Class XII Session 2025-26
Subject - Physics
Sample Question Paper - 7

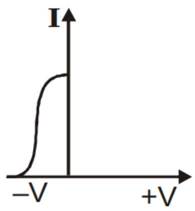
Time Allowed: 3 hours **Maximum Marks: 70**

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. Different voltages are applied across a PN junction and the currents are measured for each value. Which of the following graphs is obtained between voltage and current? **[1]**

a)


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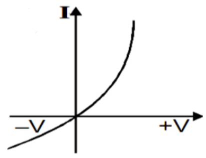

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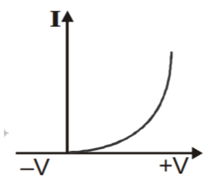

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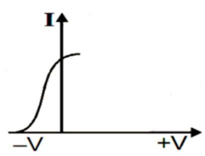

2. The instrument among the following which measures the emf of a cell most accurately is: **[1]**

a) an ammeter
b) a voltmeter
c) potentiometer
d) post office box

3. Which of the following is not due to total internal reflection? **[1]**

a) Difference between apparent and real depth of a pond
b) Working of optical fibre

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c) Mirage on hot summer days

d) Brilliance of diamond

4. Consider the two idealised systems: (i) a parallel plate capacitor with large plates and small separation and (ii) a long solenoid of length L > > R, radius of cross-section. In (i), E is ideally treated as a constant between plates and zero outside. In (ii), magnetic field is constant inside the solenoid and zero outside. These idealised assumptions, however, contradict fundamental laws as below: **[1]**

a) case (ii) contradicts en $\oint H.d1 = I_{en}$

b) case (ii) contradicts Gauss's law for magnetic fields.

c) case (i) agrees with $\oint E.d1 = 0$

d) case (i) contradicts Gauss's law for electrostatic fields.

5. The earth has volume V and surface area A, then capacitance would be: **[1]**

a) $4\pi\varepsilon_0\frac{V}{A}$

b) $12\pi\varepsilon_0\frac{V}{A}$

c) $4\pi\varepsilon_0\frac{A}{V}$

d) $12\pi\varepsilon_0\frac{A}{V}$

6. A proton and an α-particle enters a uniform magnetic field perpendicular to y-axis with the same speed. If proton takes 25μ sec to make 5 revolutions, then time period for the α-particle would be **[1]**

a) 50 μsec

b) 10 μsec

c) 5 μsec

d) 25 μsec

7. The dimensional formula for emf ε in MKS system will be **[1]**

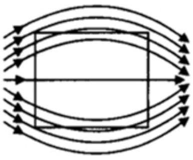
a) $[MLT^{-2}Q^{-2}]$

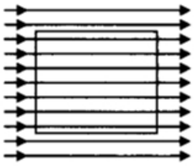
b) $[ML^{-2}Q^{-1}]$

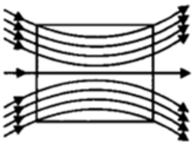
c) $[ML^2T^{-2}Q^{-1}]$

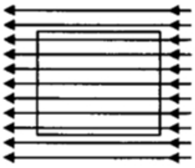
d) $[ML^2T^{-1}]$

8. A uniform magnetic field exists in space in the plane of paper and is initially directed from left to right. When a bar of soft iron is placed in the field parallel to it, the lines of force passing through it will be represented by **[1]**

a) 

b) 

c) 

d) 

9. A double-slit experiment is performed with light of wavelength 500 nm. A thin film of thickness 2 μm and refractive index 1.5 is introduced in the path of the upper beam. The location of the central maximum will: **[1]**

a) shift downward by nearly two fringes

b) shift upward by nearly two fringes

c) remain unshifted

d) shift downward by ten fringes

10. Following figure shows for Gaussian surfaces S_1, S_2, S_3 and S_4. **[1]**

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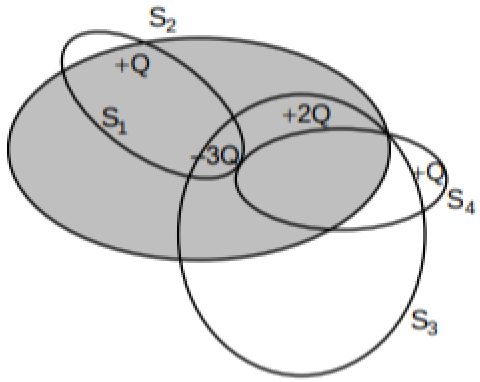


Now, match the following columns and mark the correct code given below:

	Column - I		Column - II
(i)	ϕ_{s_1}	(p)	$+\frac{Q}{\varepsilon_0}$
(ii)	ϕ_{s_2}	(q)	0
(iii)	ϕ_{s_3}	(r)	$-\frac{Q}{\varepsilon_0}$
(iv)	ϕ_{s_4}	(s)	$-\frac{2Q}{\varepsilon_0}$

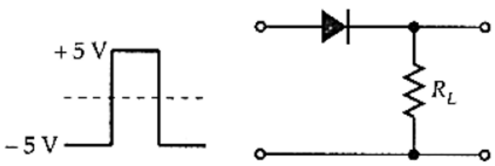
a) (i) q; (ii) s; (iii) r; (iv) p

b) (i) s; (ii) q; (iii) r; (iv) p

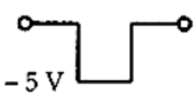
c) (i) r; (ii) s; (iii) p; (iv) q

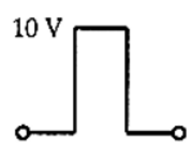
d) (i) q; (ii) r; (iii) s; (iv) p

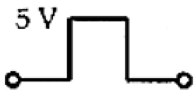
11. If in a p-n junction, a square input signal of 10 V is applied as shown, **[1]**

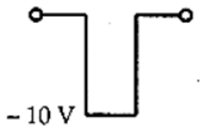


then the output across R_L will be

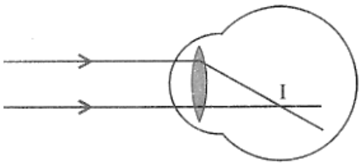
a) 

b) 

c) 

d) 

12. In the figure, the image is formed of retina. The eye has: **[1]**



Human eye

a) colour blindness

b) hypermetropia

c) myopia

d) astigmatism

13. **Assertion (A):** The energy of X-ray photon is greater than that of light (visible) photon. **[1]**

Reason (R): X-ray photon in vacuum travels faster than light photon.

a) Both A and R are true and R is the correct

b) Both A and R are true but R is not the

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explanation of A. correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

14. **Assertion (A):** When a charged capacitor is filled completely with a metallic slab, its capacitance is increased by a large amount. **[1]**

Reason (R): The dielectric constant for metal is infinite.

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):** Newton's rings are formed in the reflected system. When the space between the lens and the glass plate is filled with a liquid of refractive index greater than that of glass, the central spot of the pattern is dark. **[1]**

Reason (R): The reflections in Newton's ring cases will be from a denser to a rarer medium and the two interfering rays are reflected under similar conditions.

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 sample of paramagnetic salt contains 2.0×10^{24} atomic dipoles each of dipole moment 1.5×10^{-23} JT^{-1}. The sample is placed under homogeneous magnetic field of 0.84 T and cooled to the 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)? **[2]**

OR

A neutral point is found on the axis of a bar magnet at a distance of 10 cm from its one end. If the length of the magnet be 10 cm and B_H = 0.3 G, find the magnetic moment of the magnet.

19. The V-I characteristic of a silicon diode is as shown in the figure. Calculate the resistance of the diode at **[2]**

a. I_D = 15 mA and

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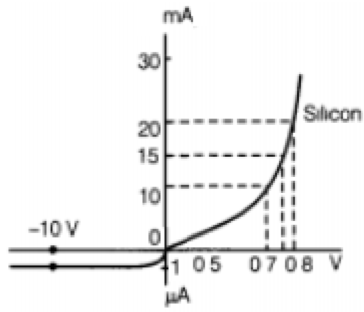
b. V_D = -10V



20. In a Geiger-Marsden experiment, calculate the distance of closest approach to the nucleus of Z = 80, when an a-particle of 8 MeV energy impinges on it before it comes momentarily to rest and reverses its direction. **[2]**

21. A charged particle of mass'm', charge 'q' moving at uniform velocity 'v', enters a uniform magnetic field 'B' acting normal to the plane of the paper. Deduce expression for the (t) radius of the circular path in which it travels, (ii) kinetic energy of the particle (assuming v << c). **[2]**

Section C

22. A cell of emf 'E' and internal resistance 'r' is connected across a variable load resistor R. Draw the plots of the terminal voltage V versus (i) R and (ii) the current I. **[3]**

    It is found that when R = 4 Ω, the current is 1 A when R is increased to 9 Ω, the current reduces to 0.5 A. Find the values of the emf E and internal resistance r.

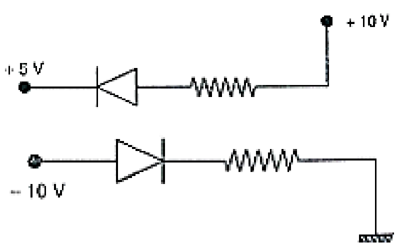
23. Ultra-violet light of wavelength 200 nm from a source is incident on a metal surface. If the stopping potential is -2.5 V, **[3]**

    a. Calculate the work function of the metal, and
    b. How would the surface respond to a high intensity red light of wavelength 6328 A produced by a laser?

24. Explain, with the help of a circuit diagram, how the thickness of depletion layer in a p-n junction diode changes when it is forward biased. In the following circuits which one of the two diodes is forward biased and which is reverse biased? **[3]**

i.

ii.



25. Draw a graph showing the variation of binding energy per nucleon with mass number of different nuclei. Write any two salient features of the curve. How does this curve explain the release of energy both in the processes of nuclear fission and fusion? **[3]**

26. Calculate the de-Broglie wavelength associated with the electron revolving in the first excited state of hydrogen atom. The ground state energy of the hydrogen atom is -13.6 eV. **[3]**

27. **[3]**

    a. State two conditions for two light sources to be coherent.
    b. Give two points of difference between an interference pattern due to a double-slit and a diffraction pattern due to a single slit.

28. Deduce an expression for the mutual inductance of two long coaxial solenoids but having different radii and different number of turns. **[3]**

OR

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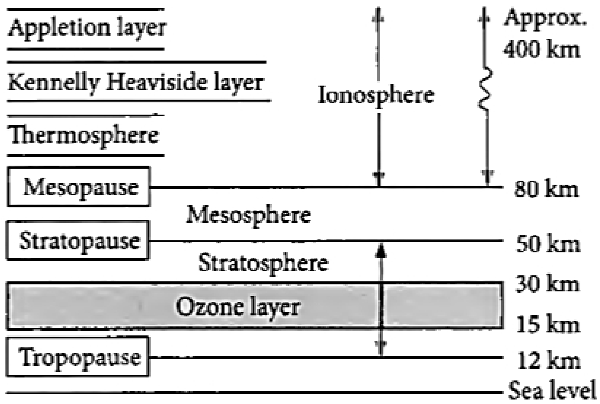
i. Define the term self-inductance and write its S.I. unit.

ii. Obtain the expression for the mutual inductance of two long co-axial solenoids S_1 and S_2 wound one over the other, each of length L and radii r_1 and r_2 and n_1 and n_2 number of turns per unit length, when a current I is set up in the outer solenoid S_2.

Section D

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

Radio waves are produced by the accelerated motion of charges in conducting wires. Microwaves are produced by special vacuum tubes. Infrared waves are produced by hot bodies and molecules also known as heat waves. UV rays are produced by special lamps and very hot bodies like Sun.



(a) Solar radiation is

i. transverse electromagnetic wave

ii. longitudinal electromagnetic waves

iii. both longitudinal and transverse electromagnetic waves

iv. none of these.

a) Option (iii) b) Option (ii)

c) Option (iv) d) Option (i)

(b) What is the cause of greenhouse effect?

a) X-rays b) Ultraviolet rays

c) Infrared rays d) Radiowaves

(c) Biological importance of ozone layer is

a) It layer reduces greenhouse effect b) it stops ultraviolet rays

c) it reflects radiowaves d) none of these.

OR

Earth's atmosphere is richest in

a) ultraviolet b) X-rays

c) microwaves d) infrared

(d) Ozone is found in

a) mesosphere b) ionosphere

c) stratosphere d) troposphere

30. When electric dipole is placed in uniform electric field, its two charges experience equal and opposite forces, **[4]**

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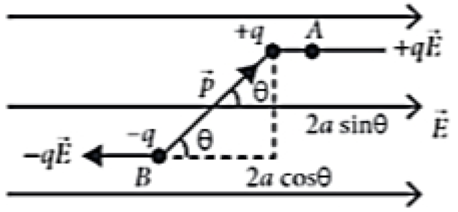
which cancel each other and hence net force on electric dipole in uniform electric field is zero. However these forces are not collinear, so they give rise to some torque on the dipole. Since net force on electric dipole in uniform electric field is zero. so no work is done in moving the electric dipole in uniform electric field. However some work is done in rotating the dipole against the torque acting on it.



i. The dipole moment of a dipole in a uniform external field $\vec{E}$ is $\vec{P}$. Then find the torque $\vec{\tau}$ acting on the dipole.

ii. An electric dipole consists of two opposite charges, each of magnitude 1.0 μC separated by a distance of 2.0 cm. The dipole is placed in an external field of 10^5 NC^{-1}. Then find the maximum torque on the dipole.

iii. Find the θ when torque on a dipole in uniform electric field is minimum.

iv. What is the net force F and torque τ on the dipole when an electric dipole is held at an angle in a uniform electric field?

v. An electric dipole of moment p is placed in an electric field of intensity E. The dipole acquires a position such that the axis of the dipole makes an angle θ with the direction of the field. Assuming that the potential energy of the dipole to be zero when θ = 90^o, Find the torque and the potential energy of the dipole.

Section E

31. a. Draw a labelled ray diagram of an astronomical telescope to show the image formation of a distant object. Write the main considerations required in selecting the objective and eyepiece lenses in order to have large magnifying power and high resolution of the telescope. **[5]**

b. A compound microscope has an objective of focal length 1.25 cm and eyepiece of focal length 5 cm. A small object is kept at 2.5 cm from the objective. If the final image formed is at infinity, find the distance between the objective and the eyepiece.

OR

i. State Huygens principle. A plane wave is incident at an angle i on a reflecting surface. Construct the corresponding reflected wavefront. Using this diagram, prove that the angle of reflection is equal to the angle of incidence.

ii. What are the coherent sources of light? Can two independent sodium lamps act like coherent sources? Explain.

iii. A beam of light consisting of a known wavelength 520 nm and an unknown wavelength λ, used in Young's double slit experiment produces two interference patterns such that the fourth bright fringe of unknown wavelength coincides with the fifth bright fringe of known wavelength. Find the value of λ.

32. a. Describe briefly the process of transferring the charge between the two plates of a parallel plate capacitor when connected to a battery. Derive an expression for the energy stored in a capacitor. **[5]**

b. A parallel plate capacitor is charged by a battery to a potential difference V. It is disconnected from the battery and then connected to another uncharged capacitor of the same capacitance. Calculate the ratio of the energy stored in the combination to the initial energy on the single capacitor.

OR

i. Derive an expression for potential energy of an electric dipole $\vec{p}$ in an external uniform electric field $\vec{E}$. When is the potential energy of the dipole (1) maximum, and (2) minimum?

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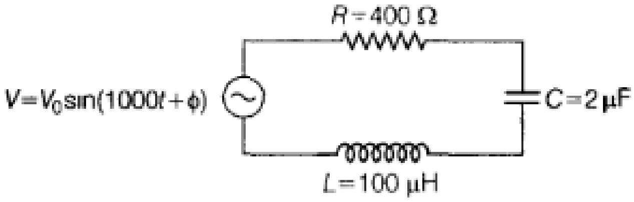
ii. An electric dipole consists of point charges -1.0 pC and +1.0 pC located at $(0, 0)$ and (3 mm, 4 mm) respectively in x - y plane. An electric field $\vec{E} = \left(\frac{1000V}{m}\right)\hat{i}$ is switched on in the region. Find the torque $\vec{\tau}$ acting on the dipole.

33. i. Determine the value of phase difference between the current and the voltage in the given series L-C-R circuit. **[5]**

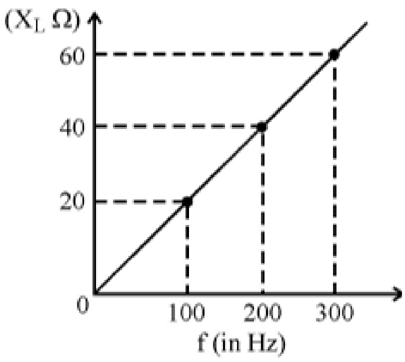


ii. Calculate the value of additional capacitor which may be joined suitably to the capacitor C that would make the power factor of the circuit unity.

OR

a. Show that an ideal inductor does not dissipate power in an ac circuit.

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.

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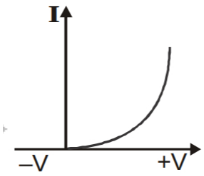
Solution

Section A

1.

(c) 

Explanation:

The correct graph for a PN junction under varying voltages shows a nonlinear relationship between voltage and current. As the voltage increases in the forward bias region, the current increases exponentially. This behavior is characteristic of diodes, where small increases in voltage lead to large increases in current after a certain threshold (the forward voltage). The graph typically starts at zero current, rises steeply, and levels off in reverse bias, indicating that the current remains very low until breakdown occurs. Correct option accurately represents this exponential increase in current with voltage.

2.

(c) potentiometer

Explanation:

The instrument among the following which measures the emf of a cell most accurately is a potentiometer.

3. **(a)** Difference between apparent and real depth of a pond

Explanation:

Difference between apparent and real depth of a pond

4.

(b) case (ii) contradicts Gauss's law for magnetic fields.

Explanation:

case (ii) contradicts Gauss's law for magnetic fields.

5.

(b) $12\pi\varepsilon_0\frac{V}{A}$

Explanation:

$V=\frac{4}{3}\pi R^3$ and A = $4\pi R^2$

$\therefore\frac{V}{A}=\frac{R}{3}\Rightarrow R=\frac{3V}{A}$

$C=4\pi\varepsilon_0R=4\pi\varepsilon_0\left(\frac{3V}{A}\right)=\frac{12\pi\varepsilon_0V}{A}$

6.

(b) 10 μsec

Explanation:

$T_p=\frac{25}{5}=5\mu\text{s}$

From the above problem,

$T_\alpha=2T_p=2\times5=10\mu$ sec

7.

(c) $[ML^2T^{-2}Q^{-1}]$

Explanation:

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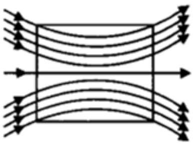
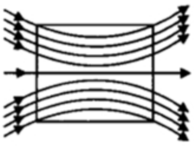
$\varepsilon = \frac{[W]}{[q]} = \frac{[ML^2T^{-2}]}{[Q]}$
= $[ML^2T^{-2}Q^{-1}]$

8.

(c) 

Explanation:



9.

(b) shift upward by nearly two fringes

Explanation:

Displacement of the central bright fringe,

$\Delta x = \frac{\beta}{\lambda}$ (μ - 1)t

$= \frac{\beta(1.5-1)\times 2\times 10^{-6}}{500\times 10^{-9}} = 2\beta$, upward

10.

(b) (i) s; (ii) q; (iii) r; (iv) p

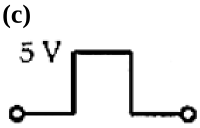
Explanation:

The solution correctly matches the electric flux through the Gaussian surfaces with their corresponding values based on Gauss's law.

i. For surface S_1, the flux ϕ_{s_1} is positive, indicating that it encloses a positive charge Q, leading to $\phi_{s_1} = +\frac{Q}{\varepsilon_0}$.
ii. For surface S_2, the flux ϕ_{s_2} is zero, suggesting that it does not enclose any net charge, hence $\phi_{s_2} = 0$.
iii. For surface S_3, the flux ϕ_{s_3} is negative, indicating that it encloses a negative charge, resulting in $\phi_{s_3} = -\frac{Q}{\varepsilon_0}$
iv. For surface S_4, the flux ϕ_{s_4} is negative and greater in magnitude, suggesting it encloses a net negative charge of $-2Q$, leading to $\phi_{s_4} = -\frac{2Q}{\varepsilon_0}$. Thus, the matches are: - ϕ_{s_1} with $+\frac{Q}{\varepsilon_0}$ (p) - ϕ_{s_2} with 0 (q) - ϕ_{s_3} with $-\frac{Q}{\varepsilon_0}$ (r) - ϕ_{s_4} with $-\frac{2Q}{\varepsilon_0}$ (s)

11.

(c)



Explanation:

When the input level is -5 V, the diode gets reverse biased. No output is obtained across R_L. When the input level becomes +5 V, the diode gets forward biased and the current flows through R_L. The diode is ideal, the output across R_L will be exactly 5V.

12.

(c) myopia

Explanation:

myopia

13.

(c) A is true but R is false.

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Explanation:

A is true but R is false. Both X-ray photons and light photons travel at the same speed in a vacuum.

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

Explanation:

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

16.

(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. Dipole moment of each atomic dipole,

$m = 1.5 \times 10^{-23}$ JT^{-1}

Total number of atomic dipoles, $N = 2.0 \times 10^{24}$

Initial total magnetic moment at temperature $T_1 = 4.2$ K is

M_1 = 15% of mN

$= \frac{15}{100} \times 1.5 \times 10^{-23} \times 2.0 \times 10^{24}$ $JT^{-1} = 4.5$ JT^{-1}

According to Curie's law,

$M = \text{Constant} \times \frac{B}{T}$

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

Now $B_1 = 0.84$ T, $T_1 = 4.2$ K, $B_2 = 0.98$ T, $T_2 = 2.8$ K

Hence the final dipole moment at temperature $T_2 = 2.8$ K is

$M_2 = M_1 \times \frac{B_2}{B_1} \times \frac{T_1}{T_2} = 4.5 \times \frac{0.98}{0.84} \times \frac{4.2}{2.8} JT^{-1}$

$= 7.9$ JT^{-1}

OR

Here, 2l = 10 cm, H = 0.3 G, M = ?

r = 10 + l = 10 + 5 = 15 cm = 15×10^{-2} m

As neutral point is on the axis of bar magnet, therefore,

$H = \frac{\mu_0}{4\pi}\frac{2M}{r^3} = 10^{-7}\frac{2\times M}{(15\times10^{-2})^3}$

$M = \frac{(15\times10^{-2})^3 H}{2\times10^{-7}} = \frac{3375\times10^{-6}\times0{\cdot}3\times10^{-4}}{2\times10^{-7}}$

$M = 506.25 \times 10^{-3} = 0.506$ Am^2

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19. a. From the given curve, V = 0.8 volt for current 20 mA and V = 0.7 volt for current 10 mA,

$\Rightarrow \Delta I=(20-10)\mathrm{mA}$

$\Rightarrow \quad \Delta I=10mA=10\times 10^{-3}\mathrm{A}$

$\Rightarrow \quad \Delta I=10^{-2}\mathrm{A}$

and $\Delta V=(0.8-0.7)=0.1\mathrm{V}$

Resistance of the diode is given by, $R=\frac{\Delta V}{\Delta I}$

$\Rightarrow R=\frac{0.1}{10^{-2}}$

$\Rightarrow R=10\Omega$

b. For V = -10V, we have

$I=-1\mu A=-1\times 10^{-6}A$

resistance of diode is given by, R = $\frac{V}{I}$

$\Rightarrow \quad R=\frac{-10}{-1\times 10^{-6}}=1.0\times 10^{7}\Omega$

20. Here Z = 80, K = 8 MeV = 8 $\times$ 1.6 $\times$ 10^{-13} J

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

$=\frac{9\times 10^9\times 2\times 80\times\left(1.6\times 10^{-19}\right)^2}{8\times 1.6\times 10^{-13}}\ \mathrm{m}$

= 28.2 $\times$ 10^{-15}m = 28.2 fm

21. i. Force exerted by the magnetic field

= Centripetal force on the charge

or $qvB\sin 90^{\circ}=\frac{mv^2}{r}$

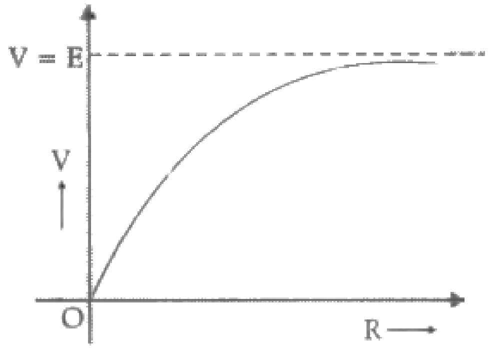
$\therefore$ Radius $r=\frac{mv}{qB}$

ii. Velocity,$v=\frac{qBr}{m}$

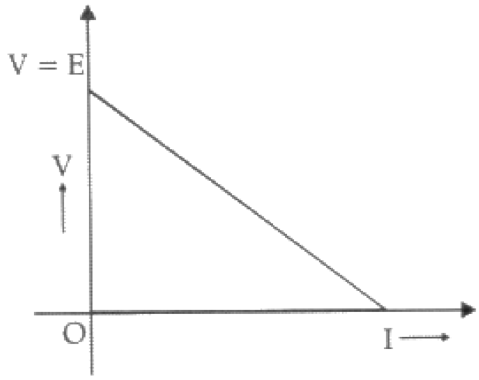
$\therefore \mathrm{K.E.}=\frac{1}{2}mv^2=\frac{1}{2}m\left(\frac{qBr}{m}\right)^2=\frac{B^2q^2r^2}{2m}$

Section C

22. i.



ii.



$I=\frac{E}{R+r}$ (V=E-Ir and V=IR)

$I=\frac{E}{4+r}$

$\Rightarrow$ E = 4 + r ...(i)

0.5 = $\frac{E}{9+r}$

Also E = 4.5 + 0.5r ...(ii)

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From equation (i) and (ii),

$4 + r = 4.5 + 0.5r$

$\therefore r = 1\ \Omega$ (internal resistance)

Using this value of r, we get,

$E = 5V$

23. a. $\lambda = 200$ nm, stopping potential = -2.5 V

$K.E. = 2.5 \times 1.6 \times 10^{-19}\ J = 4 \times 10^{-19}\ J$

$E = h\nu = h\frac{c}{\lambda}$

$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{200 \times 10^{-9}}$

$= 9.945 \times 10^{-19}\ J$

Work function = E - eV

$= (9.945 \times 10^{-19} - 4 \times 10^{-19}) J$

$= 5.595 \times 10^{-19}\ J$

b. Wavelength of red light = 6328 $\overset{\circ}{A}$

$E = h\nu = h\frac{c}{\lambda}$

$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{6328 \times 10^{-10}}$

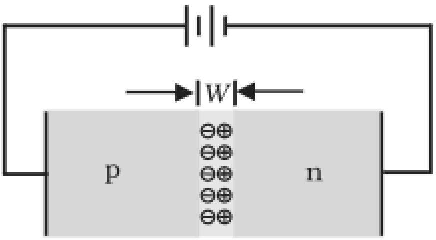
$= 0.00314 \times 10^{-16}\ J$

$= 3.14 \times 10^{-19}\ J$

Energy of red light < work function of metal surface

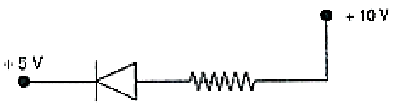
$\therefore$ No emission of photoelectrons takes place.

24. When an external voltage V is applied across a semiconductor diode such that p-side is connected to the positive terminal of the battery and n-side to the negative terminal [Fig.], it is said to be forward biased.

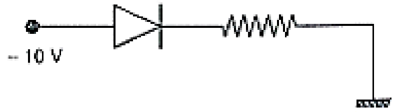


The applied voltage mostly drops across the depletion region and the voltage drop across the p-side and n-side of the junction is negligible. (This is because the resistance of the depletion region – a region where there are no charges – is very high compared to the resistance of n-side and p-side.) The direction of the applied voltage (V) is opposite to the built-in potential V_0. As a result, the depletion layer width decreases [Fig.]

i. In this case, the p-side is at +10V, whereas the n-side is at +5V. As, $V_p > V_n$, hence the diode is forward biased.



ii. In this case, the p-side is at -10V, whereas the n-side is at 0 V. As, $V_p < V_n$, hence the diode is reverse biased.



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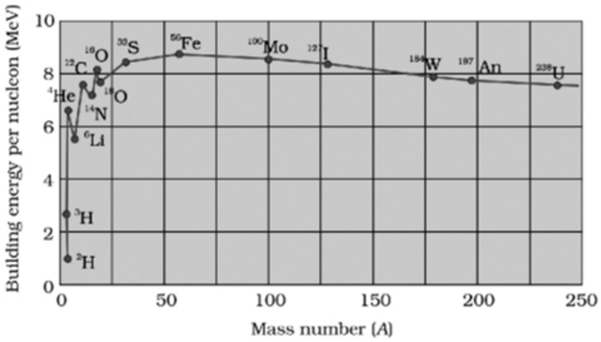
25. 

Salient feature of B.E. curve

i. B.E/nucleon is pratically constant i.e. independent of the atomic number for nuclei of middle mass number (30 < A < 17)

ii. Binding energy per nucleon is lower for both light nuclei (A < 30) and heavy nuclei (A > 70).

Very heavy nucleus has lower B.E./nucleon will undergo fission and split into two medium sized nuclei with large B.E./nucleon and release tremendous amount of energy (Fission process)

When two very light nuclei, having low binding energy per nucleon combine together and form a medium sized nuclei of higher B.E. per nucleon releases enormous amount of energy (Fusion process)

26. Energy of the electron in the first excited state

$E_1 = -\frac{13.6}{2^2} eV$ = -3.4 eV

= -3.4 $\times$ 1.6 $\times$ 10^{-19} J

= -5.44 $\times$ 10^{-19} J

Associated kinetic energy = Negative of total energy

K = 5.44 $\times$ 10^{-19} J

de-Broglie wavelength, $\lambda = \frac{h}{p}$

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

$\lambda = \frac{6.63 \times 10^{-34}}{(2 \times 9.1 \times 10^{-31} \times 5.44 \times 10^{-19})^{\frac{1}{2}}}$ m

$\lambda = \frac{6.63 \times 10^{-34}}{(99.008)^{\frac{1}{2}} \times 10^{-25}}$ m

$\approx$ 0.663 $\times$ 10^{-9} m = 0.663 nm = 6.63 A^o

Hence, the de-Broglie wavelength associated with the electron is 6.63 A^o

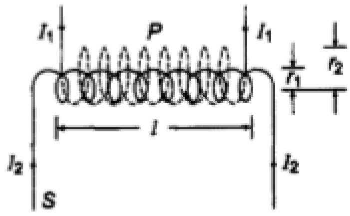
27. a. Conditions for light sources to be coherent:-

Two sources produce waves of same frequency.

Two sources produce waves of constant phase difference.

b. In interference pattern the fringes are equally spaced (dark and bright) and of equal intensity and in diffraction the central maxima is brightest and is wider two times as the other maxima with intensity decreasing away from the Centre.

28. Let coaxial solenoid P is wound over an another solenoid.



Let l = length of both solenoid

r_1 and r_2 = radii of P and S

$A_2 = \pi r_2^2$ [area of secondary coil, S]

Magnetic induction in solenoid, P

$B_1 = \mu_0 n_1 I_1$

where, $n_1 = \frac{N_1}{l}$

$\therefore$Total flux linked with solenoid S,

$\phi_2 = B_1 A_2 N_2$

$\Rightarrow \quad \phi_2 = B_1 \left(\pi r_2^2\right) N_2 = \left(\mu_0 n_1 I_1\right) \pi r_2^2 N_2$

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$\phi_2 = \left(\mu_0 \frac{N_1}{l} I_1\right) \pi r_2^2 N_2$

$\Rightarrow \quad \phi_2 = \frac{\mu_0 \pi I_1 N_1 N_2 r_2^2}{l}$ ...(i)

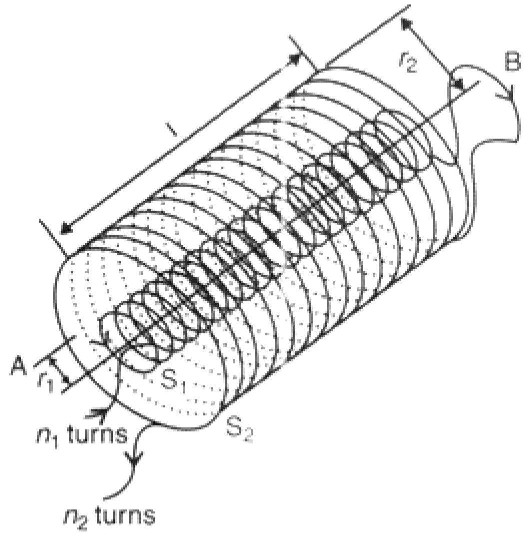
But $\phi_2 = MI_1$

were, M = coefficient of mutual induction

$\Rightarrow MI_1 = \frac{\mu_0 \pi N_1 N_2 r_2^2}{l} I_1 \Rightarrow M = \frac{\mu_0 \pi N_1 N_2 r_2^2}{l}$

OR

i. Self-Inductance is the property by which an opposing induced emf is produced in a coil due to a change in current, or magnetic flux, linked with the coil.
   The S.I. unit of self-inductance is Henry (H).
ii. In this question, a long co-axial solenoids S_1 and S_2 wound one over the other, each of length L and radii r_1 and r_2 and n_1 and n_2 number of turns per unit length, when a current I is set up in the outer solenoid S_2.



   Let a current l_2 flow in the secondary coil

   $\therefore$ $B_2 = \frac{\mu_0 N_2 i_2}{l}$

   $\therefore$ Flux linked with the primary coil = $\frac{\mu_0 N_2 N_1 A_1 i_2}{l}$

   $= M_{12} i_2$

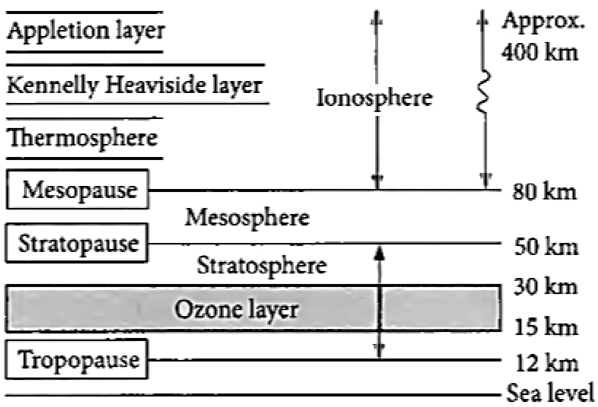
   Hence, $M_{12} = \frac{\mu_0 N_2 N_1 A_2}{l}$

   $\mu_0 n_2 n_1 A_1 l \left(n_1 = \frac{N_1}{l}; n_2 = \frac{N_2}{l}\right)$

Section D

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

Radio waves are produced by the accelerated motion of charges in conducting wires. Microwaves are produced by special vacuum tubes. Infrared waves are produced by hot bodies and molecules also known as heat waves. UV rays are produced by special lamps and very hot bodies like Sun.



(i) **(d)** Option (i)

Explanation:

transverse electromagnetic wave

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(ii) **(c)** Infrared rays

Explanation:

Greenhouse effect is due to infrared rays.

(iii) **(b)** it stops ultraviolet rays

Explanation:

Ozone layer absorbs the harmful ultraviolet radiations coming from the sun.

OR

(d) infrared

Explanation:

The atmosphere of earth is richest in infrared radiation.

(iv) **(c)** stratosphere

Explanation:

Ozone layer lies in stratosphere.

30. i. $\vec{\tau} = \vec{P} \times \vec{E}$

As τ = either force $\times$ perpendicular distance between the two forces

= qaE sin θ or τ = PE sin θ

or $\vec{P} \times \vec{E}$ ($\because$ qa = P)

ii. The maximum torque on the dipole in an external field is given by

τ = pE = q(2a) $\times$ E

Here, q = $1\mu C = 10^{-6}C$, 2a = 2 cm = 2 $\times$ 10^{-2} m, E = 10^5 NC^{-1}, τ = ?

$\therefore \tau = 10^{-6} \times 2 \times 10^{-2} \times 10^5 = 2 \times 10^{-3}$ Nm

$\therefore$ the maximum torque on the dipole 2×10^{-3} Nm.

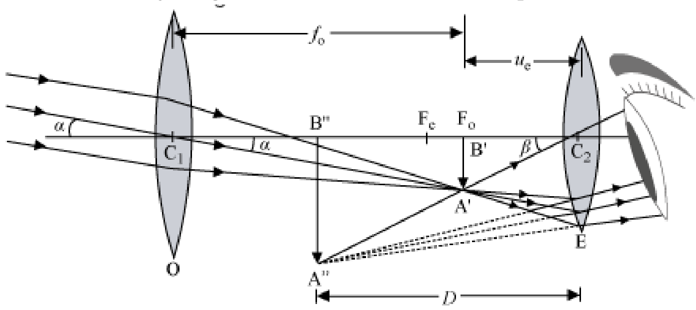
iii. When θ is 0 or 180^0, the τ is minimum, which means the dipole moment should be parallel to the direction of the uniform electric field.

iv. The net force is zero and torque acts on the dipole, trying to align p with E.

v. Torque, τ = pE sin θ and potential energy U = -pE cos θ

Section E

31. a. Consider the ray diagram of Astronomical telescope.



When the final image is formed at the least distance of distinct vision,

Magnifying power, $M = \frac{\beta}{\alpha}$

Since α and β are small, we have:

$\therefore M = \frac{\tan\beta}{\tan\alpha}$ ...(i)

In $\Delta A'B'C_2, \tan\beta = \frac{A'B'}{C_2B'}$

In $\Delta A'B'C_1, \tan\alpha = \frac{A'B'}{C_1B'}$

From equation (i), we get:

$M = \frac{A'B'}{C_2B'} \times \frac{C_1B'}{A'B'}$

$\Rightarrow M = \frac{C_1B'}{C_2B'}$

Here, $C_1B' = +f_0$

$\Rightarrow C_2B' = -u_e$

$\Rightarrow M = \frac{f_0}{-u_e}$ ...(ii)

Using the lens equation $\left(\frac{1}{v} - \frac{1}{u} = \frac{1}{f}\right)$ for the eyepieces, we get,

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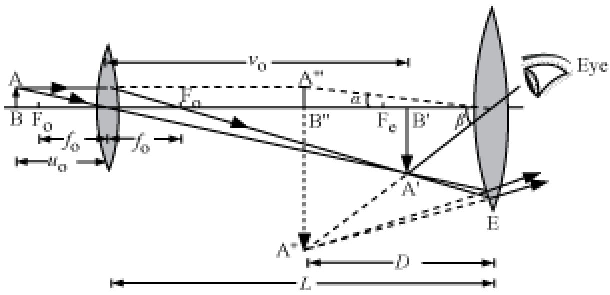
$\frac{1}{-D} - \frac{1}{-u_e} = \frac{1}{f_e}$
$-\frac{1}{D} + \frac{1}{u_e} = \frac{1}{f_e}$
$\Rightarrow \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D}$
$\Rightarrow \frac{f_0}{u_e} = \frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$
$\Rightarrow \frac{-f_0}{u_e} = \frac{-f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$
or $M = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$

In order to have a large magnifying power and high resolution of the telescope, its objective lens should have a short length.

b.



Distance between the objective and the eyepiece, L = $v_0 + |u_e|$

To find v_0, we have:

u_0 = -2.5 cm and f_0 = 1.25 cm

Now, $-\frac{1}{u_0} + \frac{1}{v_0} = \frac{1}{f_0}$

or v_0 = 2.5 cm

To find u_e, we have:

$v_e = \infty$ and f_e = 5 cm

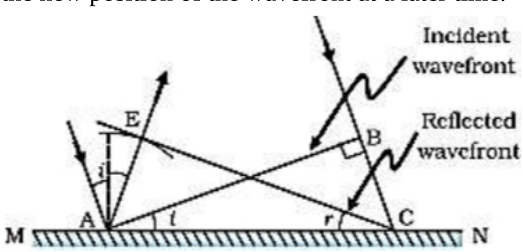
Calculating using the same formula as above, we get:

u_e = -5 cm

$\therefore$ L = 2.5 + 5 = 7.5 cm

OR

i. Each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the spread of the wave. Each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. These wavelets emanating from the wavefront are usually referred to as secondary wavelets and if we draw a common tangent to all these spheres, we obtain the new position of the wavefront at a later time.



$\triangle$EAC is congruent to $\triangle$BAC; so <i = <r

ii. Two sources are said to be coherent if the phase difference between them does not change with time.

No, two independent sodium lamps cannot be coherent.

Two independent sodium lamps cannot be coherent as the phase between them does not remain constant with time.

iii. $4\beta_2 = 5\beta_1$

$4 \times \frac{\lambda D}{d} = 5 \times \frac{\lambda_{\text{known}} D}{d}$

$\Rightarrow \lambda = \frac{5}{4} \times \lambda_{\text{hnoun}}$

$= \frac{5}{4} \times 520$

= 650 nm

32. a. Consider a parallel plate capacitor which is connected across a battery. The electrons are transferred from the negative terminal of the battery to the metallic plate connected to the negative terminal and acquires a negative charge. Similarly, the

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electrons move from the second plate to the positive terminal of the battery and acquire a positive charge. This process continues until the potential difference between the two plates becomes equal to the potential difference between the terminals of the battery. Thus, the charge is developed on the capacitor.

Let 'dW' be the work done by the battery in increasing the charge on the capacitor is given by, having the charge q and potential V is:

dW = V dq

where V = $\frac{q}{C}$

$\therefore$ dW = $\frac{q}{C}$dq

Total work done in charging up the capacitor is given by,

W = $\int$ dW = $\int_0^Q \frac{q}{c}$dq

$\therefore$ W = $\frac{Q^2}{2C}$

Hence total energy stored in the plates of the capacitor is given by, W = $\frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$

b. Charge on the plates of the capacitor is given by q = CV

When uncharged capacitor of same capacitance is connected to the charged capacitor, sharing of charges takes place between the two capacitors till both the capacitors acquire same potential $\frac{V}{2}$

Energy stored in the combination of capacitors is given by,

$U_2 = \frac{1}{2}C(\frac{V}{2})^2 + \frac{1}{2}C(\frac{V}{2})^2 = \frac{CV^2}{4}$

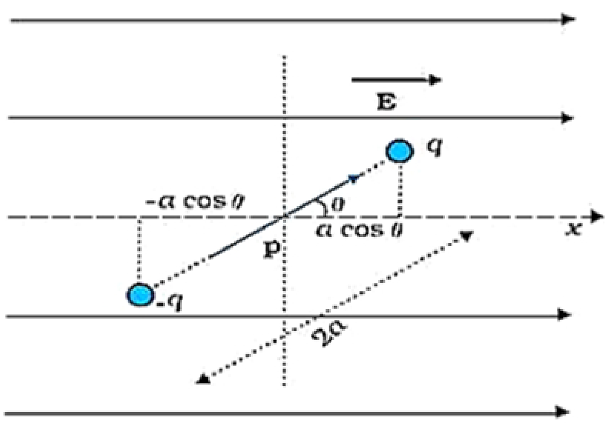
Energy stored by a single capacitor before connecting is given by, $U_1 = \frac{1}{2}CV^2$

Ratio of energy stored in the combination to that in the single capacitor is given by,

$\frac{U_2}{U_1} = \frac{CV^2/4}{CV^2/2}$ = 1 : 2 , Hence these are required results.

OR

i.



The amount of work done in rotating the dipole from $\theta = \theta_0$ to $\theta = \theta_1$ by the external torque

$$W = \int_{e_0}^{\theta_1} \tau_{ext} d\theta$$

$$= \int_{\theta_0}^{a} pE \sin\theta d\theta$$

$W = pE(\cos\theta_0 - \cos\theta_1)$

For $\theta_0 = \frac{\pi}{2}$ and $\theta_1 = \theta$

$= pE\left(\cos\frac{\pi}{2} - \cos\theta\right)$

$U(\theta) = -pE\cos\theta = -\vec{p}\cdot\vec{E}$

1. Potential energy is maximum when:
   $\vec{p}$ is antiparallel to $\vec{E}$
2. Potential energy is minimum when:
   $\vec{p}$ is along to $\vec{E}$

ii. **Dipole Moment Calculation:**

The charge q = 1.0×10^{-12}C.

Separation vector $\vec{d}$ = (3 mm, 4 mm) = (3×10^{-3} m, 4×10^{-3} m)

Dipole moment $\vec{p} = q\vec{d}$ = ($1.0 \times 10^{-12} \times 3 \times 10^{-3}$, $1.0 \times 10^{-12} \times 4 \times 10^{-3}$) = ($3.0 \times 10^{-15}$, 4.0×10^{-15}) C.m.

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Torque Calculation:

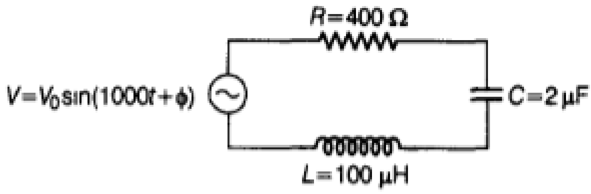
Electric field $\vec{E}=1000\hat{i}\ \mathrm{V/m}$

Torque $\vec{\tau}=\vec{p}\times\vec{E}$

$\vec{\tau}=\left(3.0\times10^{-15}\hat{i}+4.0\times10^{-15}\hat{j}\right)\times1000\hat{i}=\left(4.0\times10^{-15}\times1000\right)\hat{k}$

$\vec{\tau}=4.0\times10^{-12}\ \mathrm{N\cdot m}\hat{k}$

The torque is $\vec{\tau}=4.0\times10^{-12}\ \mathrm{N\cdot m}\hat{k}$

33. i. 

$V=V_0\sin(1000t+\phi)\Rightarrow\omega=1000\mathrm{Hz}$

$R=400\Omega, C=2\mu F, L=100\mathrm{mH}$

Capacitive reactance, $X_c=\frac{1}{\omega C}$

$\Rightarrow\quad X_C=\frac{1}{1000\times2\times10^{-6}}$

$\Rightarrow\quad X_c=\frac{10^3}{2}\Rightarrow X_c=500\Omega$

Inductive reactance, $X_L=\omega L$

$\Rightarrow\quad X_L=1000\times100\times10^{-3}\Rightarrow X_L=100\Omega$

So, $X_c>X_L$

$\Rightarrow\tan\phi$ is negative.

Hence, the voltage lags behind the current by a phase angle ϕ .

Phase difference, $\tan\phi==\frac{X_L-X_C}{R}$

$\tan\phi=\frac{100-500}{400}\Rightarrow\tan\phi=\frac{-400}{400},\tan\phi=-1$

$\Rightarrow\quad\tan\phi=-\tan\left(\frac{\pi}{4}\right)\Rightarrow\phi=-\frac{\pi}{4}$

This is the required value of the phase difference between the current and the voltage in the given series L-C-R circuit.

ii. Suppose, new capacitance of the circuit is C'. Thus, to have power factor unity

$\cos\phi'=1=\frac{R}{\sqrt{R^2+(X_L-X_C')^2}}$

$\Rightarrow\quad R^2=R^2+\left(X_L-X_C'\right)^2$

$\Rightarrow\quad X_L=X_C'=\frac{1}{\omega C'}$ or $\quad\omega L=\frac{1}{\omega C'}$

$\Rightarrow\omega^2=\frac{1}{LC'}$ or $(1000)^2=\frac{1}{LC'}\ (\because\omega=1000)$

$\Rightarrow\quad C'=\frac{1}{L\times10^6}=\frac{1}{100\times10^{-3}\times10^6}$

$=\frac{10}{10^6}=\frac{1}{10^5}=10^{-5}$

$\Rightarrow\quad C'=10^{-5}\mathrm{F}=10\times10^{-6}\mathrm{F}=10\mu F$

As, C' > C, hence, we have to add an additional capacitor of capacitance = $10\mu F-2\mu F=8\mu F$ in parallel with previous capacitor.

OR

a. Power dissipation = P = $V_{rms} I_{rms}\cos\phi$

$\cos\phi=\frac{R}{Z}$

For ideal inductor R = 0

$\therefore\cos\phi=0$

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

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

b. i. Inductive reactance = $X_L=2\pi fL$

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

From graph, at f = 100 Hz

$X_L=20\ \Omega$

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

= 0.032 H = 32 mH

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ii. Power dissipation is maximum when

$2\pi fL = \frac{1}{2\pi fC}$

$f = 300\ s^{-1}$

$L = 0.032\ H$

$2\pi fL = \frac{1}{2\pi fC}$

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

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

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