Class XII Session 2026-27
Subject - Physics
Sample Question Paper - 6

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

General Instructions:

1. There are 33 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.
3. All the sections are compulsory.
4. **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.
5. There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
6. Use of calculators is not allowed.

Section A

1. At absolute zero temperature, a semiconductor acts as a/an **[1]**

   a) Resistor b) dielectric

   c) insulator d) conductor

2. Drift is the random motion of the charged particles within a conductor, **[1]**

   a) along with accelerated motion in the direction of the field

   b) along with a decelerated motion in the direction of the field

   c) along with a very slow net motion in the opposite direction of the field

   d) along with zero motion in the direction of the field

3. The focal length (f) of spherical mirror of radius curvature R is: **[1]**

   a) 2R b) $\frac{R}{2}$

   c) $\frac{3}{2R}$ d) R

4. The main use of studying a hysteresis curve for a given material is to estimate the **[1]**

   a) current loss b) power loss

   c) voltage loss d) hysteresis loss

5. Two spheres of radii R_1 and R_2 joined by a conducting wire are raised to a potential **[1]**

V. Let the surface charge densities of two spheres be respectively σ_1 and σ_2. Then:

a) $\sigma_2 = \left(\frac{R_1}{R_2}\right)\sigma_1$ b) $\sigma_2 = \left(\frac{R_2}{R_1}\right)\sigma_1$

c) $\sigma_2 = \sigma_1$ d) $\sigma_2 = \left(\frac{R_2}{R_1}\right)^2\sigma_1$

6. A wire of length l is used to form a coil. The magnetic field at its centre for a given current in it is minimum, if the coil has **[1]**

a) 1 turns b) 4 turns

c) data is not sufficient d) 2 turns

7. Two identical circular coaxial coils A and B, arranged in vertical planes parallel to each other, carry currents in the same direction. If the distance between the coils is decreased at a constant rate, the current: **[1]**

a) increases in both A and B. b) increases in A and decreases in B.

c) decreases in both A and B. d) remains same in both A and B.

8. Which of the following statements is not correct about the magnetic field? **[1]**

a) magnetic lines of force do not cut each other

b) tangents to the magnetic lines give the direction of the magnetic field.

c) inside the magnet, the lines go from north to south pole of the magnet

d) the magnet lines form a closed loop

9. In Young's double slit experiment, intensity at a point is (1/4) of the maximum intensity. Angular position of this point is: **[1]**

a) $\sin^{-1}\left(\frac{\lambda}{d}\right)$ b) $\sin^{-1}\left(\frac{\lambda}{2d}\right)$

c) $\sin^{-1}\left(\frac{\lambda}{4d}\right)$ d) $\sin^{-1}\left(\frac{\lambda}{3d}\right)$

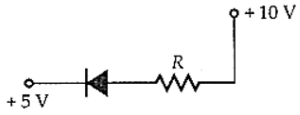
10. Which of the following is not true for a region with uniform electric field? **[1]**

a) it may contain dipoles b) it may have uniformly distributed charge

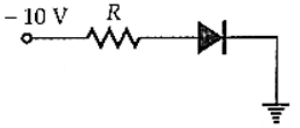
c) it may have formly distributed charge d) it can have free charges

11. In the following figure, the diodes which are forward biased, are **[1]**

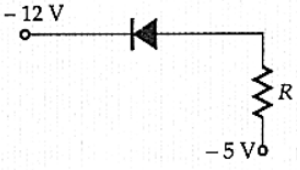
A.

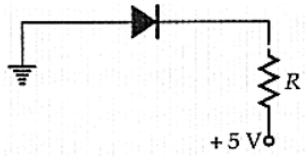


B.



C.



D. 

a) C only
b) A, C and D
c) B and C
d) C and A

12. A biconvex lens of focal length f is cut into two identical plano convex lenses. The focal length of each part will be **[1]**

a) 2f
b) $\frac{f}{2}$
c) 4f
d) f

13. **Assertion (A):** In photoelectric effect, the kinetic energy of the emitted photoelectrons increases with increase in the intensity of the incident light. **[1]**
Reason (R): Photoelectric current depends on the wavelength of the incident light.

a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
b) Both Assertion (A) and Reason (R) are true, but Reason (R) is **not** the correct explanation of the Assertion (A).
c) Assertion (A) is true, but Reason (R) is false.
d) Assertion (A) is false and Reason (R) is also false.

14. **Assertion (A):** The capacitance of a parallel plate capacitor increases when a dielectric constant of medium between the plates. **[1]**
Reason (R): Capacitance of a parallel plate capacitor is directly proportional to dielectric constant of medium between the plates.

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.

15. **Assertion (A):** When a thin transparent sheet is placed in front of both the slits of Young's experiment, the fringe width will increase. **[1]**
Reason (R): In Young's experiment the fringe width is directly proportional to wavelength of the source used.

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):** A bulb connected in series with a solenoid is connected to ac source. If a soft iron core is introduced in the solenoid, the bulb will glow brighter. **[1]**
Reason (R): On introducing soft iron core in the solenoid, the inductance increases.

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

17. The magnetic field in a plane electromagnetic wave is given by $B_y = (2 \times 10^{-7})$ T sin $(0.5 \times 10^3 x + 1.5 \times 10^{11} t)$. **[2]**

a. What is the wavelength and frequency of the wave?

b. Write an expression for the electric field.

18. A semiconductor has equal electron and hole concentration of 6×10^8 m^{-3}. On doping with certain impurity, electron concentration increases to 9×10^{12} m^{-3}. **[2]**

i. Identify the new semiconductor obtained after doping.

ii. Calculate the new hole concentration.

iii. How does the energy gap vary with doping?

19. Which state of the triply ionized Be^{+++} has the same orbital radius as that of the ground state of hydrogen? Compare the energies of two states. **[2]**

20. Calculate the work done in rotating a magnet of magnetic moment 3.0 JT^{-1} through an angle of 60° from its position along a magnetic field of strength 0.34×10^{-4} T. **[2]**

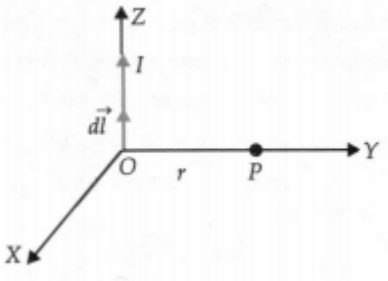
OR

A sample of paramagnetic salt contains 2.0×10^{24} atomic dipoles each of dipole moment 1.5×10^{-23} J T^{-1}. The sample is placed under a homogeneous magnetic field of 0.64 T, and cooled to a temperature of 4.2 K. The degree of magnetic saturation achieved is equal to 15%. What is the total dipole moment of the sample for a magnetic field of 0.98 T and a temperature of 2.8 K? (Assume Curie's law)

21. Use Biot-Savart law to obtain an expression for the magnetic field at the centre of a coil bent in the form of a square of side 2a carrying current I. **[2]**

OR

State Biot-Savart law. A current I flows in a conductor placed perpendicular to the plane of the paper. Indicate the direction of the magnetic field due to a small element $\vec{dl}$ at point P situated at a distance $\vec{r}$ from the element as shown in Fig.



Section C

22. Three cells A, B and C of emfs $2\ V, 3\ V$ and 5 V respectively are connected in parallel to each other. Their internal resistances are $5\Omega, 5\Omega$ and 1Ω respectively. Calculate the currents flowing through the cells A, B and C. **[3]**

23. a. State briefly, with what purpose was Davisson and Germer experiment performed and what inference was drawn from this. **[3]**

b. Obtain an expression for the ratio of the accelerating potentials required to accelerate a proton and an α-particle to have the same de-Broglie wavelength

associated with them.

24. a. Explain the characteristics of a $p-n$ junction diode that makes it suitable for its use as a rectifier. **[3]**

b. With the help of a circuit diagram, explain the working of a full wave rectifier.

25. Explain the concept of nuclear energy with reference to binding energy curve. **[3]**

26. Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength $975\overset{o}{A}$. **[3]**

i. How many different lines are possible in the resulting spectrum?

ii. Calculate the longest wavelength amongst them. You may assume the ionization energy for hydrogen atom as 13.6 eV.

27. A metallic rod of length l and resistance R is rotated with a frequency ν, with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius l, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere. **[3]**

i. Derive the expression for the induced emf and the current in the rod.

ii. Due to the presence of the current in the rod and of the magnetic field, find the expression for the magnitude and direction of the force acting on this rod.

iii. Hence obtain the expression for the power required to rotate the rod.

OR

A coil of number of turns N, area A, is rotated at a constant angular speed ω , in a uniform magnetic field B, and connected to a resistor R.

Deduce expressions for: (i) maximum emf induced in the coil. (ii) power dissipation in the coil.

28. A double slit set-up was initially placed in a tank filled with water and the interference pattern was obtained using a laser light. When water is replaced by a transparent liquid of refractive index $n > n_{\text{water}}$,what will be the effect on the following? **[3]**

a. Speed, frequency and wavelength of the light of laser beam.

b. The fringe width, shape of interference fringes and shift in the position of central maximum.

Section D

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

In an electromagnetic wave both the electric and magnetic fields are perpendicular to the direction of propagation, that is why electromagnetic waves are transverse in nature. Electromagnetic waves carry energy as they travel through space and this energy is shared equally by the electric and magnetic fields. Energy density of an electromagnetic waves is the energy in unit volume of the space through which the wave travels.

(a) The electromagnetic waves propagated perpendicular to both $\vec{E}$ and $\vec{B}$. The electromagnetic waves travel in the direction of

a) $\vec{E} \cdot \vec{B}$ b) $\vec{B} \times \vec{E}$

c) $\vec{B} \cdot \vec{E}$ d) $\vec{E} \times \vec{B}$

(b) Fundamental particle in an electromagnetic wave is

a) proton b) photon

c) phonon d) electron

(c) Electromagnetic waves are transverse in nature is evident by

a) polarisation b) diffraction

c) reflection d) interference

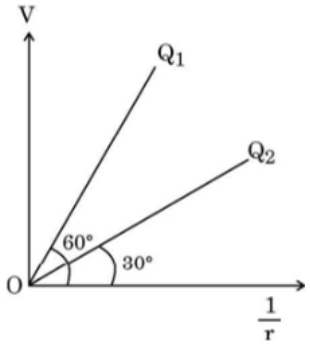
(d) For a wave propagating in a medium, Name the property that is independent of the others.

a) wavelength b) all these depend on each other

c) velocity d) frequency

30. Electrostatics deals with the study of forces, fields and potentials arising from static charges. Force and electric field, due to a point charge is basically determined by Coulomb's law. For symmetric charge configurations, Gauss's law, which is also based on Coulomb's law, helps us to find the electric field. A charge/a system of charges like a dipole experience a force/torque in an electric field. Work is required to be done to provide a specific orientation to a dipole with respect to an electric field. **[4]**

i. The figure shows the variation of potential V with $\frac{1}{r}$ for two point charges Q_1 and Q_2, where V is the potential at a distance r due to a point charge. Find $\frac{Q_1}{Q_2}$. (1)



ii. An electric dipole of dipole moment of 6×10^{-7} C-m is kept in a uniform electric field of 10^4 N/C such that the dipole moment and the electric field are parallel. Calculate the potential energy of the dipole. (1)

iii. An electric dipole of dipole moment $\vec{p}$ is initially kept in a uniform electric field $\vec{E}$ such that $\vec{p}$ is perpendicular to $\vec{E}$. Find the amount of work done in rotating the dipole to a position at which $\vec{p}$ becomes antiparallel to $\vec{E}$. (2)

Section E

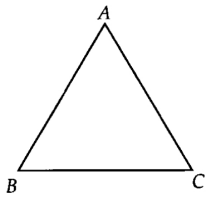
31. i. Draw a labelled ray diagram of an astronomical telescope to show the image formation of a distant object by it in normal adjustment. What are the main considerations required in selecting the objective and eyepiece lenses so that the telescope has large magnifying power and high resolution? **[5]**

ii. A biconvex lens of focal length 20 cm is immersed in water, whose refractive index is $\frac{4}{3}$. Find the change, if any, in the nature and the focal length of the lens. Refractive index of the material of convex lens is $\frac{3}{2}$.

OR

a. Write two points of difference between an interference pattern and a diffraction pattern.

b. i. A ray of light incident on face AB of an equilateral glass prism, shows minimum deviation of 30°. Calculate the speed of light through the prism.



ii. Find the angle of incidence at face AB so that the emergent ray grazes along the face AC.

32. A capacitor of capacitance C_1 is charged to a potential V_1 while another capacitor of capacitance C_2 is charged to a potential difference V_2. The capacitors are now disconnected from their respective charging batteries and connected in parallel to each other. **[5]**

i. Find the total energy stored in the two capacitors before they are connected.

ii. Find the total energy stored in the parallel combination of two capacitors.

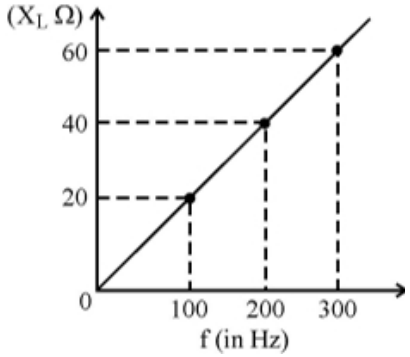
iii. Explain the reason for the difference of energy in parallel combination in comparison to the total energy before they are connected

OR

Calculate potential on the axis of a disc of radius R due to a charge Q uniformly distributed on its surface.

33. a. Show that an ideal inductor does not dissipate power in an ac circuit. **[5]**

b. The variation of inductive reactance (X_L) of an inductor with the frequency (f) of the ac source of 100 V and variable frequency is shown in the fig.



i. Calculate the self-inductance of the inductor.

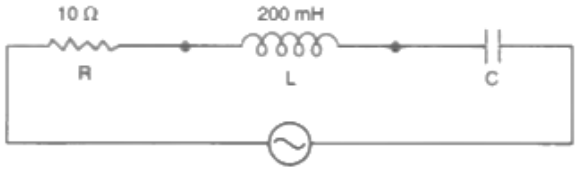
ii. When this inductor is used in series with a capacitor of unknown value and a resistor of 10Ω at 300 s^{-1}, maximum power dissipation occurs in the circuit. Calculate the capacitance of the capacitor.

OR

In the following circuit, calculate:

i. the capacitance of the capacitor, if the power factor of the circuit is unity,

ii. the Q-factor of this circuit. What is the significance of the Q-factor in ac circuit? Given the angular frequency of the ac source to be 100 rad/s. Calculate the average power dissipated in the circuit.



Solution

Section A

1. **(c)** insulator
Explanation:
At absolute zero temperature, a semiconductor acts as an insulator.

2. **(c)** along with a very slow net motion in the opposite direction of the field
Explanation:
The electrons in a conductor have random velocities and when an electric field is applied, they suffer repeated collisions and in the process move with a small average velocity, opposite to the direction of the field. This is equivalent to positive charge flowing in the direction of the field.

3. **(b)** $\frac{R}{2}$
Explanation:
The relationship between **the focal length f** and **radius** of **curvature r** for spherical mirror is given by R = 2f. Therefore, $f = \frac{R}{2}$

4. **(d)** hysteresis loss
Explanation:
The area of hysteresis loop gives an idea of hysteresis loss of the magnetic material.

5. **(a)** $\sigma_2 = \left(\frac{R_1}{R_2}\right)\sigma_1$
Explanation:
The solution is correct because it applies the principle of conservation of charge and the relationship between surface charge density and radius for conductors in electrostatic equilibrium. When two spheres are connected by a conducting wire, they reach the same electric potential. The electric potential V of a sphere is related to its surface charge density σ and radius R by the formula $V = \frac{\sigma R}{\epsilon_0}$, where ϵ_0 is the permittivity of free space. Since both spheres are at the same potential V, we can set up the equation: $\frac{\sigma_1 R_1}{\epsilon_0} = \frac{\sigma_2 R_2}{\epsilon_0}$ This simplifies to: $\sigma_1 R_1 = \sigma_2 R_2$ Rearranging this gives: $\sigma_2 = \left(\frac{R_1}{R_2}\right)\sigma_1$ This shows that the surface charge density on the second sphere is proportional to the surface charge density on the first sphere, scaled by the ratio of their radii.
Thus, the solution correctly identifies the relationship between the surface charge densities of the two spheres.

6. **(a)** 1 turns
Explanation:
The magnetic field at the center of a coil is directly related to the number of turns and the current flowing through it. For a single turn, the magnetic field is maximized for a given length of wire because it allows the entire length to contribute to the field without being divided among multiple turns. As the number of turns increases, the effective area of the coil

decreases, leading to a weaker magnetic field at the center. Therefore, having just one turn results in the minimum magnetic field strength at the center for the given length of wire.

7.

(c) decreases in both A and B.
Explanation:
decreases in both A and B.

8.

(c) inside the magnet, the lines go from north to south pole of the magnet
Explanation:
Inside the magnet the lines go from south to north pole of the magnet

9.

(d) $\sin^{-1}\left(\frac{\lambda}{3d}\right)$
Explanation:
$I = I_{max}cos^2(\phi/2)$
$\frac{I_{max}}{4} = I_{max}cos^2(\phi/2)$
$cos(\phi/2) = 1/2$
or, $\frac{\phi}{2} = \frac{\pi}{3}$
Therefore,$\phi = \frac{2\pi}{3}$
Also, $\phi = \frac{2\pi}{\lambda}.\Delta x$
So, $\frac{2\pi}{3} = \frac{2\pi}{\lambda}\Delta x \Rightarrow \Delta x = \frac{\lambda}{3}$
where, $\Delta x = dsin\theta$
Substituting we get,
$sin\theta = \frac{\lambda}{3d}$
or, $\theta = sin^{-1}(\frac{\lambda}{3d})$

10.

(c) it may have formly distributed charge
Explanation:
In each of the cases given above, the electric field is not uniform.

11.

(d) C and A
Explanation:
In both figures (A) and (C), p-side is at higher potential than the n-side.

12. **(a)** 2f
Explanation:
The focal length of each part will be 2f

13.

(d) Assertion (A) is false and Reason (R) is also false.
Explanation:
Assertion (A) is false and Reason (R) is also false.

14. **(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.

15.

(d) A is false but R is true.

Explanation:

Fringe width $\beta = \frac{\lambda D}{d}$ shall remain the same as the waves travel in air only, after passing through the thin transparent sheet. Due to introduction of thin sheet, only path difference of the wave is changed due to which there is shift of position of fringes only, which is given as $\Delta x = \frac{D(\mu-1)t}{d}$, where μ is refractive index of thin sheet and t is its thickness.

16.

(d) A is false but R is true.

Explanation:

On introducing soft iron core, the bulb will glow dimmer. This is because on introducing soft iron core in the solenoid, its inductance L increases, the inductive reactance, $X_L = \omega L$ increases and hence the current through the bulb decreases.

Section B

17. a. Comparing the given equation with

$B_y = B_0 \sin\left[2\pi\left(\frac{x}{\lambda} + \frac{t}{T}\right)\right]$

We get $k = 0.5 \times 10^{-3}\ m^{-1}$, $\lambda = \frac{2\pi}{0.5\times10^3} m = 1.26$ cm.

and $\frac{1}{T} = \nu = \frac{1.5\times10^{11}}{2\pi} = 23.9$ GHz

b. $E_0 = B_0 C = 2 \times 10^{-7}\ T \times 3 \times 10^8\ m/s = 6 \times 10^1\ V/m$

The electric field component is perpendicular to the direction of propagation and the direction of magnetic field. Therefore, the electric field component along the z-axis is obtained as

$E_z = 60 \sin (0.5 \times 10^3\, x + 1.5 \times 10^{11}\, t)\ V/m$

18. i. As the electron concentration increases after doping, so the new semiconductor obtained is of n-type.

ii. As $n_e\, n_h = n_i^2$

$\therefore n_h = \frac{n_i^2}{n_e} = \frac{\left(6\times10^8\right)^2}{9\times10^{12}} = 4 \times 10^4\ m^{-3}$

iii. The energy gap decreases with doping.

19. Radius of nth orbit is given by

$r = \frac{n^2h^2}{4\pi^2 mKZe^2}$ i.e. $r \propto \frac{n^2}{Z}$

For hydrogen, Z = 1, n =1 in ground state

$\therefore \frac{n^2}{Z} = \frac{1^2}{1} = 1$

For Beryllium, Z = 4, as orbital radius is same, $\frac{n^2}{Z} = 1$

$\therefore n^2 = 1 \times Z = 1 \times 4 = 4$

$n = \sqrt{4} = 2$

Hence second level of triply ionised Be^{+++} has same radius as ground level of hydrogen.

Now, energy of electron in nth orbit is $E = -\frac{2\pi^2 mK^2Z^2e^4}{n^2h^2}$

$\therefore E \propto \frac{Z^2}{n^2}$

$\frac{E_{(Be)}}{E_{(H)}} = \frac{\left[\frac{Z^2}{n^2}\right]_{Be}}{\left[\frac{Z^2}{n^2}\right]_H} = \frac{\frac{16}{4}}{\frac{1}{1}} = 4$

20. Here, W = ?, M = 3.0 Jt^{-1}, $\theta_2 = 60^o$, $\theta_1 = 0^o$

B = 0.34×10^{-4} T

W = -Mb (cos θ_2 - cos θ_1)

= $-3.0 \times 0.34 \times 10^{-4}$ (cos 60° - cos 0°)

= 5.1×10^{-5} J

OR

A sample of paramagnetic consist of Number of atomic dipoles is, n = 2.0×10^{24}

Dipole moment of each atomic dipole, M = 1.5×10^{-23} JT^{-1}

When the magnetic field, B_1 = 0.64T

The sample is cooled to temperature, $T_1 = 4.2^oK$

The total dipole moment of the atomic dipole, M_{tot} = n × M

$= 2 \times 10^{24} \times 1.5 \times 10^{-23}$

= 30 JT^{-1}

Magnetic saturation is achieved at 15%.

Hence, effective dipole moment, $M_1 = \frac{15}{100} \times 30 = 4.5 JT^{-1}$

When the magnetic field, B_2 = 0.98T

Temperature, $T_2 = 2.8^oK$

Its total dipole moment = M_2

According to Curie's law, we have the ratio of two magnetic dipoles as:

$\frac{M_2}{M_1} = \frac{B_2}{B_1} \times \frac{T_1}{T_2}$

$\therefore M_2 = \frac{B_2 T_1 M_1}{B_1 T_2}$

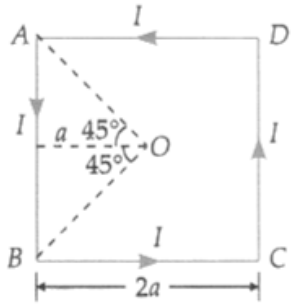
$= \frac{0.98 \times 4.2 \times 4.5}{2.8 \times 0.64}$ = 10.336 JT

Therefore, 10.336 JT^{-1} is the total dipole moment of the sample for a magnetic field of 0.98 T and a temperature of 2.8 K.

21. Refer to figure below, Magnetic field at O due to finite length of wire AB is

$B_1 = \frac{\mu_0 I}{4\pi a}(\sin\alpha + \sin\beta)$

$= \frac{\mu_0 I}{4\pi a}(\sin 45^\circ + \sin 45^\circ) = \frac{\sqrt{2}\mu_0 I}{4\pi a}$



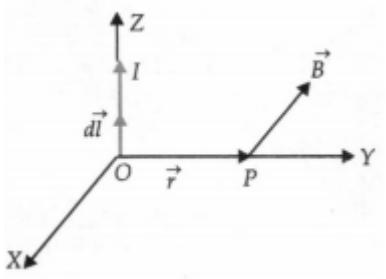
The magnetic field at O due to conductors BC, CD, and DA will also be of the same magnitude and direction. Therefore, the resultant field at O is

B = 4 B_1 = $\frac{4 \times \sqrt{2}\mu_0 I}{4\pi a} = \frac{\sqrt{2}\mu_0 I}{\pi a}$

directed normally outwards.

OR

For the statement of Biot-Savart law, refer to point 2 of Glimpses. $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I(d\vec{l}\times\vec{r})}{r^3}$



Current element $\vec{dl}$ is along Z-direction and position vector $\vec{r}$ is along Y-direction, so

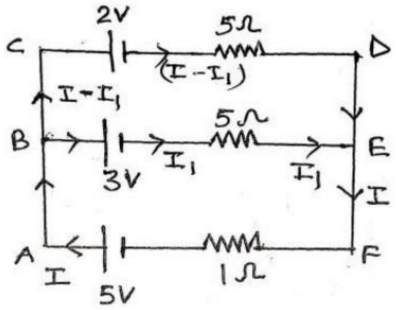
$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I(dl\hat{k}\times r\hat{j})}{r^3}$

$= \frac{\mu_0}{4\pi}\frac{Idl}{r^2}(-\hat{i})\ [\hat{k}\times\hat{j} = -\hat{i}]$

Hence the magnetic field at point P is directed along negative X-direction as shown in Fig.

Section C

22.



In loop ABEFA,

$5 - 3 - 5I_1 - I = 0$

$2 = 5I_1 + I$ ...(1)

In loop CBEDC,

$2 - 3 - 5I_1 + 5I - 5I_1 = 0$

$-1 = 10I_1 - 5I$ ...(2)

Solving equation (1) and (2)

$I = \frac{5}{7}\ A$ in arm AF/through the cell of 5V(A)

$I_1 = \frac{9}{35}\ A$ in arm BE/through the cell of 3V(B)

$I - I_1 = \frac{16}{35}\ A$ in arm CD/through the cell of 2V(C)

23. a. Purpose of Davisson Germer Experiment was to verify the wave nature of electron. It confirms the de Broglie relations for matter waves / Diffraction effect of electron beams from crystal

b. de Broglie wavelength

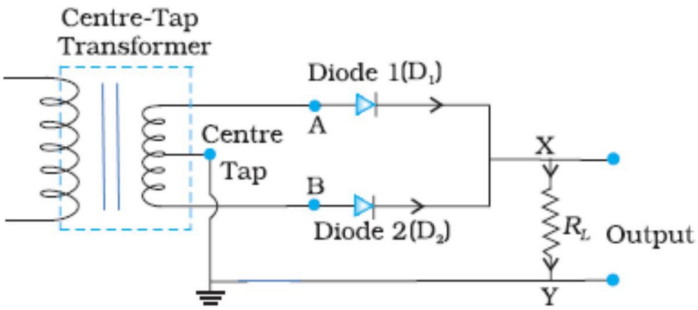
$\lambda = \frac{h}{\sqrt{2mqV}}$

$\therefore \frac{h}{\sqrt{2\,m_p eV_p}} = \frac{h}{\sqrt{2\,m_\alpha eV_\alpha}}$

$\therefore \frac{V_p}{V\alpha} = \frac{8}{1}$

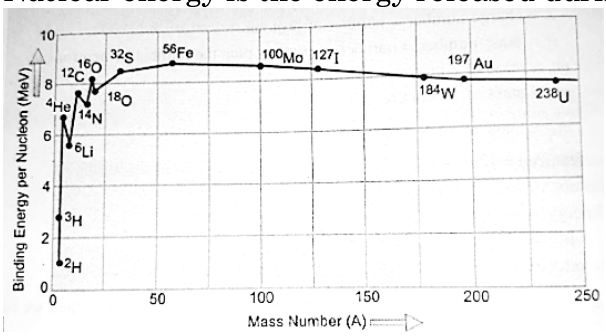
24. a. p-n junction diode allows current to pass only when it is forward biased

b.



When input voltage to A, with respect to the centre tap at any instant is positive, at that instant voltage at B, being out of phase will be negative, diode D_1 gets forward biased and conducts while D_2 being reverse biased does not conduct. Hence during this half cycle an output current and output voltage across R_L is obtained. During second half of the cycle when voltage at A becomes negative with respect to centre tap, the voltage at B would be positive. Hence D_1 would not conduct but D_2 would be giving an output current and output voltage. Thus output voltage is obtained during both halves of the cycle.

25. Nuclear energy is the energy released during a nuclear reaction.



The curve of average binding energy per nucleon ($\bar{B}$) against mass number (Figure) shows a long flat region from about A = 30 to A = 170. In this region, $\bar{B}$ is almost constant. However, for nuclei with A < 30 and A > 170, value of $\bar{B}$ is less than the plateau value. Clearly, nuclei with mass numbers in the range $30 \leq A \leq 170$ are more tightly bound than the nuclei with A < 30 and nuclei with A > 170. Hence when we transmute less tightly bound nuclei into more tightly bound nuclei through nuclear reactions, the nuclear energy may be released.

The nuclear reaction can thus prove to be a source of energy. Nuclear energy is released on account of mass defect in the reaction.

The nuclear reactions which can be practical sources of energy are of two broad types.

(i) Nuclear fission, in which a heavier nucleus breaks into lighter ones.

(ii) Nuclear fusion, in which lighter nuclei fuse into a heavier one.

In both the cases, energy released is estimated from mass defect (Δm) from Einstein's mass energy relation,

$E = (\Delta m)\, c^2$

26. i. Energy of the ground state (n = 1) = – (ionization energy) = –13.6 eV

The wavelength of the incident radiation, $\lambda = 975\ \text{Å}$

$\therefore$ The energy of the incident photon = hc/λ

$= \frac{6.63\times10^{-34}\times3\times10^{8}}{975\times10^{-10}\times1.6\times10^{-19}} = 12.75$ eV

Let electron is exerted to nth orbit,

$\Rightarrow 12.75 = 13.6\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$

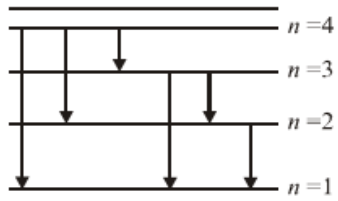
$\Rightarrow n = 4$

The quantum transitions to the less excited states gives six possible lines as follows:

n = 4 : (4 $\rightarrow$ 3), (4 $\rightarrow$ 2), (4 $\rightarrow$ 1)

n = 3 : (3 $\rightarrow$ 2), (3 $\rightarrow$ 1)

n = 2 : (2 $\rightarrow$ 1)



ii. The longest wavelength emitted is for the transitions (4 $\rightarrow$ 3) where energy difference is minimum.

$E_{min} = (E_4 - E_3) = 13.6 \left(\frac{1}{3^2} - \frac{1}{4^2}\right) = 0.661$ eV

Thus $\lambda_{max} = \frac{hc}{E_{min}}$

$= \frac{6.63\times10^{-34}\times3\times10^{8}}{0.661\times1.6\times10^{-19}}$ m

o

≈ 18807 A

27. i. In the one revolution, change of area,

$dA = \pi l^2$

$\therefore$ Change of magnetic flux in one revolution of the rod,

$d\phi_B = \vec{B}\cdot d\vec{A} = BdA\cos 0^\circ = B\pi l^2$

(Given, magnetic field intensity, $\vec{B}$ is parallel to change in area, $d\vec{A}$)

If period of revolution is T,

a. Induced emf (e) = {tex}\frac {d\phi}{dt} = \frac {Bπl^2}{T} = Bπl^2 \nu{/tex} ($\because \nu = \frac{1}{T}$)

b. Induced current in the rod,

$I = \frac{e}{R} = \frac{\pi\nu Bl^2}{R}$

(Given R = resistance of the rod)

ii. Magnitude of force acting on the rod,

$|\vec{F}| = |I(\vec{l}\times\vec{B})| = BIlsin90^0 = \frac{\pi\nu B^2 l^3}{R}$

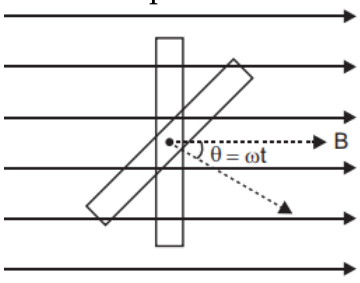
The external force required to rotate the rod opposes the Lorentz force acting on the rod, i.e external force acts in the direction opposite to the Lorentz force.

iii. Power required to rotate the rod,

$P = \vec{F}.\vec{v} = Fvcos0^0 = \frac{\pi\nu B^2 l^3 v}{R}$

OR

i. Suppose initially the plane of coil is perpendicular to the magnetic field B. When coil rotates with angular speed ω, then after time t, the angle between magnetic field vector B and normal to plane of coil is



$\theta = \omega$t

$\therefore$ At this instant magnetic flux linked with the coil $\phi = BA\cos\omega t$. If coil contains, N-turns, then emf induced in the coil.

If coil contains, N-turns, then emf induced in the coil

$\varepsilon = -N\frac{d\phi}{dt} = -N\frac{d}{dt}(BA\cos\omega t)$

$= +NBA\omega\sin\omega t$

$\therefore$ For maximum value of emf ε,

sin ωt = 1

$\therefore$ Maximum emf induced, $\varepsilon_{max} = NBA\omega$

ii. If R is resistance of coil, the current induced, $I = \frac{\varepsilon}{R}$

$\therefore$ Instantaneous power dissipated,

$P = \varepsilon I = \varepsilon\left(\frac{\varepsilon}{R}\right) = \frac{\varepsilon^2}{R}$

$= \frac{N^2B^2A^2\omega^2\sin^2\omega t}{R}$

but, $\left(\sin^2\omega t\right)_{av} = \frac{1}{2}$ (Average power dissipated in a complete cycle is obtained by taking average value of $\sin^2\omega$t over a complete cycle which is $\frac{1}{2}$)

$\therefore$ Average power dissipated $P_{av} = \frac{N^2B^2A^2\omega^2}{2R}$

28. a.
- Speed of light will decrease
- Frequency remains unaffected
- Wavelength decreases

b.
- Fringe width decreases
- Shapes does not change
- Position of central maxima does not change.

Section D

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

In an electromagnetic wave both the electric and magnetic fields are perpendicular to the direction of propagation, that is why electromagnetic waves are transverse in nature. Electromagnetic waves carry energy as they travel through space and this energy is shared equally by the electric and magnetic fields. Energy density of an electromagnetic waves is the energy in unit volume of the space through which the wave travels.

(a) **(d)** $\vec{E}\times\vec{B}$

Explanation:

Electromagnetic waves propagate in the direction of $\vec{E}\times\vec{B}$.

(b) **(b)** photon

Explanation:

Photon is the fundamental particle in an electromagnetic wave.

(c) **(a)** polarisation

Explanation:

Polarisation establishes the wave nature of electromagnetic waves.

(d) **(d)** frequency

Explanation:

Frequency ν remains unchanged when a wave propagates from one medium to another. Both wavelength and velocity get changed.

30. i. $\because$ V = k $\frac{Q}{r}$

Slope of graph is proportional to Q

$\frac{Q_1}{Q_2} = \frac{\tan 60^\circ}{\tan 30^\circ}$ = 3

ii. U = - p E cosθ

θ = 0°

U = -(6 $\times$ 10^{-7}) $\times$ (10^4)

U = -6 $\times$ 10^{-3} J

iii. $\because$ Work done W= - p E ($\cos\theta_2$ - $\cos\theta_1$)

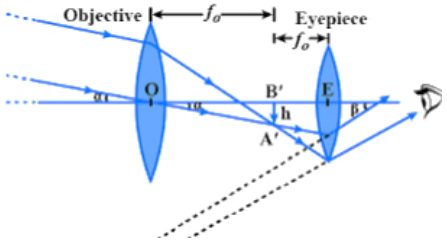
where $\theta_2 = 180^o$, $\theta_1 = 90^o$

$\Rightarrow$ W = -p E (cos 180° - cos 90°)

W = +p E

Section E

31. i.



The main considerations required in selecting the objective and eyepiece lenses are ;

For large magnifying power

$f_o > f_e$

For high resolution

Aperture of objective should be large

ii. $\frac{1}{f_a} = (n_g - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$\frac{1}{f_a} = \left(\frac{n_g}{n_w} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$\frac{f_w}{f_a} = \frac{(n_g - 1)}{\left(\frac{n_g}{n_w} - 1\right)}$

$\frac{f_w}{20} = \frac{\left(\frac{3}{2} - 1\right)}{\left(\frac{3}{2} \times \frac{3}{4} - 1\right)} = \frac{\frac{1}{2}}{\frac{1}{8}} = 4$

f_w = 80 cm

Changes in focal length Δf = 80 - 60

= 20 cm

Nature of the lens is converging because f_w is positive.

OR

a. i. The interference pattern has a number of equally spaced bright and dark bands. The diffraction pattern has a central bright maximum which is twice as wide as the other maxima. The intensity falls as we go to successive maxima away from the centre, on either side.

ii. We calculate the interference pattern by superposing two waves originating from the two narrow slits. The diffraction pattern is a superposition of a continuous family of waves originating from each point on a single slit.

b. i. $\mu = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin\left(\frac{90}{2}\right)}{\sin\left(\frac{60}{2}\right)} = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}}$

$= \sqrt{2}$

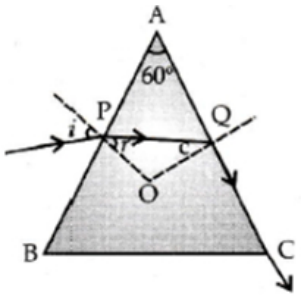
Here A = 60°, δ_m = 30°.

Now $\mu = \frac{c}{v} \Rightarrow$ v = $\frac{c}{\mu}$:

$\Rightarrow$ v = $\frac{3\times10^8}{\sqrt{2}}$ = 2.12 $\times$ 10^8 ms^{-1}

the speed of light through the prism is 2.12 $\times$ 10^8 ms^{-1}

ii.



n = $\sqrt{2}$

$\therefore$ n = $\frac{1}{\sin c}$ (for face AC)

$\sqrt{2} = \frac{1}{\sin c}$

$\Rightarrow$ sin c = $\frac{1}{\sqrt{2}}$ = sin 45°

$\Rightarrow$ c = 45°

$\therefore \angle APQ$ = 180° - (60° + 45°)

= 75°

$\therefore$ r = 90° - 75° = 15°

i = ?

n = $\frac{\sin i}{\sin r}$

$\Rightarrow \sqrt{2} = \frac{\sin i}{\sin 15''}$

$\Rightarrow$ sin i = $\sqrt{2} \times \sin 15'' = \sqrt{2} \times 0.2588$

32. i. Total energy stored in the two capacitors before they are connected,

$u_i = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2$

ii. After the two capacitors are connected in parallel, the common potential is

$V = \frac{\text{Total charge}}{\text{Total capacitance}} = \frac{q_1+q_2}{C_1+C_2} = \frac{C_1V_1+C_2V_2}{C_1+C_2}$

Total energy stored in the parallel combination,

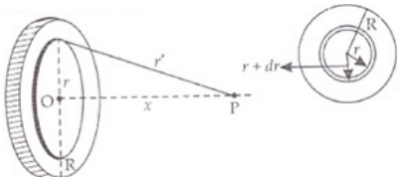
$U_f = \frac{1}{2}(C_1 + C_2)\,V^2 = \frac{1}{2}(C_1 + C_2)\left(\frac{C_1V_1+C_2V_2}{C_1+C_2}\right)^2$

$= \frac{1}{2}\frac{(C_1V_1+C_2V_2)^2}{C_1+C_2}$

iii. Clearly, $U_f < U_i$. Thus the total energy of the parallel combination is less than the sum of the energies stored in the two capacitors before they are connected. During sharing of charges, some energy is lost as heat due to the flow of charges in connecting wires.

OR

Consider a point P on the axis perpendicular to the plane of disc and at distance x from the center O of the disc as shown in the figure.



Now consider a ring of radius r of thickness dr on a disc of radius R, as shown in the figure, Let us consider disc is divided into a large number of rings, Again let the charge on the ring is dq then potential dV due to ring at P, will be

$dV = \frac{kdq}{r'}\left[\because r' = \sqrt{r^2 + x^2}\right]$

dq is the charge on the ring = σ area of ring

$= \sigma \cdot \left[\pi(r + dr)^2 - \pi r^2\right]$

$dq = \sigma \cdot \pi\left[r^2 + dr^2 + 2rdr - r^2\right]$

Because dr is small, therefore, dr_2 is negligible.

$\therefore dq = \sigma\pi(2rdr) = 2\pi r\sigma \cdot dr$

$\therefore dV = \frac{k.2\pi r\sigma dr}{\sqrt{(r^2+x^2)}}$

So the potential due to charged disc

$\int_0^V dV = \int_0^R \frac{k.2\pi\sigma dr}{\sqrt{r^2+x^2}}$

$V = k.2\pi\sigma \cdot \int_0^R \frac{rdr}{(r^2+x^2)^{12}} = k.\pi\sigma \int_0^R r \cdot \left(r^2+x^2\right)^{-1/2} 2dr = \frac{k\pi\sigma[\sqrt{r^2+x^2}]_0^R}{1/2}$

$= 2\pi k\sigma \left[\left(R^2+x^2\right)^{1/2} - x\right] = \frac{2\pi\sigma}{4\pi\varepsilon_0}\left[\left(R^2+x^2\right)^{1/2} - x\right]$

[$\because$ $\pi R^2\sigma$ = Q(charge on disc) $\sigma = \frac{Q}{\pi R^2}$

$= \frac{\pi 2R^2\sigma}{4\pi\varepsilon_0 R^2}[\sqrt{R^2+x^2} - x]$ thus the potential due to a disc is given by,

$V = \frac{2Q}{4\pi\varepsilon_0 R^2}[\sqrt{R^2+x^2} - x]$

33. a. Power dissipation = P = V_{rms} I_{rms} cos ϕ

cos ϕ = $\frac{R}{Z}$

For ideal inductor R = 0

$\therefore$ cos ϕ = 0

$\therefore$ P = V_{rms} I_{rms} cos ϕ = 0

Thus, ideal inductor does not dissipate power in an ac circuit.

b. i. Inductive reactance = X_L = 2πfL

$\therefore$ L = $\frac{X_L}{2\pi f}$

From graph, at f = 100 Hz

X_L = 20 Ω

$\therefore$ L = $\frac{X_L}{2\pi f}$ = $\frac{20}{2\pi\times100}$

= 0.032 H = 32 mH

ii. Power dissipation is maximum when

2πfL = $\frac{1}{2\pi fC}$

f = 300 s^{-1}

L = 0.032 H

2πfL = $\frac{1}{2\pi fC}$

Or, 2π $\times$ 300 $\times$ 0.032 = $\frac{1}{2\pi\times300\times C}$

$\therefore$ C = 8.8 $\times$ 10^{-6} F = 8.8 μF

OR

i. Calculation of Capacitance

As power factor is unity,

$\therefore$ X_L = X_C also L=200mH and R= 10 Ω

$\Rightarrow \omega = \frac{1}{\sqrt{LC}}$

100 = $\frac{1}{\sqrt{200\times10^{-3}\times C}}$

$10^4 \times 2 \times 10^2 \times 10^{-3} \times$ C = 1

hence ca[pacitance is given by ,C = $\frac{1}{2\times10^3}$ F

= 0.5 $\times$ 10^{-3} F

= 0.5mF

ii. Q-factor of circuit and its importance Calculation of average power dissipated

Quality factor, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

$= \frac{1}{10}\sqrt{\frac{200\times10^{-3}}{0.5\times10^{-3}}}$

$= \frac{1}{10}\times$ 20 = 2

Significance: It measures the sharpness of resnance.

Average Power dissipated,

$P = V_{rms}\ I_{rms} \cos\phi$

$= 50 \times \frac{50}{10}\times$ 1 W

= 250 watts