Class: XII

SESSION : 2022-2023

SUBJECT: PHYSICS (THEORY)

SAMPLE QUESTION PAPER - 24

with SOLUTION

Maximum Marks: 70 Marks **Time Allowed**: 3 hours.

General Instructions:

(1) There are 35 questions in all. All questions are compulsory

(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.

(3) Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.

(4) There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.

5. Use of calculators is not allowed.

Section A

1. When light rays from the sun fall on a convex lens along the direction parallel to its axis: **[1]**

   a) focal length for all colours is the same
   b) focal length for red colour is the shortest
   c) focal length for violet colour is the shortest
   d) focal length for yellow colour is the longest

2. If potential (in volts) in a region is expressed as V(x, y, z) = 6xy - y + 2yz, the electric field (in N/C) at point (1, 1, 0) is: **[1]**

   a) $-(6\hat{i}+5\hat{j}+2\hat{k})$
   b) $-(2\hat{i}+3\hat{j}+\hat{k})$
   c) $-(6\hat{i}+9\hat{j}+\hat{k})$
   d) $-(3\hat{i}+5\hat{j}+3\hat{k})$

3. The energy band gap is maximum in: **[1]**

   a) Metals
   b) Insulators
   c) Superconductors
   d) Semiconductors

4. The p-n junction diode works as insulator, if connected: **[1]**

   a) none of these
   b) AC
   c) in reverse bias
   d) in forward bias

5. X-rays are produced when an element of high atomic weight is bombarded by high energy **[1]**

a) electrons

b) neutrons

c) protons

d) photons

6. If two coils of inductances L_1 and L_2 are linked such that their mutual inductance is M, then the maximum value of M is **[1]**

a) $L_1 - L_2$

b) $L_1 + L_2$

c) $L_1 \times L_2$

d) $\sqrt{L_1 L_2}$

7. Radio wave diffracts around building although light waves do not. The reason is that radio waves: **[1]**

a) are not electromagnetic waves

b) carry news

c) travel with speed larger than C

d) have much larger wavelength than light

8. In Young's double-slit experiment, the source is white light. One of the holes is covered by a red filter and another by a blue filter. In this case **[1]**

a) there shall be an interference pattern for red distinct from that for blue

b) there shall be no interference fringes

c) there shall be alternate interference patterns of red and blue

d) there shall be an interference pattern for red mixing with one for blue

9. The ratios between Bohr radii are **[1]**

a) 1 : 4 : 9

b) 1 : 3 : 5

c) 2 : 4 : 6

d) 1 : 2 : 3

10. An n-type semiconductor is formed by adding impurity materials: **[1]**

a) cobalt, aluminium or selenium

b) aluminium, boron or selenium

c) phosphorus, antimony or arsenic

d) aluminium, boron or indium

11. Electric charges are distributed in a small volume. The flux of the electric field through a spherical surface of radius 1 m surrounding the total charge is 100 V-m. The flux over the concentric sphere of radius 2 m will be: **[1]**

a) 200 V-m

b) 50 V-m

c) 25 V-m

d) 100 V-m

12. The SI unit of electric flux is: **[1]**

a) newton per coulomb

b) volt $\times$ meter

c) joule per coulomb

d) weber

13. Which one of the following statements is wrong in the context of X-rays generated from an X-ray tube? **[1]**

a) Wavelength of characteristic X-rays decreases when the atomic number of the target increases.

b) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target.

c) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube.

d) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in the X-ray tube.

14. Two identical photocathodes receive light of frequencies v_1 and v_2. If the velocities of the photoelectrons (of mass m) coming out are v_1 and v_2 respectively, then: **[1]**

a) $v_1^2 + v_2^2 = \frac{2h}{m}(v_1 - v_2)$

b) $v_1 - v_2 = \left[\frac{2h}{m}(v_1 - v_2)\right]^{1/2}$

c) $v_1^2 - v_2^2 = \frac{2h}{m}(v_1 - v_2)$

d) $v_1 + v_2 = \left[\frac{2h}{m}(v_1 - v_2)\right]^{1/2}$

15. **Assertion (A):** The average thermal velocity of the electrons in a conductor is zero. **[1]**
Reason (R): The direction of motion of electrons is randomly oriented.

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

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

16. **Assertion (A):** Unlike electric forces and gravitational forces, nuclear force has limited range. **[1]**
Reason (R): Nuclear force do not obey inverse square law.

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

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

17. What is the charge induced in coil of 100 turns of resistance 100 Ω, if magnetic flux changes from 2 Tm^2 to - 2 Tm^2? **[1]**

a) 0.4 C

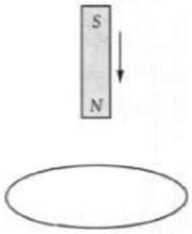
b) 2 C

c) 2.8 C

d) 4 C

18. **Assertion (A):** The bar magnet falling vertically along the axis of the horizontal coil will be having an acceleration of less than g. **[1]**

Reason (R): Clockwise current is induced in the coil.



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

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

Section B

19. i. The work function for the surface of aluminium is 4.2 eV. How much potential difference will be required to stop the emission of maximum energy electrons emitted by light of 2000 Å wavelength? **[2]**

ii. What will be the wavelength of that incident light for which stopping potential will be zero? Given h = 6.6×10^{-34} Js, c = $3 \times 10^{8} ms^{-1}$.

20. Must every magnetic field configuration have a north pole and a south pole? What about the field due to a toroid? **[2]**

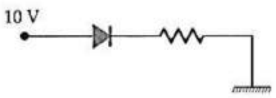
OR

A short bar magnet of magnetic moment 0.9 JT^{-1} is placed with its axis at 30^{o} to a uniform magnetic field. It experiences a torque of 0.063 J.

i. Calculate the magnitude of the magnetic field.

ii. In which orientation will the bar magnet be in stable equilibrium in the magnetic field?

21. In the circuits shown in figure, which one of the two diodes is forward biased and which is reverse biased? **[2]**

i. 

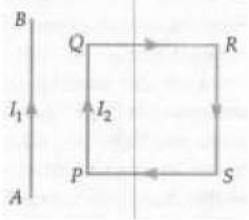
ii. 

22. What is meant by binding energy per nucleon? The binding energies of deutron (${}_1H^2$) and alpha particle (${}_2H^4$) are 1.25 and 7.2 MeV per nucleon respectively. Which nucleus is more stable? **[2]**

23. A galvanometer can be converted into a voltmeter of a certain range by connecting a resistance of 980Ω in series with it. When the resistance is 470Ω connected in series, the range is halved. Find the resistance of the galvanometer. **[2]**

OR

In Fig. the straight wire AB is fixed while the loop PQRS is free to move under the influence of the electric currents flowing in them. In which direction does the loop begin to move? Give reason for your answer.



24. Two monochromatic waves emanating from two coherent sources have the displacements represented by, $y_1 = a \cos \omega t$ and $y_2 = a \cos (\omega t + \phi)$, where ϕ is the phase difference between the two displacements. Show that the resultant intensity at a point due to their superposition is given by $I = 4I_0 \cos^2 \frac{\phi}{2}$, where $I_0 \propto a^2$. Hence obtain the conditions for constructive and destructive interference. **[2]**

25. Explain the two processes involved in the formation of a p-n junction diode. Hence define the term barrier potential. **[2]**

Section C

26. Two short magnets a and b of magnetic moments 0.108 Am^2 and 0.192 Am^2 are placed along mutually perpendicular straight lines meeting at a point P. Find the magnitude and direction of magnetic field at point P, if it lies at distances 30 cm and 60 cm respectively from the centres of the two magnets. **[3]**

27. Define the term electric dipole moment. Is it a scalar or vector? Deduce an expression for the electric field at a point on the equatorial plane of an electric dipole of length 2a. **[3]**

28. Mrs. Rajlakshmi had a sudden fall and was thereafter unable to stand straight. She was in great pain. Her daughter Rita took her to the doctor. The doctor took a photograph of Mrs. Rajlakshmi's bones and found that she had suffered a fracture. He advised her to rest and take the required treatment. **[3]**

    i. Name the electromagnetic radiation used to take the photograph of the bones.
    ii. How is this radiation produced?
    iii. Mention the range of the wavelength of this electromagnetic radiation.
    iv. Write two values displayed by Rita.

OR

Answer the following questions:

i. Name the EM waves which are suitable for RADAR systems used in aircraft navigation. Write the range of frequency of these waves.
ii. If the earth did not have atmosphere, would its average surface temperature be higher or lower than what it is now? Explain.
iii. An EM wave exerts pressure on the surface on which it is incident. Justify.

29. i. Compare Maxwell's electromagnetic theory with the Huygens wave theory of light. **[3]**

ii. Define the incident angle of a light wave.

OR

Monochromatic light of wavelength 589 nm is incident from air on a water surface. What are the wavelength, frequency and speed of (a) reflected, and (b) refracted light? Refractive index of water is 1.33.

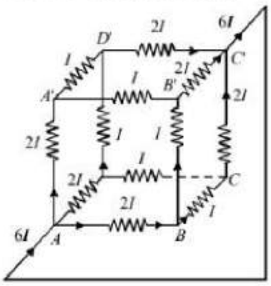
30. i. Obtain the expression for the cyclotron frequency. **[3]**

ii. A deuteron and a proton are accelerated by the cyclotron. Can both be accelerated with the same oscillator frequency? Give a reason to justify your answer.

Section D

31. i. State Kirchhoffs rules. **[5]**

ii. A battery of 10 V and negligible internal resistance is connected across the diagonally opposite corners of a cubical network consisting of 12 resistors each of 1Ω resistance.



Use Kirchhoffs rules to determine

a. the total current in the network.

b. the equivalent resistance of the network

OR

Two cells of emfs 1.5 V and 2 V and internal resistances 2 Ω and 1 Ω respectively have their negative terminals joined by a wire of 6 Ω and positive terminals by a wire of 4 Ω resistance. A third resistance wire of 8 Ω connects the middle points of these wires. Draw the circuit diagram. Using Kirchhoff laws, find the potential difference at the end of this third wire.

32. a. Derive the expression for the angle of deviation for a ray of light passing through an equilateral prism of refracting angle A. **[5]**

b. A prism is found to give a minimum deviation of 51°. The same prism gives a deviation of 62°48' for two values of the angles of incidence, namely, $46^{\circ}6'$ and $82^{\circ}42'$. Determine the refractive angle of the prism and the refractive index of its material.

OR

An angular magnification of 30X is desired using an objective of focal length 1.25 cm and an eyepiece of focal length 5 cm. How will you set up the compound microscope?

33. Draw a schematic arrangement of the Geiger-Marsden experiment for studying a-particle scattering by a thin foil of gold. Describe briefly by drawing trajectories of the scattered α-particles, how this study can be used to estimate the size of the nucleus? **[5]**

OR

For scattering by an inverse-square field (such as that produced by a charged nucleus in Rutherford's model) the relation between impact parameter b and the scattering angle θ is given by

$$b=\frac{Ze^2\cot\theta/2}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$$

a. What is the scattering angle for b = 0?

b. For a given impact parameter b, does the angle of deflection increase or decrease with increase in energy?

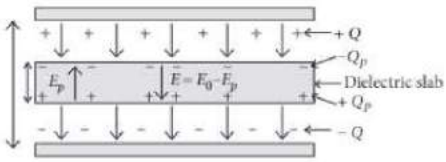
c. What is the impact parameter at which the scattering angle is 90° for Z = 79 and initial energy equal to 10 MeV?

d. For a given energy of the projectile, does the scattering angle increase or decrease with decrease in impact parameter?

Section E

34. **Read the text carefully and answer the questions:** **[4]**

A dielectric slab is a substance which does not allow the flow of charges through it but permits them to exert electrostatic forces on one another. When a dielectric slab is placed between the plates, the field E_0 polarises the dielectric. This induces charge $-Q_p$ on the upper surface and $+Q_p$ on the lower surface of the dielectric. These induced charges set up a field E_p inside the dielectric in the opposite direction of $\vec{E}_0$ as shown.



(i) In a parallel plate capacitor, the capacitance increases from 4 μF to 80 μF, on introducing a dielectric medium between the plates. What is the dielectric constant of the medium?

(ii) A parallel plate capacitor with air between the plates has a capacitance of 8 pF. The separation between the plates is now reduced half and the space between them is filled with a medium of dielectric constant 5. Calculate the value of capacitance of the capacitor in second case.

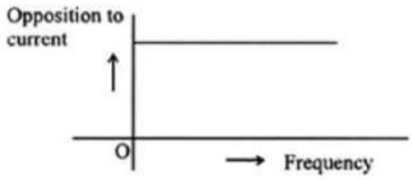
(iii) What happens to the charge and the electric field between the plates of capacitor on introducing the dielectric between the plates of capacitor?

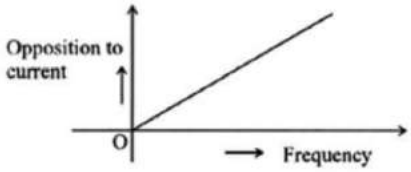
OR

A parallel plate capacitor of capacitance 1 pF has separation between the plates is d. When the distance of separation becomes 2d and wax of dielectric constant x is inserted in it the capacitance becomes 2pF. What is the value of x?

35. **Read the text carefully and answer the questions:** **[4]**

The graphs (a) and (b) represent the variation of the opposition offered by the circuit element to the flow of alternating current with the frequency of the applied emf.





(i) Identify the circuit element corresponding to graph A

(ii) Write the expression for the impedance offered by the series combination of the above two elements connected across the AC sources.

(iii) Which will be ahead in phase in this circuit, voltage or current?

OR

Identify the circuit element corresponding to graph B

SOLUTION

Section A

1. **(c)** focal length for violet colour is the shortest
   Explanation: When light rays from the sun fall on a convex lens along the direction parallel to its axis the focal length for violet color is the shortest.

2. **(a)** $-(6\hat{i} + 5\hat{j} + 2k)$
   Explanation: Given that V = 6xy - y + 2yz
   Now, $\vec{E} = -\left(\hat{i}\frac{\partial V}{\partial x} + \hat{j}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$
   $= -[(6y)\hat{i} + (6x - 1 + 2z)\hat{j} + (2y)\hat{k}]$
   $\therefore \vec{E}$ at (1, 1, 0) = $-(6\hat{i} + 5\hat{j} + 2\hat{k})$

3. **(b)** Insulators
   Explanation: Insulators
4. **(c)** in reverse bias
   Explanation: in reverse bias
5. **(a)** electrons
   Explanation: X-rays are produced when an element of high atomic weight is bombarded by high energy electrons.
6. **(d)** $\sqrt{\mathrm{L_1L_2}}$
   Explanation: $M = k\sqrt{L_1L_2}$
   here k is coefficient of coupling. Its maximum value is 1 for tight coupling.
7. **(d)** have much larger wavelength than light
   Explanation: Radio wave have much larger wavelength than light wave.
8. **(b)** there shall be no interference fringes
   Explanation: For sustained interference, the source must be coherent and should emit the light of same frequency.
   In the Young Double Slit experiment, one hole is covered with red and other with blue, which has different frequency, so no interference takes place.
9. **(a)** 1 : 4 : 9
   Explanation: $r_n \propto n^2$
   or $1^2 : 2^2 : 3^2$
10. **(c)** phosphorus, antimony or arsenic
    Explanation: phosphorus, antimony or arsenic
11. **(d)** 100 V-m
    Explanation: Flux does not depend on the size and shape of the close surface, and so, it remains the same.
12. **(b)** volt $\times$ meter
    Explanation: SI unit of electric flux is
    $\frac{\mathrm{N \times m^2}}{\mathrm{C}} = \frac{\mathrm{J \times m}}{\mathrm{C}}$ = volt $\times$ m

13. **(b)** Cut-off wavelength of the continuous X-rays depends on the atomic number of the target.
Explanation: Cut-off wavelength of the continuous X-rays depends on the atomic number of the target.

14. **(c)** $v_1^2 - v_2^2 = \frac{2h}{m}(v_1 - v_2)$
Explanation: $hv_1 = hv_0 + \frac{1}{2}mv_1^2$
$hv_2 = hv_0 + \frac{1}{2}mv_2^2$
$\therefore \quad h(v_1 - v_2) = \frac{1}{2}m(v_1^2 - v_2^2)$
$\therefore \quad v_1^2 - v_2^2 = \frac{2h}{m}(v_1 - v_2)$

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

16. **(b)** Both A and R are true but R is not the correct explanation of A.
Explanation: Both A and R are true but R is not the correct explanation of A.

17. **(d)** 4 C
Explanation: Magnetic flux change per coil
$= 2 - (-2)\ \mathrm{Tm}^2 = 4\ \mathrm{Tm}^2$
$\frac{E}{R} = i = \frac{dQ}{dt}, \quad E = -\frac{d\phi}{dt}$
$\therefore dQ = \frac{4 \times 100}{100} = 4\ \mathrm{C}$

18. **(c)** A is true but R is false.
Explanation: Due to the change of flux, the anticlockwise current is induced in the coil which opposes the motion of the magnet and so $a < g$.

Section B

19. i. Here $W_0 = 4.2 \text{ eV} = 4.2 \times 1.6 \times 10^{-19}$ J,

$\lambda = 2000 \text{ Å} = 2000 \times 10^{-10}$m, V_0 = ?

The maximum K.E. of the emitted photoelectron,

$K_{\max} = \frac{hc}{\lambda} - W_0$

$= \frac{6.6\times10^{-34}\times3\times10^{8}}{2000\times10^{-10}} - 4.2 \times 1.6 \times 10^{-19}$

$= 3.18 \times 10^{-19}$J

Stopping potential,

$V_0 = \frac{K_{\max}}{e}$

$= \frac{3.18\times10^{-19}}{1.6\times10^{-19}}$ = 1.9875 V.

ii. For threshold wavelength λ_0, $K_{\max} = 0$. Hence

$\lambda_0 = \frac{hc}{W_0} = \frac{6.6\times10^{-34}\times3\times10^{8}}{4.2\times1.6\times10^{-19}}$

$= 2.946 \times 10^{-7}$ m = 2946 Å.

20. No, it is not necessary that every magnetic field configuration have a north pole and a south pole. This is true only if the source of the magnetic field has a net non-zero magnetic moment.

A toroid and infinite straight conductor do not have north and south poles because both have no net magnetic moment.

OR

i. Magnetic moment M = 0.9 J/T

$\tau = 0.063$ J, $\theta = 30^{\circ}$

We know $\tau = M \times B$

$= MB \sin\theta$

$0.063 = 0.9 \times B \times \sin 30^{o}$

$B = \frac{2\times0.063}{0.9} = 0.14$ T

ii. Stable equilibrium is position of minimum energy. Since $U = -\vec{M}\cdot\vec{B}$

U = - MB cos θ

Where U is the energy stored or P.E. of the magnet inside magnetic field B.

So, when $\theta = 0$, U = -MB is the minimum energy.

Thus, when $\vec{M}$ and $\vec{B}$ are parallel to each other bar magnet is in stable equilibrium.

21. i. The p-n junction is reverse biased.
    ii. The p-n junction is forward biased.
22. Binding energy per nucleon is defined as the average energy required to extract one nucleon from the nucleus. The stability of a nucleus depends upon its binding energy per nucleon. More is the binding energy, more stable is the nucleus.

    Given: Binding energies of deutron ($_1H^2$) and alpha particle ($_2H^4$) are 1.25 and 7.2 MeV per nucleon respectively.

    Since binding energy per nucleon of alpha particle is greater than that of deutron, therefore, alpha particle is more stable than deutron.
23. The current for full scale deflection of a voltmeter is given by

    $I_g = \frac{V}{R_g+R}$

    In first case, $I_g = \frac{V}{R_g+980}$

    In second case, $I_g = \frac{V/2}{R_g+470}$

    $\therefore \frac{V}{R_g+980} = \frac{V}{2(R_g+470)}$

    or $2R_g + 940 = R_g + 980$

    or $R_g = 40\ \Omega$

OR

The currents in QR and PS have no effect on AB. There is a force of attraction between AB and PQ and a force of repulsion between AB and SR. But PQ is closer to AB than SR, so force of attraction is stronger than the force of repulsion. So the loop begins to move towards AB.

24. By the principle of superposition, the resultant displacement at the observation point will be y = $y_1 + y_2$ = a [cos ωt + cos $(\omega t + \phi)$]

    $= 2a \cos\frac{\phi}{2}\cdot \cos\left(\omega t + \frac{\phi}{2}\right)$

    Amplitude of the resultant displacement = $2a \cos\frac{\phi}{2}$

    $\because$ Intensity $\propto$ (amplitude)^2

    $\therefore$ Intensity, I = $4ka^2 \cos\frac{\phi}{2}$, where k = a proportionality constant.

    If I_0 is the intensity of each source, then $I_0 = ka^2$ and $I = 4I_0 \cos^2\frac{\phi}{2}$

    For constructive interference:

    $\cos\frac{\phi}{2} = \pm1$ or $\frac{\phi}{2} = n\pi$ or $\phi = 2n\pi$

For destructive interference :

$\cos\frac{\phi}{2} = 0$ or $\frac{\phi}{2} = (2n+1)\frac{\pi}{2}$ or $\phi = (2n+1)\pi$

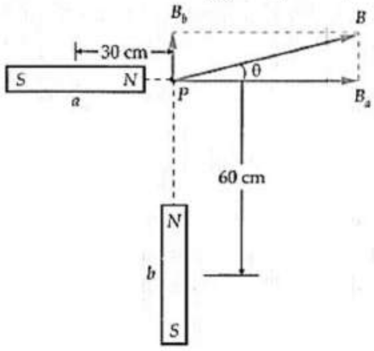
25. **Diffusion:** It is the process of movement of majority charge carriers from their majority zone (i.e., electrons from n p and holes from p → n) due to the electric field developed at the junction. Motion gives rise to diffusion current.

Drift: Process of movement of minority charge carriers (Le., holes from n → p and electrons from p → n) due to the electric field developed at the junction.

Barrier potential: The loss of electrons from the n-region and gain of electrons by p-region causes a difference of potential across the junction, whose polarity is such as to oppose and then stop the further flow of charge carriers. This (stopping) potential is called Barrier potential.

Section C

26. As shown in figure, the point P lies on the axial line of both the magnets a and b.



$\therefore B_a = \frac{\mu_0}{4\pi}\frac{2m_1}{r_1^3} = \frac{10^{-7}\times2\times0.108}{(0.30)^3}$

$= 8 \times 10^{-7}$ T (along the axis of a)

$B_b = \frac{\mu_0}{4\pi}\cdot\frac{2m_2}{r_2^3} = \frac{10^{-7}\times2\times0.192}{(0.60)^3}$

$= 2 \times 10^{-7}$ T (along the axis of b)

The resultant field at P is

$B = \sqrt{B_a^2 + B_b^2} = 10^{-7}\sqrt{8^2+2^2} = 8.24 \times 10^{-7}$ T

If the field B makes angle θ with the direction of B_a, then

$\tan\theta = \frac{B_b}{B_a} = \frac{2}{8} = 0.25$ or $\theta = 14^{\circ}$

27. Electric dipole moment of an electric dipole is equal to the product of its either charge and the length of the electric dipole. It is denoted by p.

Unit of dipole moment is C-m.

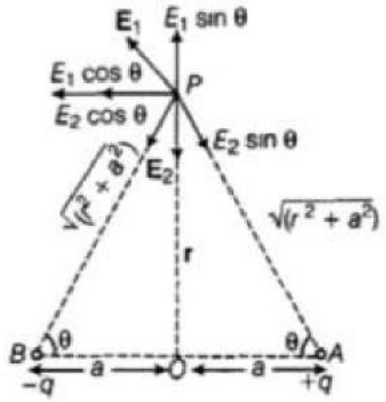
It is a vector quantity and its direction is from a negative charge to positive charge.

Let an electric dipole AB consists of two charges +q and -q separated by a distance 2a.

Electric field at point P due to charge +q,

$E_1 = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{\left[\sqrt{r^2+a^2}\right]^2}$

$E_1 = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{(r^2+a^2)}$ along AP



Electric field at point P due to charge -q placed at B

$E_2 = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{r^2+a^2}$ along PB

On resolving E_1 and E_2 into rectangular components, we get the resultant electric field at point P. Here vertical components of electric field will cancel each other, so resultant electric field will be towards left which can be calculated as -

$E = E_1 \cos\theta + E_2 \cos\theta$

$= \frac{1}{4\pi\varepsilon_0} \times \frac{q}{(r^2+a^2)}\cos\theta + \frac{1}{4\pi\varepsilon_0} \times \frac{q}{(r^2+a^2)}\cos\theta$

$= 2 \times \frac{1}{4\pi\varepsilon_0} \times \frac{q}{(r^2+a^2)} \times \frac{a}{\sqrt{(r^2+a^2)}}$

$= \frac{1}{4\pi\varepsilon_0} \times \frac{q.2a}{(r^2+a^2)^{3/2}}$

$\therefore E = \frac{1}{4\pi\varepsilon_0} \times \frac{p}{(r^2+a^2)^{3/2}}$

If r >> a, i.e., for short dipole we have

$E = \frac{1}{4\pi\varepsilon_0} \times \frac{p}{r^3}$

This equation shows that electric field due to dipole at a distance 'r' from its perpendicular bisector decreases with r and proportional to dipole moment.

28. a. X-rays
    b. By using X-rays tubes (Or: By bombarding a metal target with high energy electrons)
    c. The wavelength range of X-rays is from (10 nm to 10 pm)
    d. Alertness, empathy; concern for her mother, knowledgeable.

OR

i. The EM waves suitable for radar systems is microwaves. These rays are produced by special vacuum tubes, namely klystrons, magnetrons and Gunn diodes. The frequency range for this wave is from 300 MHz to 300 GHz.
ii. The temperature of the earth would be lower because the greenhouse effect of the atmosphere(which maintains the average temperature of earth) would be absent.
iii. An EM wave has momentum, i.e. p = Energy(E) / Speed of light(c)
    That's why when it is incident upon a surface it exerts pressure on it, known as radiation pressure.

29. i. The two theories are similar in the respect that according to both the theories, light is a wave motion. However by electromagnetic theory light does not need any medium to propagate while by Huygen's, wave theory a medium is a must. That is why he assumed a hypothetical medium 'ether' through which light wave travels in a vacuum.

ii. The angle between incident wavefront with the interface is called the incident angle of the light wave.

OR

Given, $\lambda = 589nm$
$c = 3 \times 10^8 m/s, \mu = 1.33$

a. For reflected light,
Wavelength $\lambda = 589nm = 589 \times 10^{-9}m$
$\nu = \frac{c}{\lambda} = \frac{3\times10^8}{589\times10^{-9}}$
$= 5.09 \times 10^{14} Hz$
Hence, the speed, frequency, and wavelength of the reflected light are 3×10^8 m/s, 5.09×10^{14} Hz, and 589 nm respectively.

b. Frequency of light does not depend on the property of the medium in which it is travelling. Hence, the frequency of the refracted ray in water will be equal to the frequency of the incident or reflected light in air.
$v = \frac{c}{\mu}$
$v = \frac{3\times10^8}{1.33} = 2.26 \times 10^8 \mathrm{m/s}$
Wavelength of light in water is given by the relation,
$\lambda = \frac{c}{\nu}$
$= \frac{2.26\times10^8}{5.09\times10^{14}}$
$= 444.007 \times 10^{-9}\mathrm{m} = 444.01\ nm$
Hence the speed, frequency and wavelength of refracted light are 2.26×10^8 m/s, 5.09×10^{14} Hz and 444.01 nm respectively.

30. i. In a cyclotron, a charged particle is accelerated between the gaps of two dees. As, the charge particle completes one rotation both dees change their polarity and charged particle is accelerated toward another dees. In this way, the charged particle moves in the circular path whose radius is r,in the presence of magnetic field created by magnetic poles. Thus, in equilibrium,
magnetic force on q = centripetal force on q.
$\Rightarrow qvB\sin 90^\circ = \frac{mv^2}{r} \Rightarrow qvB = \frac{mv^2}{r} [\because \sin 90^\circ = 1]$
$\Rightarrow \quad r = \frac{mv}{qB}$
Time period of charged particle is,
$\Rightarrow T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$
Frequency, $f = \frac{1}{T} = \frac{qB}{2\pi m}$
$\therefore$ The frequency of oscillation of the charged particle from the above expression is
$\Rightarrow f = qB/2\pi m$
It is also known as Cyclotron frequency.

ii. Let the mass of proton= m
Charge of proton= q
Mass of deuteron= 2m
Charge of deuteron =q
Cyclotron frequency, $f = \frac{Bq}{2\pi m} \Rightarrow f \propto \frac{q}{m}$

For proton frequency, $f_p \propto \frac{q}{m}$ .... (i)

For deuteron frequency, $f_d \propto \frac{q}{2m}$ .... (ii)

From Eqs. (i) and (ii), we get, $f_p = 2f_d$

Thus, the frequency of proton is twice that of deuteron.

Since, both proton and deutron are of different masses, so they both dont have same frequency.

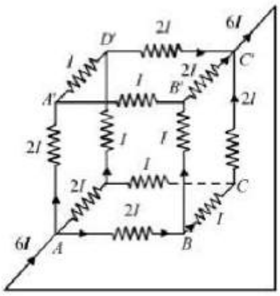
Section D

31. i. **Kirchhoffs Ist rule or Junction Rule:** The algebraic sum of electric currents at any junction of electric circuit is equal to zero i.e., $\sum I = 0$

Kirchhoff's IInd rule or Voltage Law: In any closed mesh of electrical circuit, the algebraic sum of emfs of cells and the product of currents and resistances is always equal to zero.

i.e., $\sum E + \sum IR = 0$

ii. a) Let 6I current be drawn from the cell. Since the paths AA', AD and AB are symmetrical, current through them is same. As per Kirchhoff's junction rule, the current distribution is shown in the figure.



Let the equivalent resistance across the combination be R.

$E = V_A - V_B = (6I)R$

$\Rightarrow$ 6IR = 10 [$\because$ E = 10 V] ....(i)

Applying Kirchoff's second rule in loop AA'B'C'A

$- 2I \times 1 - I \times 1 - 2I \times 1 + 10 = 0$

$\Rightarrow 5I = 10$

$\Rightarrow I = 2A$

Total current in the network = $6I = 6 \times 2 = 12$ A

b) From Eq. (i), 6IR = 10

$6 \times 2 \times R = 10$

$R = \frac{10}{12} = \frac{5}{6}\Omega$

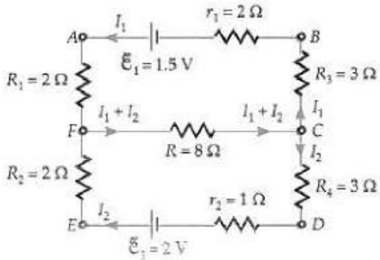
OR

As shown in Figure, the positive terminals of cells ε_1 and ε_2, are connected to the wire AE of resistance 4 Ω and negative terminals to the wire BD of resistance 6 Ω. The 8 Ω wire is connected between the middle points F and C of the wires AE and BD respectively.

$\therefore R_1 = R_2 = \frac{4}{2} = 2\Omega$

and $R_3 = R_4 = \frac{6}{2} = 3\Omega$

The distribution of current in various branches is shown in Figure.



Applying Kirchhoff's second law to the loop ABCFA, we get

$I_1 \times r_1 + I_1 \times R_1 + (I_1 + I_2) R + I_1 \times R_3 = \varepsilon_1$

$I_1 \times 2 + I_2 \times 2 + (I_1 + I_2) \times 8 + I_1 \times 3 = 1.5$

$15I_1 + 8\,I_2 = 1.5$ ...(i)

Applying Kirchhoff's second law to the loop CDEFC, we get

$I_2 \times r_2 + I_2 \times R_2 + (I_1 + I_2) \times R + I_2 \times R_4 = \varepsilon_2,$

$I_2 \times 1 + I_2 \times 2 + (I_1 + I_2) \times 8 + I_2 \times 3 = 2$

$8I_1 + 14I_2 = 2$

or $4I_1 + 7I_2 = 1$ ...(ii)

On solving equations (i) and (ii), we get

$I_1 = \frac{5}{146}$ A and $I_2 = \frac{18}{146}$ A

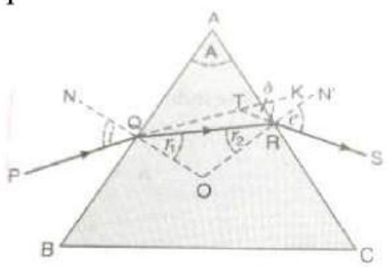
Current through the 8 Ω resistance wire is

$I_1 + I_2 = \frac{5}{146} + \frac{18}{146} = \frac{23}{146}$ A

P.D. across the ends of 8 Ω resistance wire

$= \frac{23}{146} \times 8 = 1.26$ A

32. a. Consider that a ray of light PQ is incident on the refracting face AB of the prism at point Q as shown in figure. When light passes through a prism refraction takes place at both the surfaces of the prism.



In figure, i and e are the angle of incidence and emergence respectively. Angles r_1 and r_2 are angle of refraction at both the surfaces of the prism. A is the angle of prism and δ be the angle of deviation.

The rays PQ, QR and RS are called incident ray, refracted ray and emergent ray respectively. Produce SR backwards, so as to meet the ray PQ at point T, when produced. Then, KTS = δ is called the angle of deviation.

Since $\angle$ TQO = i and $\angle$RQO = r_1, we have

$\angle TQR = i - r_1$

Also, $\angle$TRO = e and $\angle$QRO = r_2. Therefore,

$\angle TRQ = e - r_2$

Now, in triangle TQR, the side QT has been produced outwards. Therefore,

$\delta = \angle TQR + \angle TRQ = (i - r_1) + (e - r_2)$

or $\delta = (i + e) - (r_1 + r_2)$ ....(i)

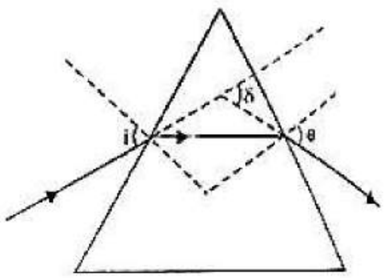
In triangle QRO, the sum of the angles is 180^o. Therefore,

$r_1 + r_2 + \angle QOR = 180^o$ ...(ii)

In quadrilateral AQOR, each of the angles AQO and ARO is 90^o. Since the sum of the four angles of a quadrilateral is four angles, the sum of the remaining two angles should be 180^o i.e.

$A + \angle QOR = 180^o$ ....(iii)
From the equation (ii) and (iii), we have
$r_1 + r_2 = A$ ...(iv)
In the equation (i), substituting for $(r_1 + r_2)$ we have
$\delta = (i + e) - A$
or $A + \delta = i + e$
Hence, $\delta = (i + e) - A$

b. The incident ray is deviated through $\delta = 62^\circ 48'$ when angle $i = 40^o 6'$. From the principle of reversibility of light, it is clear from the figure that the emergent ray (for which angle $e = 82^o 42'$) is also deviated through the same angle δ. Now,



$\delta = (i + e) - A$
or $A = (i + e) - \delta$
$= 40^\circ 6' + 82^\circ 42' - 62^\circ 48'$
or $A = 60^\circ$
which is the refractive angle of the prism.
For minimum deviation, $i = e$
Hence, $\delta_{\min} = 2i - A$
or $i = \left(\frac{\delta_{\min} + A}{2}\right)$
$= \frac{(51^\circ + 60^\circ)}{2} = 55^\circ 30'$
which is the angle of incidence at minimum deviation? The refractive index of the material of the prism is given by
$\mu = \frac{\sin \frac{(\delta_{\min} + A)}{2}}{\sin \frac{A}{2}}$
or $\mu = \frac{\sin\left(\frac{51^\circ + 60^\circ}{2}\right)}{\sin \frac{60^\circ}{2}}$
or $\mu = 1.648$

OR

In normal adjustment, image is formed at least distance of distinct vision,
d = 25 cm

Angular magnification of eyepiece $= \left(1 + \frac{D}{f_e}\right)$

$= \left(1 + \frac{25}{5}\right) = 6$

Since the total magnification is 30, magnification of objective lens,

$m = \frac{30}{6} = 5$

Now, $m = -\frac{v_0}{u_0} = 5$ or $v_0 = -5u_0$

As $\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$

$\therefore \frac{1}{-5u_0} - \frac{1}{u_0} = \frac{1}{1.25}$

$-\frac{6}{5u_0} = \frac{1}{1.25}$

$u_0 = -\frac{6\times1.25}{5} = -1.5cm$

i.e. object should be held at 1.5 cm in front of objective lens.

As $v_0 = -5u_0$

$\therefore v_0 = -5(-1.5) = 7.5cm$

Now, $\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

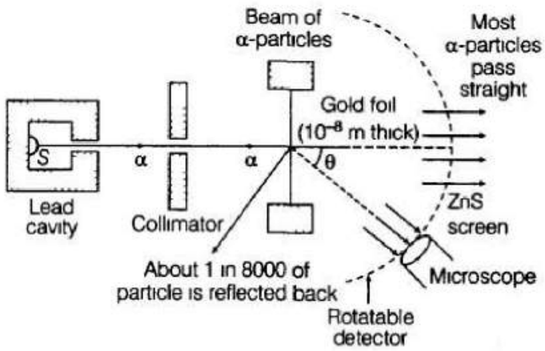
$\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{-25} - \frac{1}{5} = -\frac{6}{25}$

$u_e = -\frac{25}{6} = -4.17cm$

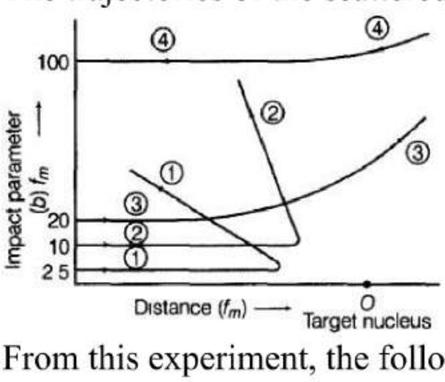
Separation between the objective lens and eyepiece $= |u_e| + |v_0|$

= 4.17 + 7.5 = 11.67 cm

33. The Schematic diagram of Geiger-Marsden experiment is shown below:



The trajectories of the scattered α-particles is:



From this experiment, the following is observed.

i. Most of the α-particles pass straight through the gold foil. It means that they do not suffer any collision with gold atoms.

ii. About one α-particle in every 8000 α-particles deflect by more than 90°. As most of the α-particles go undeflected and only a few get deflected, this shows that most of the space in an atom is empty. Thus, with the help of these observations regarding the deflection of a-particles, the size of the nucleus was predicted.

At the distance of head on approach, the entire kinetic energy of α-particle is converted into electrostatic potential energy. This distance of head on approach gives an upper limit of the size of nucleus (denoted by r_0) and is given by:

$$E_k = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(2e)}{r_0}$$

$$r_0 = \frac{1}{4\pi\varepsilon_0}\frac{2Ze^2}{E_k}$$

This is about 10^{-14}m.

OR

The impact parameter is given by $b = \frac{Ze^2 \cot \theta/2}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$

a. Here ,Given b = 0 ∴ $\frac{Ze^2 \cot \theta/2}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)} = 0$

or $\cot \frac{\theta}{2} = 0$

∴ $\frac{\theta}{2} = 90^\circ$ or $\theta = 180^\circ$

which is the value expected physically for a head-on collision.

b. For a given value of b,

$\frac{Ze^2 \cot \theta/2}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$ = constant

∴ As the energy $\left(\frac{1}{2}mv^2\right)$ increases, the value of $\cot \frac{\theta}{2}$ increases and hence the value of scattering angle θ decreases, as expected.

c. Given $\theta = 90^\circ, Z = 79, e = 1.6 \times 10^{-19}$C

$E = \frac{1}{2}mv^2 = 10$MeV

$= 10 \times 10^6 \times 1.6 \times 10^{-19}$ J $= 1.6 \times 10^{-12}$ J

$\therefore b = \frac{Ze^2 \cot \theta/2}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$

$= \frac{9\times10^9\times79\times\left(1.6\times10^{-19}\right)^2 \cot 45^\circ}{1.6\times10^{-12}}$ m

$= 9 \times 79 \times 1.6 \times 10^{-11}$ m

$= 1137.6 \times 10^{-11}$ m $= 1.1 \times 10^{-14}$ m

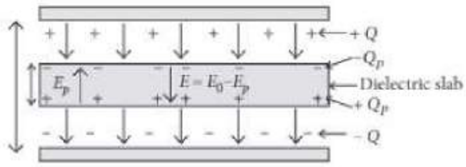
d. For a given energy $\left(\frac{1}{2}mv^2\right)$ of the projectile, the decrease in impact parameter b implies a decrease in the value of $\cot \theta/2$ and hence an increase in the scattering angle θ.

Section E

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

A dielectric slab is a substance which does not allow the flow of charges through it but permits them to exert electrostatic forces on one another. When a dielectric slab is placed between the plates, the field E_0 polarises the dielectric. This induces charge -Q_p on the upper surface and +Q_p on the lower surface of the dielectric. These induced charges set up a field E_p inside the dielectric in the opposite direction of $\vec{E}_0$

as shown.



(i) 20

k = $\frac{\text{Capacitance with dielectric}}{\text{Capacitance without dielectric}}$

= $\frac{80\mu F}{4\mu F}$ = 20

(ii) 80 pF

Capacitance of the capacitor with air between plates

C' = $\frac{\varepsilon_0 A}{d}$ = 8 pF

With the capacitor is filled with dielectric (k = 5) between its plates and the distance between the plates is reduced by half, capacitance become

C = $\frac{\varepsilon_0 kA}{d/2} = \frac{\varepsilon_0 \times 5 \times A}{d/2}$ = 10 C' = 10 × 8 = 80 pF

(iii)increases the capacity of the condenser,

If a dielectric medium of dielectric constant K is filled completely between the plates then capacitance increases by K times.

OR

4

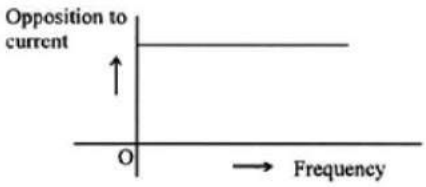
C = $\frac{\varepsilon_0 A}{d}$ = 1pF ...(i)

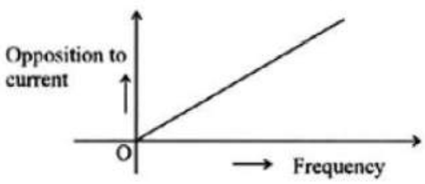
C' = $\frac{x\varepsilon_0 A}{(2d)}$ = 2pF ....(ii)

Divide (ii) by (i), $\frac{x}{2} = \frac{2}{1} \Rightarrow$ x = 4

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

The graphs (a) and (b) represent the variation of the opposition offered by the circuit element to the flow of alternating current with the frequency of the applied emf.





(i) From graph (a), it is clear that resistance (opposition to current) is not changing with frequency, and we know that resistance of a resistor does not depend on frequency of applied source. So the circuit element here is a pure resistance (R). i.e. the circuit is a pure resistive circuit.

(ii) Impedance offered by the series combination of resistance R and inductor L.

$Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (2\pi f L)^2}$, X_L being the inductive reactance of the circuit.

(iii)In an L-R circuit, the applied ac voltage leads the ac current in phase by $\pi/2$.

OR

From graph (b), it is clear that resistance increases linearly with frequency, so the circuit element here is an inductor.

As we know that, inductive resistance, $X_L = 2\pi f L$

$\Rightarrow \quad X_L \propto f$, f being frequency of the ac voltage or current.