are connected as shown in Figure 1.

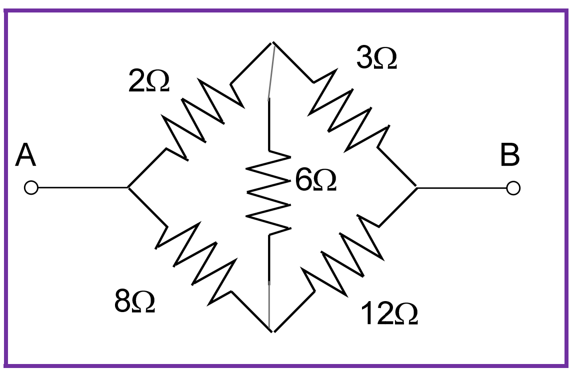


Figure 1

The effective resistance i.e. equivalent resistance between the points A and B is :

O 4Ω

O 5Ω

O 15Ω

O 20Ω

Answer:

4Ω

c. The Biot Savart's Law in vector form is:

- O $\frac{\mu_0}{4\pi}\frac{dl(\vec{I} x \vec{r})}{r^3}$
- O $\frac{\mu_0}{4\pi}\frac{I(\vec{dl} x \vec{r})}{r^3}$
- O $\frac{\mu_0}{\pi}\frac{I(\vec{r} x \vec{dl})}{r^3}$
- O $\frac{\mu_0}{4\pi}\frac{I(\vec{dl} x \vec{r})}{r^2}$

Answer:

$\overrightarrow{\delta B} = \frac{\mu_0}{4\pi}\frac{I(\vec{dl} x \vec{r})}{r^3}$

d. In an astronomical telescope of refracting type:

- O Eyepiece has greater focal length.
- O Objective has greater focal length.
- O Objective and eyepiece have equal focal length.
- O Eyepiece has greater aperture than the objective.

Answer:

Objective has greater focal length.

e. The particles which cannot be accelerated by a cyclotron or a Van de Graff generator are:

- O Alpha particles
- O Beta particles
- O Neutrons
- O Protons

Answer:
Neutrons

2. Answer all questions briefly and to the point: [15]

a. A large hollow metallic sphere has a positive charge of 35.4 μC at its centre. Find how much electric flux emanates from the sphere.

Answer:

$$\text{Electric flux}(\phi_E) = \frac{\text{Electric charge}(q)}{\varepsilon_0}$$

$$= \frac{35.4 \times 10^{-6}}{8.85 \times 10^{-12}}$$

$= 4 \times 10^6$ Nm^2/C

b. A current 'I' flows through a metallic wire of radius 'r' and the free electrons in it drift with a velocity vd. Calculate the drift velocity of the free electrons through the wire of the same material, having double the radius, when same current flows through it.

Answer:
Now Drift velocity

$$v d = \frac{I}{neA}$$

But radius is doubled then new area of cross-section
A' = 4A
Now Drift velocity

$$v d' = \frac{I}{neA'}$$

$$v d' = \frac{I}{4neA'}$$

$$v d' = \frac{v_d}{4} = \frac{1}{4} \text{th of the original}$$

c. Name any one instrument which works on the principle of Tangent law in magnetism.

Answer:
Deflection magnetometer.

d. State the SI unit of magnetic dipole moment.

Answer:
$A - m^2$.

e. Alternating current flowing through a certain electrical device leads over the potential difference across it by 90^0. State whether this device is a resistor, capacitor or an inductor.

Answer:
Capacitor.

f. What is the shape of the wavefront diverging from a point source of light?

Answer:
Spherical wave front.

g. The critical angle for a given transparent medium and air is i_c. A ray of light travelling in air is incident on this transparent medium at an angle of incidence equal to the polarizing angle i_p. What is the relation between the two angles i_c and i_p?

Answer:
For critical angle (ic)

Refractive index (μ) = $\frac{1}{\sin i_c}$

For angle of polarization (i_p)
Refractive index μ = tan i_p
From equation (1) and (2)

$\frac{1}{\sin i_c} = \tan i_p$ or cosec i_c = tan i_p

h. Find the focal length and nature of a lens whose optical power is -5D.

Answer:
Given power of lens = -5D

Focal length = $= \frac{1}{\text{Power of lens}}$

$= \frac{100}{5}$

= -20 cm.
This is concave lens.

i. What is Modulation? Explain in brief.

Answer:
The phenopehnon of super position of message signal with high frequency carrier wave is called modulation.
There are three types of modulation:
i. Amplitude modulation
ii. Frequency modulation
iii. Phase modulation

j. What are the dark lines seen in the solar spectrum called?

Answer:
The dark lines seen in the solar spectrum is called Fraunhofer's lines.

k. What is the relation between wavelength and momentum of moving particles?

Answer:

De-broglie wavelength $\lambda = \frac{h}{\text{Momentum (P)}}$

l. Name the series of lines in the hydrogen spectrum which lies in the ultra-violet region.

Answer:
Lyman series.

m. Fill in the blank in the given nuclear reaction:

$\_\_\_\_\_\_\_\_\_\_\_ + {}^{27}_{13}\text{Al} \rightarrow {}^{25}_{12}\text{Mg} + {}^{4}_{2}\text{He}$

Answer:
${}_1H^2 + {}^{27}_{13}Al \rightarrow {}^{25}_{12}Mg + {}^{4}_{2}He$

n. Give an example where energy is converted into matter.

Answer:
Pair production: when an energetic γ-ray photon falls on a heavy substance, it is absorbed by some nucleus of the substance and its energy gives rise to the production of an electron and a positron.
$h_v \rightarrow {}_{-1}\beta^0 + {}_{+1}\beta^0$
(γ-photon) (electron) (positron)

o. To convert a pure semiconductor into n-type semiconductor, what type of impurity is added to it?

Answer:
Penta-valent impurity is added.

Part: II

Answer six questions in this part, choosing two questions from each of the Sections A, B and C

Section: A

Answer any two questions

Question: 2

i. Write an expression (Derivation not required) for intensity of electric field in :
   a. Axial position.

Answer:
Electric field intensity in axial position

$$E_1 = \frac{1}{r\pi\varepsilon_0}\frac{2p}{r^3}$$

Where p = Electric dipole moment,
r = distance of point from centre of dipole

   b. Broad side position of an electric dipole, in terms of its length (2a) dipole moment (p) and distance (r). [3]

Answer:
Electric field intensity in Broad-side position.

$$E_2 = \frac{1}{r\pi\varepsilon_0}\frac{p}{(r^2 - a^2)^{3/2}}$$

c. What is the ratio of these two intensities i.e E1 : E2, for a short electric dipole?

Answer:

For a short electric dipole a2 may be neglected.

$$\frac{E_1}{E_2} = \frac{2}{1}$$

or $E_1 : E_2 = 2 : 1$

ii. Three capacitors C_1 = 6μF , C_2 = 12μF and C_3 = 20μF are connected to a 100V battery as shown in figure 2 below. [3]

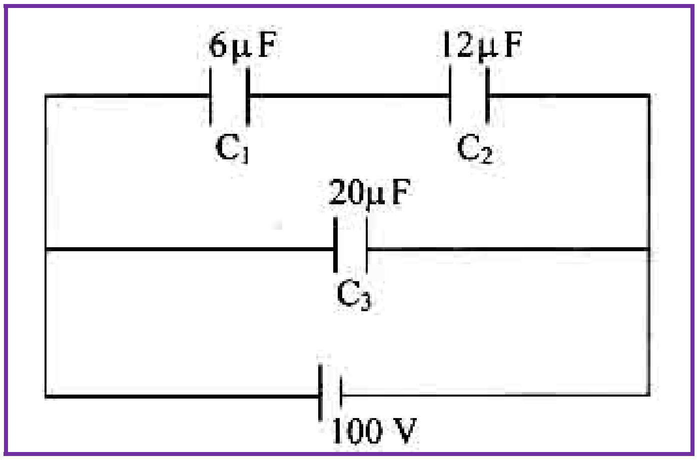


Figure 2

Calculate :

a. Charge on each plate of capacitor C_1.

Answer:

As given figure equivalent capacitance of C_1 and C_2 in series

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{1}{6} + \frac{1}{12} = \frac{2+1}{12} = \frac{3}{12}$$

$$\frac{1}{C_{eq}} = \frac{1}{4}$$

C_{eq} = 4μF

Charge on 4 μF capacitor

.q = CV

= 4 x 10^{-6} x 100

= 4 x 10^{-4} C.

Charge on one plate is +4 x 10^{-4} C.

And on second plate is -4 x 10^{-4} C.

b. Electrostatic potential energy stored in capacitor C_3.

Answer:
Electric potential difference across the plate of C3 capacitor = 100V.

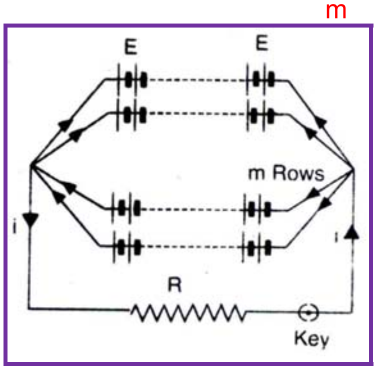
Energy $=\frac{1}{2}CV^2$

$=\frac{1}{2} x 20 x 10^{-6} x 100 x 100$
$= 10^{-1}$
= 0.1 Joule

iii. 'n' Cells , each of emf 'e' and internal resistance 'r' are joined in series to form a row. 'm' such rows are connected in parallel to form a battery of N = mn cells. This battery is connected to an external resistance 'R'.
i. What is the emf of this battery and how much is its internal resistance?

Answer:
Let E_1, E_2.....E_n are emfs and $r_1 r_2$ ……………rn are the internal resistance of n cells.
For 1st cell,
$E_1 = V_1 + I r_1$
$V_1 = E_1 - ir_1$
For IInd cell,
$V_2 = E_2 - ir_2$
For nth cell,
$V_n = E_n - ir_n$
Total voltage difference
$V = V_1 + V_2 + V_3$ ………..V_n
$V = (E_1 + E_2 \ldots\ldots + E_n) - i(r_1+r_2 \ldots\ldots r_n)$
Where
$E_{eq} = E_1 + E_2 \ldots\ldots + E_n$
req = r1 + r2……………= r_n = r
and $r_1 = r_2 \ldots\ldots = r_n = r$
then E_{eq} = nE
r_{eq} = nr
if m rows of series of n cells are connected in parallel then
Total emf of battery
Equivalent emf = nE

Total internal resistance = $\frac{nr}{m}$



ii. Show that current 'I' flowing through the external resistance 'R' is given by :

$I = \frac{Ne}{mR + nr}$ [3]

Answer:

The electric current flow in the circuit

$$I = \frac{\text{Total emf}}{\text{Total resistance}}$$

$$I = \frac{nE}{\frac{nr}{m} + R}$$

$$I = \frac{mnE}{nr + mR}$$

Question: 3

i. In the circuit figure 3 $E_1 = 17V$, $E_2 = 21$ V , $R_1 = 2\Omega$, $R_2 = 3\Omega$, and $R_3 = 5\Omega$. Using Kirchoff's laws, Find the currents flowing through the resistors R_1 , R_2 and R_3. (Internal resistance of each of the batteries are negligible.) [4]

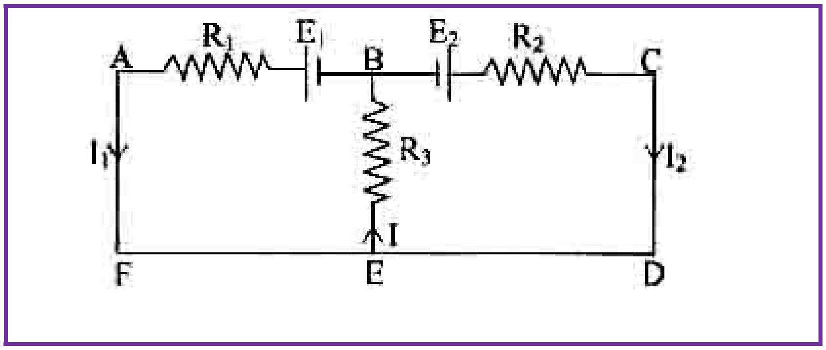


Figure 3

Answer:

Given : $E_1 = 17V$, $E_2 = 21$, $R_1 = 2\Omega$, $R_2 = 3\Omega$ and $R_3 = 5\Omega$

In loop AFEB

$E_1 = i_1R_1 + iR_3$

$17 = 2i_1 = 5i$

In loop BCDE

$E_2 = i_2R_2 + iR_3$

$2I = 3i_2 + 5i$

By Kirchhoff's 1^{st} law, $i_1 + i_2 = i$

From equation (1) and (2)

$17 = 2i_1 + 5(i_1 + i_2)$

$= 2i_1 + 5i_1 + 5i_2$

$17 = 7i_1 + 5i_2$

From equation (2) and (3)

$21 = 3i_2 + 5(i_1 + i_2)$

$= 3i_2 + 5i_1 + 5i_2$

$21 = 5i_1 + 8i_2$

On solving Equation (4) and (5)

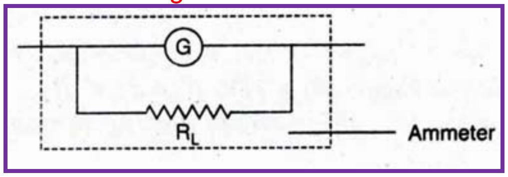
$i_1 = 1A$

$i_2 = 2A$

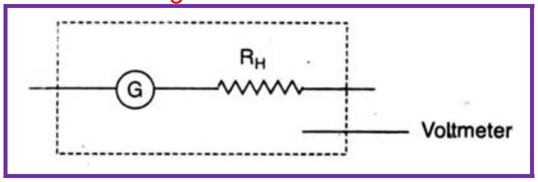
$i = i_1 + i_2 = 1 + 2 = 3A$

ii. You are provided with one low resistance R_1, and one high resistance R_H and two galvanometers. One galvanometer is to be converted to an ammeter and other to a voltmeter. Show how you will do this with the help of simple, labelled diagrams. [2]

Answer:
Convertion of galvanometer into ammeter



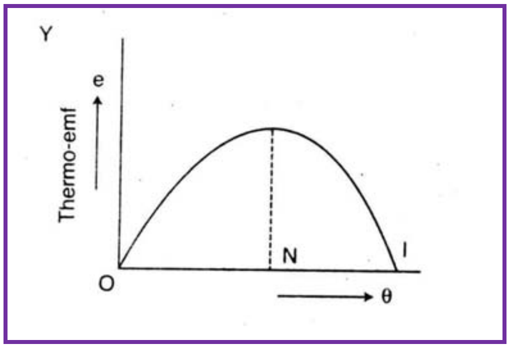
Convertion of galvanometer into voltmeter



iii.

a. Plot a labelled graph to show variation of thermo-emf 'e' versus temperature difference 'θ' between the two junctions of a thermocouple. Mark 'N' as neutral temperature and 'I' as temperature of inversion. [2]

Answer:



b. What is Peltier effect ? [3]

Answer:
When a current is passed through a circuit formed by two dissimilar metals, heat is produced at one junction and absorbed at the other. This effect is known as the Peltier effect.

Question: 4

i. Figure 4 below shows two infinitely long and thin current carrying conductors X and Y kept in vacuum, parallel to each other , at a distance 'a'. [2]

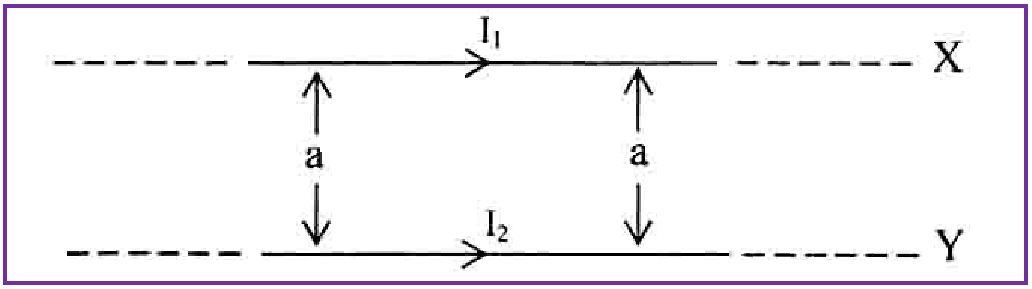


Figure 4

a. How much force per unit length acts on the conductor Y due to the current flowing through X ? Write your answer in terms of $\left(\frac{\mu_0}{4\pi}\right)$, I_1, I_2 , and a.

(Derivation of formula is not required.)

Answer:

The force per unit length acts on the conductor Y due to the current flowing through X is

$$\frac{F}{l} = \frac{\mu_0}{4\pi} \cdot \frac{2I_1I_2}{a}$$

b. Define ampere, in terms of force between two current carrying conductors.

Answer:

The ampere is defined as the amount of electrical current required to maintain a force of 2 x 10^{-7} newton or electrical current required to maintain a force of 2 x 10^{-7} newton per meter between two infinitely long parallel wires of negligible cross section held one meter apart in vacuum.

ii. A metallic rod CD rests on a thick metallic wire PQRS with arms PQ and RS parallel to each other , At a distance l=40 cm, as shown in figure 5. A uniform magnetic field B = 0.1T acts perpendicular to the plane of this paper, pointing inwards (i.e. away from the reader) . The rod is now made to slide towards right, with a constant velocity of v = 5.0 ms^{-1}. [3]

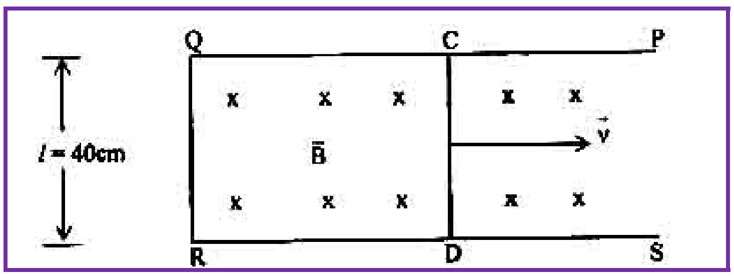


Figure 5

a. How much emf is induced between the two ends of the rod CD ?

Answer:

Induced emf

e = Bvl

= 0.1 x 5 x 0.4

= 0.2 volt

b. What is the direction in which the induced current flows ?

Answer:

Direction of current is D to C, By Flemming right hand rule.

iii.

a. Figure 6 below shows a series RCL circuit connected to an ac source which generates an alternating emf of frequency 50Hz. The readings of the voltmeters V_1 and V_2 are 80V and 60V respectively. [4]

b.

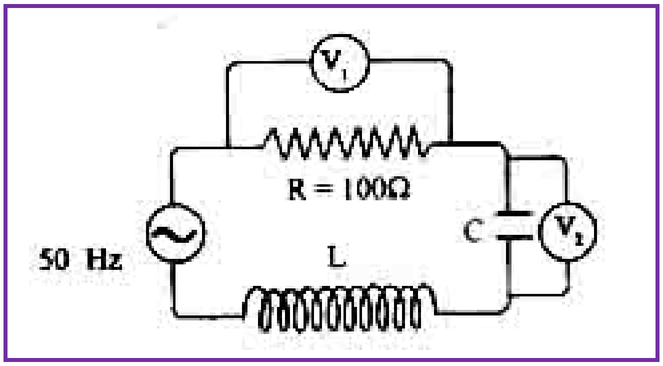


Figure 6

Find:

1. The current in the circuit.

Answer:

Electric current in circuit

$$=\frac{V_R}{R}$$

$$=\frac{80}{100}$$

i = 0.8 A

2. The capacitance C of the capacitor.

Answer:

Current in capacitor

$$i=\frac{V_C}{X_C}$$

$$i=\frac{V_C}{1/\omega C}$$

$$C=\frac{i}{\omega . V_C}=\frac{i}{(2\pi f)V_C}$$

$$C=\frac{0.8}{2 \times 3.14 \times 50 \times 60}$$

C = 42.46 μF.

c. At resonance, what is the relation between impedance of a series LCR circuit and its resistance R?

Answer:

Impedence of LCR circuit

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

At condition of resonance

Xc = XL

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

$$=\sqrt{R^2}$$

Z = R
At resonance impedance is equal to resistance.

Section: B

Question: 5

i.

a. In an electromagnetic wave , how are electric vector ($\vec{E}$), magnetic vector ($\vec{B}$) and velocity of propagation of the wave ($\vec{c}$) oriented ? [2]

Answer:

Electric vector $\vec{E}$, magnetic vector $\vec{B}$ and velocity of propagation of the wave $(\vec{c})$ in an electromagnetic wave are mutually perpendicular to each other.

b. How long would gamma radiation take to travel from sun to earth, a distance of 1.5×10^{11} m?

Answer:

Let speed of gamma radiation is equal to 3×10^8(speed of light)
Distance = 1.5×10^{11} m

$$\text{Time} = \frac{\text{Distance}}{\text{Velocity}}$$

$$= \frac{1.5 \times 10^{11}}{3 \times 10^8}$$

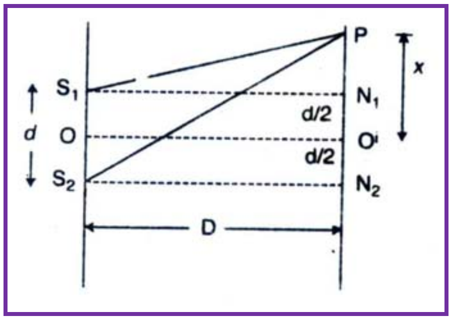
$$= 5 \times 10^2 \text{ sec.}$$

ii. With the help of a labeled diagram, show that fringe separation β in Young's Double Slit experiment is given by : [4]

$$\beta = \frac{\lambda D}{d}$$

Where the terms have their usual meaning.

Answer:



Let S_1 and S_2 are two slits and d is distance between the slits. D is distance between slits and screen then
In Δ's S_1N_1P and S_2N_2P
$S_1P^2 = S_1N_1^2 + N_1P^2$

$$S_1P^2 = D^2 + \left(x - \frac{d}{2}\right)^2 \quad ....(i)$$

and $S_2P^2 = S_2N_2^2 + N_2P_2^2$

$$S_2P^2 = D^2 + \left(x + \frac{d}{2}\right)^2 \quad ....(ii)$$

From equation (i) and (ii)

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

$$(S_2P - S_1P)(S_2P + S_1P) = X^2 + \left(\frac{d}{2}\right)^2 + 2.X.\frac{d}{2} - x^2 - \left(\frac{d}{2}\right)^2 + 2.x.\frac{d}{2}$$

$$(S_2P - S_1P) = \left(\frac{d}{2}\right)^2 \frac{2xd}{S_2P + S_1P}$$

But $S_2P \approx D \approx S_1P$

Path difference $(S_2P - S_1P) = \frac{2xd}{2D} = \frac{xd}{D}$

For bright fringe

Path difference = $n\lambda = \frac{xd}{D}$

$$x_{n-1} = \frac{(n-1)\lambda D}{d}$$

Fringe width = $x_n - x_{n-1}$

$$\beta = \frac{n\lambda D}{d} - \frac{n\lambda D}{d} + \frac{\lambda D}{d}$$

$$\beta = \frac{\lambda D}{d}$$

iii.

a. What is the difference between polarized light and unpolarised light based on the direction of elective vector ($\vec{E}$)? [2]

Answer:

Polarized Light: the vibrations of the electric vector $\vec{E}$ occur in a plane perpendicular to the direction of propagation of light, and are confined to a single direction in the plane.

Unpolarised Light: The vibrations of the electric vector $\vec{E}$ occur symmetrically in all possible directions in a plane perpendicular to the direction of propagation of light.

b. What will be the effect on the width of the central bright fringe in the diffraction of a single slit if :

1. Monochromatic light of smaller wavelength is used.

Answer:

Width of central fringe = $\frac{2\lambda D}{d}$

Width of central fringe decreases.

2. Slit is made narrower.

Answer:
Width of central fringe increases.

Question: 6

i. At what angle, a ray of light should be incident on the first face AB of a regular glass prism ABC so that the emergent ray grazes the adjacent face AC?
See Figure 7 below.(Refractive index of a glass = 1.6) [3]

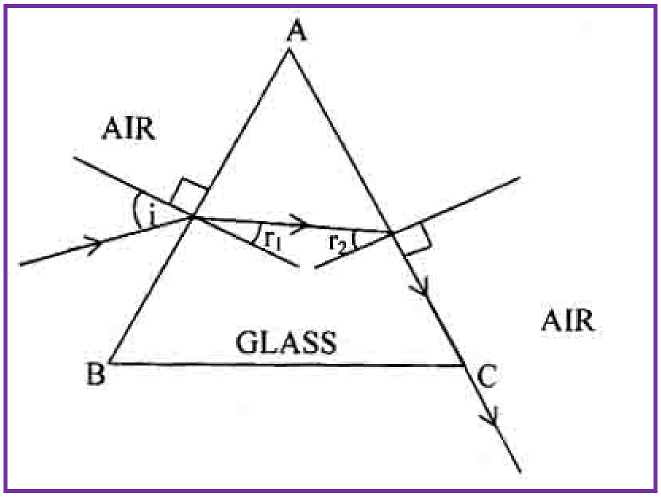


Figure 7

Answer:
At face AC, By Snell's law

$$\sin r_2 = \frac{1}{{}_a\mu_g}$$

$$\sin r_2 = \frac{1}{1.6}$$

$$r_2 = \sin^{-1}\left(\frac{1}{1.6}\right)$$

$$r_2 = 38.68^0$$

And

$$r_2 + r_1 = A$$

$$r_1 = 60 - 38.68$$

$$r_1 = 21.32^0$$

At face AB, By Snell's Law

$$\frac{\sin i}{\sin r} = {}_a\mu_g$$

$$\sin i = \sin r_1 \text{ x } {}_a\mu_g$$

$$\sin i = \sin 21.32^0 \text{ x } 1.6$$

$$\sin i = 0.5817$$

$$i = \sin^{-1}(0.5817)$$

$i = 35.57^0$

ii. A convex lens 'L' and a plane minor 'M' are arranged as shown in Figure 8 below . Position of object pin 'O' is adjusted in such a way that the inverted image 'I' formed by the lens mirror combination, coincides with the object pin 'O' . Explain how and when this happens. [2]

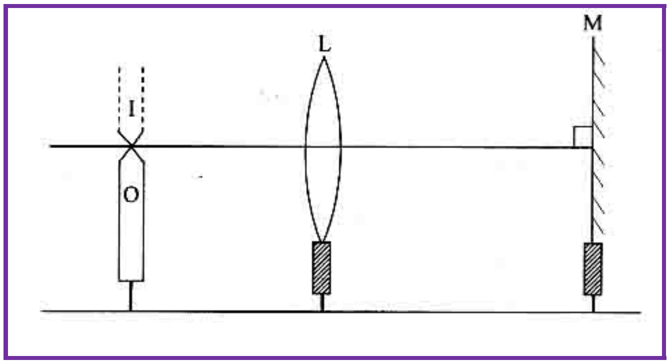
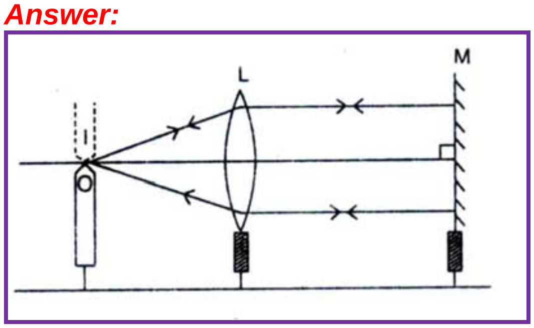


Figure 8

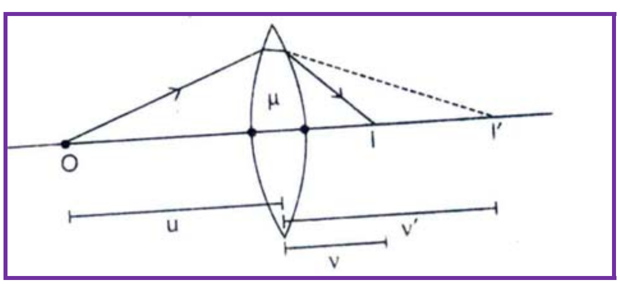
Answer:



When an object pin O lies in the focal plane of the lens L, the rays of light straight from O after refraction from the lens become parallel to the principal axis of the lens and therefore they strike normally on the plane mirror M kept behind the lens. Due to normal incidence (i = 0) , angle of refraction $r = 0^0$ i.e. , the rays are reflected back by the plane mirror on the same path and then they enter the lens as a parallel beam. The lens converges these rays in tits focal plane , thus forming the image I just above the object pin O . The image I is inverted , real and of size same as that of the object O as shown in this figure.

iii. Starting with an expression for refraction at a single spherical surface , obtain an expression for lens maker's formula. [4]

Answer:



Let O is the point object and I' is virtual image formed by 1st surface of lens and I is final image formed by lens, μ is the refractive index of medium lens.
Then by refraction formula at 1st surface (light goes rarer to denser).

$$\frac{\mu}{v'} - \frac{1}{u} = \frac{\mu - 1}{R_1} \text{..................................} (1)$$

At 2nd surface (light goes from denser to rarer).

$$\frac{1/\mu}{v} - \frac{1}{v'} = \frac{1/\mu - 1}{R_2}$$

$$\frac{1}{v} - \frac{\mu}{v'} = \frac{1-\mu}{R_2} \text{..................................} (2)$$

On adding equation (1) and (2)

$$\frac{1}{v} - \frac{1}{u} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \qquad \left[\because \frac{1}{f} = \frac{1}{v} - \frac{1}{u}\right]$$

This is the required lens maker's formula

Question: 7

i. Show that the axial chromatic aberration (fr – fv) for a convex lens is equal to the product of its mean focal length (f) and dispersive power (ω) of its material i.e Prove:
fr - fv = ωf. [3]

Answer:

Let the mean refractive index of the lens be n_Y and the mean focal-length of the lens be f_Y. Then from lens formula , we have

$$\frac{1}{f_Y} = \left(n_y - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \text{..} (i)$$

Similarly for the red and violet lights, we have

$$\frac{1}{f_R} = (n_R - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \text{..} (ii)$$

$$\frac{1}{f_V} = \left(n_v - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \text{..} (iii)$$

From equations (ii) and (iii), we get

$$\frac{1}{f_V} - \frac{1}{f_R} = \left(n_V - n_R\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{f_V} - \frac{1}{f_R} = \left[\frac{n_V - n_R}{n_Y - 1}\right]\frac{1}{f_Y}$$ .... [From equation (i)]

$$\frac{f_R - f_V}{f_V f_R} = \left(\frac{n_V - n_R}{n_Y - 1}\right)\frac{1}{f_Y}$$

Since f_V, f_R and f_Y differ only slightly, we can substitute f_V, f_R. Then we have

$$\frac{f_R - f_V}{f_Y^{\,2}} = \left[\frac{n_V - n_R}{n_Y - 1}\right]\frac{1}{f_Y}$$

$$f_R - f_V = \left(\frac{n_V - n_R}{n_Y - 1}\right)f_Y$$

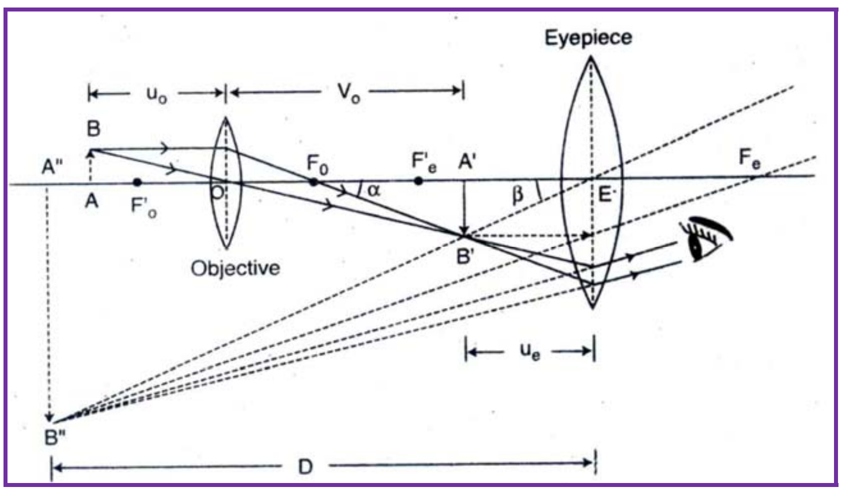
$\left[\frac{n_V - n_R}{n_Y - 1}\right]$ Is the dispersive power of the material of the lens which is dented by ω.

Thus the axial chromatic aberration (Where object is at infinity) of the lens is given by.

$f_R - f_V = \omega \times f_Y$ Proved.

ii. Draw a labeled diagram of an image formed by a compound microscope, with the image at least distance of distinct vision. Write any one expression for its magnifying power. [3]

Answer:



Expression for magnifying power of compound microscope

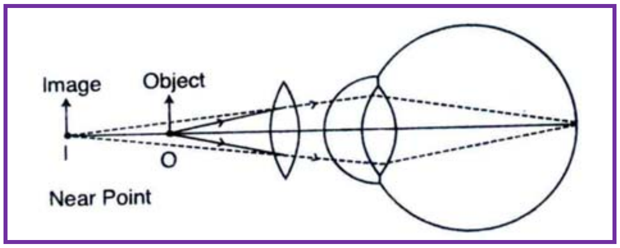
$$m = -\frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$$

iii. What is meant by long-sightedness? How can this defect be corrected? [3]

Answer:

The defect of eye in which a defective person cannot see clearly near object but can see far object is called hypermetropia.

To correct this defect person use covex lens in your spectales.
The corrected diagram is given bellow.



Section: C

Question: 8

i.

a. What is meant by 'Quantization of charge'? [3]

Answer:
The free charge on any body equal to multiple integral of basic charge (charge of electron) i.e.

$$\epsilon = \pm ne$$

b. In Thomson's experiment, prove that the ratio of charge to the mass (e/m) of an electron is given by: $\frac{e}{m}=\frac{1}{2}.\frac{E^2}{B^2}$ where the terms have their usual meaning.

Answer:
When charge is accelerated with voltage difference V then kinetic energy of charge is

$$\frac{1}{2}mv^2 = qV$$

For electron

$$q = e$$

$$\therefore \quad \frac{1}{2}mv^2 = eV$$

$$\frac{e}{m} = \frac{1}{2}\frac{v^2}{V}$$

But $$v = \frac{E}{B}$$

Then $$\frac{e}{v} = \frac{1}{2V}\frac{E^2}{B^2}$$ proved

ii. In a photo-electric cell, a retarding potential of 0.5 V is required to block the movement of electrons from the cathode when monochromatic light of wavelength 400 nm is incident on its surface. Find the work function of the material of the cathode.

Answer:

Given : $V_0 = 0.5$ volt, $\lambda = 400nm = 400 \times 10^{-9}$ m , $W = ?$

We know that

$$E_k = hv - W$$

$$W = hv - eV_0 \qquad (\because E_k = eV_0)$$

$$W = \frac{hc}{\lambda} - eV_0 \qquad \left(\because v = \frac{c}{\lambda}\right)$$

$$W = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{400 \times 10^{-9}} - 1.6 \times 10^{-19} \times 0.5$$

$$W = 4.95 \times 10^{-19} \times -0.8 \times 10^{-19}$$

$$W = 4.15 \times 10^{-19}$$

$$W = 2.59\,eV$$

c. Name a phenomenon or an experiment which proves:

i. particle nature of electro magnetic radiations.

Answer:
Photoelectric effect (Lenared and Millikan exp.)

[3]

ii. wave nature of particles.
(Description of the phenomenon / experiment is not required)

Answer:
Davisson and Germer experiment.

Question: 9

i.
a. State the postulate of Bohr's theory. [3]
I. Angular momentum of an electron

Answer:
Electron revolves in that orbit for which angular momentum of electron is equal to multiple integral of $\frac{h}{2\pi}$ i.e.

$$mvr = n\frac{h}{2\pi}$$

II. Emission of a photon

Answer:

Electron releases energy when it comes from outer orbit into inner orbit and this energy is equal to difference of energies of orbits i.e.

$E_1 - E_2 = h\nu$

b. Total energy of an electron orbiting around the nucleus of an atom is always negative. What is the significance of this?

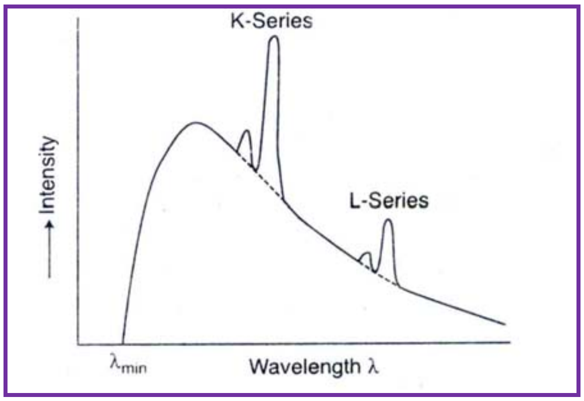
Answer:

The negative energy represent to the attractive force between e^- and nucleus i.e., electron bound with nucleus.

ii.

a. Draw a labeled graph showing variation of relative intensity of X-rays versus their wavelength λ. Mark λmin on the graph. [2]

Answer:



b. State how the value of λmin can be varied.

Answer:

The minimum wavelength is given by

$$\lambda_{min} = \frac{hc}{eV}$$

This shows that the minimum wavelength limit λ_{min} is inversely proportional to the accelerating potential (V).

c. Half life of a certain radioactive substance is 6 hours. If you had 3.2 kg of this substance in the beginning, how much of it will disintegrate in one day?

Answer:

Given N_0 = 3.2 kg. , Half-life = 6 hrs. , t = 24 hrs

Number of half-lives = $n = \frac{24}{6} = 4$

$$N = N_0 \left(\frac{1}{2}\right)^n$$

$= 3.2 \left(\frac{1}{2}\right)^4$

$= 3.2 \text{ x } \frac{1}{16}$

N = 0.2 kg

Question: 10

i.

a. What is the significance of binding energy per nucleon of a nucleus? [3]

Answer:

The significance of building energy per nucleon is that higher the average binding energy per nucleon, greater is the stability of the nucleus.

b. In a certain star, three alpha particles undergo fusion in a single reaction to form $^{12}_{6}C$ nucleus. Calculate the energy released in this reaction in MeV. [3]

Given: m($^{4}_{2}He$) = 4.002604 u and m($^{12}_{6}C$) = 12.000000 u.

Answer:

Mass of Helium nucleus ($_2He^4$)

= 3 x 4.002604 u

= 12.007812 u

Mass of $_6C^{12}$ = 12.000000 u

Mass defect Δm = 12.007812 – 12.000000

= 0.007812 u

E = Δm x 931 MeV

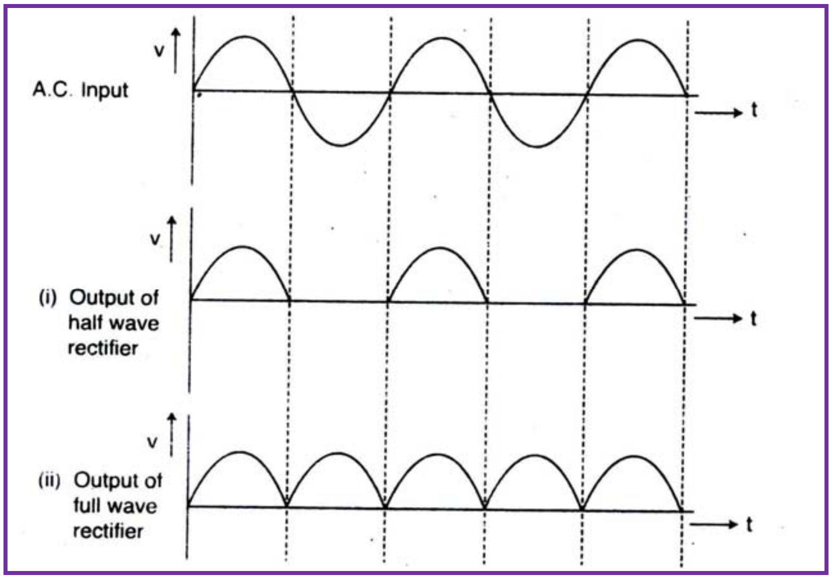
= 0.007812 x 931 MeV

E = 7.2929 MeV

ii. Show by drawing labelled diagram, the nature of output voltages in case of: [3]

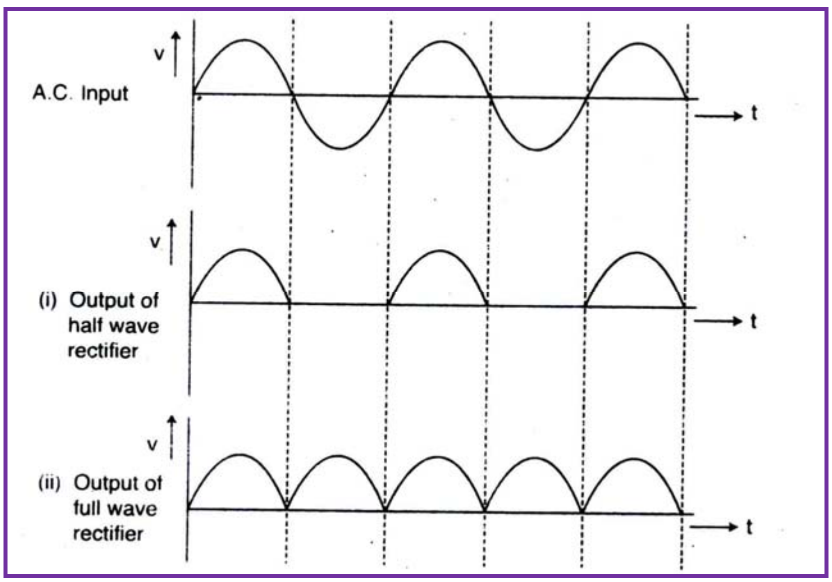
a. A half wave rectifier

Answer:



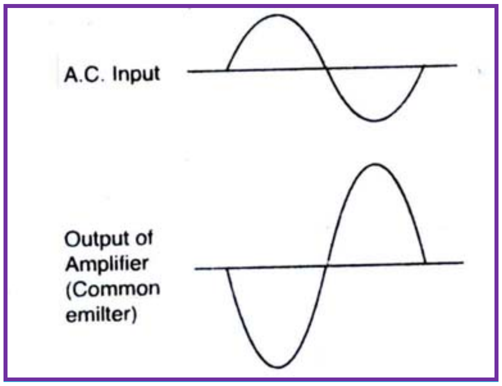
b. A full wave rectifier.

Answer:



c. An amplifier (In each case, input is an ac voltage)
Circuit diagrams of these devices are not required.

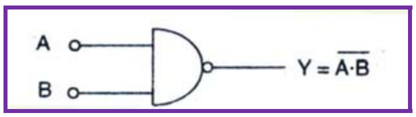
Answer:



iii. Identify the logic gates whose truth table is given below and draw its symbol: [2]

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Answer:
It is a NAND gate



Useful constants and relations:

Uses of Constants and Relations:		
1.	Speed of Light in vacuum	(c) = 3.0 x 108 ms^{-1}
2.	Planck's constant	(e) = 6.6 x 10^{-34} Js
3.	Charge of a proton	(h) = 1.6 x 10^{-19} C
4.	Permittivity of vacuum	(ε_0) = 8.85 x 10^{-12} Fm^{-1}
5.	Permeability of vacuum	(μ_0) = 4π x 10^{-7} Hm^{-1}
6.	Unified atomic mass unit	(1u) = 931 MeV
7.	Unified Atomic Mass Unit	1nm = 10^{-9} m