Class XII Session 2023-24
Subject - Physics
Sample Question Paper - 8

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. When a p-n diode is reverse biased, then **[1]**

   a) the height of the potential barrier is reduced
   b) the depletion region is increased
   c) no current flows
   d) the depletion region is reduced

2. A filament bulb (500 W, 100 V) is to be used in a 230 V main supply. When a resistance R is connected in series, it works perfectly and the bulb consumes 500 W. The value of R is: **[1]**

   a) 13 Ω
   b) 26 Ω
   c) 230 Ω
   d) 46 Ω

3. A thin convergent glass lens (μ_g = 1.5) has a power of +5.0 D. When this lens is immersed in a liquid of refractive index μ_1 it acts as a divergent lens of focal length 100 cm. The value of μ_1 must be **[1]**

   a) $\frac{4}{3}$
   b) $\frac{5}{3}$
   c) $\frac{5}{4}$
   d) $\frac{6}{5}$

4. A bar-magnet of the pole-strength 2 Amp-m is kept in a magnetic field of induction 4×10^{-5} Wb/m^2 such that the axis of the magnet makes an angle 30° with the direction of the field. If the couple acting on the magnet is found to be 80×10^{-7} Nm, then the distance between the poles of the magnet is: **[1]**

   a) 20 cm
   b) 4 m

c) 2 m

d) 8 m

5. A capacitor of capacitance C is fully charged by a 200 V supply. It is then discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat $2.5 \times 10^2 \mathrm{Jkg^{-1}K^{-1}}$ and of mass 0.1 kg. If the temperature of the block rises by 0.4 K, what is the value of C? **[1]**

a) 500 μF

b) 400 μF

c) 300 μF

d) 200 μF

6. If electron velocity is $2\hat{i} + 3\hat{j}$ and it is subjected to magnetic field of $4\hat{k}$, then its **[1]**

a) none of these

b) speed will change

c) both path will change and speed will change

d) path will change

7. A thin ring of radius R metre has charge q coulomb uniformly spread on it. The ring rotates about its axis with a constant frequency of f revolution/s. The value of magnetic induction in Wbm^{-2} at the centre of the ring is: **[1]**

a) $\frac{\mu_0 q f}{2R}$

b) $\frac{\mu_0 q f}{2\pi R}$

c) $\frac{\mu_0 q}{2fR}$

d) $\frac{\mu_0 q}{2\pi f R}$

8. At a point on the right bisector of a magnetic dipole, the magnetic: **[1]**

a) field varies as r^3

b) potential is zero at all points on the right bisector

c) field is perpendicular to the axis of dipole

d) potential varies as $\frac{1}{r^2}$

9. The relationship between phase difference $\Delta\phi$ and the path difference Δx between two interfering waves is given by: {λ = wavelength) **[1]**

a) $\Delta x = \left(\frac{2\pi}{\lambda}\right)\Delta\phi$

b) $\Delta\phi = (2\pi)\Delta x$

c) $\Delta x = \left(\frac{\lambda}{2\pi}\right)\Delta\phi$

d) $\Delta\phi = \left(\frac{\lambda}{\pi}\right)\Delta x$

10. For coulomb force to be operative the least size of the atom will be **[1]**

a) 10^{-8} m

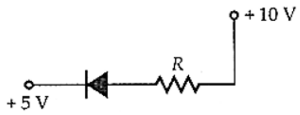
b) 10^{-15} m

c) 10^{-10} m

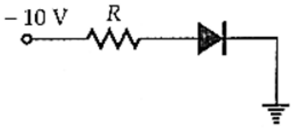
d) 10^{-12} m

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

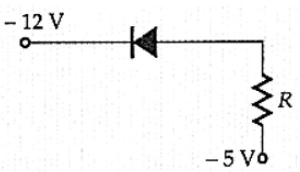
A.



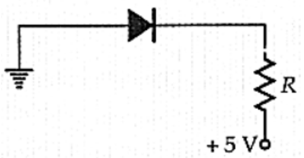
B.



C.



D.



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

12. When a ray of light enters a glass slab from air, **[1]**

a) its wavelength decreases
b) neither wavelength nor frequency changes
c) its wavelength increases
d) its frequency increases

13. **Assertion (A):** In photoelectric effect on increasing the intensity of light, both the number of electrons emitted and kinetic energy of each of them gets increased but the photoelectric current remains unchanged. **[1]**

Reason (R): The photoelectric current depends on wavelength of light.

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 and R is also false

14. **Assertion:** The capacity of a conductor, under given circumstances, remains constant irrespective of the charge present on it. **[1]**

Reason: Capacity depends on size and shape of a conductor and also on the surrounding medium.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c) Assertion is correct statement but reason is wrong statement.
d) Assertion is wrong statement but reason is correct statement.

15. **Assertion (A):** Interference pattern is made by using yellow light instead of red light, the fringes becomes narrower. **[1]**

Reason (R): In Young's double slit experiment, fringe width is given by $\beta = \frac{\lambda D}{d}$.

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:** The resistance offered by an inductor in a DC circuit is always constant. **[1]**

Reason: The resistance of the inductor in steady-state is zero.

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 and R is also false

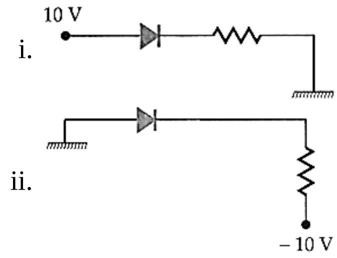
Section B

17. To which part of the electromagnetic spectrum does a wave of frequency **[2]**

i. 5×10^{19} Hz
ii. 3×10^{13} Hz
iii. 5×10^{11} Hz belong?

18. Three identical specimens of a magnetic materials nickel, antimony and aluminium are kept in a non-uniform magnetic field. Draw the modification in the field lines in each case. Justify your answer. **[2]**

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



20. A photon of energy 12.09 eV is absorbed by an electron in ground state of a hydrogen atoms. What will be the energy level of electron? The energy of electron in the ground state of hydrogen atom is - 13.6 eV **[2]**

21. What torque acts on a 40 turn coil of 100 cm^2 area carrying a current of 10 A held with its axis at right angles to a uniform magnetic of 0.2 T? **[2]**

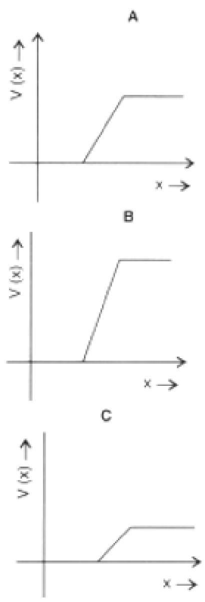
OR

A current of I ampere is flowing through the bent wire shown in the given figure. Find the magnitude and direction of the magnetic field at point O.

Section C

22. At 0°C, the resistance of a conductor B is n times that of conductor A. The temperature coefficients of A and B are α_1 and α_2 respectively. For the series combination of the two conductors, find **[3]**
   i. the resistance at 0°C and
   ii. the temperature coefficient of resistance

23. The graph of potential barrier versus width of depletion region for an unbiased diode is shown in A. In comparison to A, graphs B and C are obtained after biasing the diode in different ways. Identify the type of biasing in B, and C and justify your answer. **[3]**



24. The maximum kinetic energy of the photoelectrons emitted is doubled when the wavelength of light incident on the photosensitive surface changes from λ_1 to λ_2. Deduce expressions for the threshold wavelength and work function for the metal surface in terms of λ_1 and λ_2. **[3]**

25. i. Derive the mathematical expression for the radioactive decay for a sample of a radioactive nucleus. **[3]**

ii. How is the mean life of a given radioactive nucleus related to the decay constant?

26. a. Sketch the energy level diagram for hydrogen atom. **[3]**

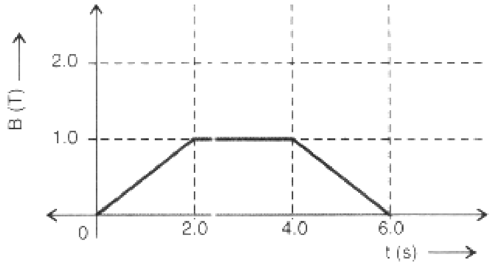
b. Find the ratio of the longest and the shortest wavelength in Lyman series in hydrogen atom.

27. In a single slit diffraction experiment, a slit of width d is illuminated by red light of wavelength 650 nm. For what value of d will **[3]**

i. the first minimum fall is at an angle of diffraction of 30°and

ii. the first maximum fall is at an angle of diffraction of 30°?

28. The magnetic field through a single loop of wire, 12 cm in radius and 8.5 ohm resistance, changes with time as shown in the figure. The magnetic field is perpendicular to the plane of the loop. Plot induced current as a function of time. **[3]**



OR

A coil of cross-sectional area A lies in a uniform magnetic field B with its plane perpendicular to the field. In this position the normal to the coil makes an angle of 0° with the field. The coil rotates at a uniform rate to complete one rotation in time T. Find the average induced emf in the coil during the interval when the coil rotates:

i. from 0° to 90°position

ii. from 90° to 180° position

iii. from 180° to 270° and

iv. from 270° to 360°

Section D

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

Electrons oscillating in a circuit give rise to radiowaves. A transmitting antenna radiates most effectively the radiowaves of wavelength equal to the size of the antenna. The infrared waves incident on a substance set into oscillation all its electrons, atoms and molecules. This increases the internal energy and hence the temperature of the substance.

(i) If v_g, v_X and v_m are the speeds of gamma rays, X-rays and microwaves respectively in vacuum, then

a) $v_g > v_X > v_m$ b) $v_g < v_X < v_m$

c) $v_g > v_X > v_m$ d) $v_g = v_X = v_m$

(ii) Which of the following will deflect in electric field?

a) ultraviolet rays b) γ-rays

c) X-rays d) cathode rays

(iii) γ-rays are detected by

a) point contact diodes b) ionization chamber

c) thermopiles d) photocells

OR

The frequency of electromagnetic wave, which best suited to observe a particle of radius 3×10^{-4} cm is the order of

a) 10^{14} Hz

b) 10^{12} Hz

c) 10^{13} Hz

d) 10^{15} Hz

(iv) We consider the radiation emitted by the human body. Which one of the following statements is true?

i. The radiation emitted is in the infrared region.
ii. The radiation is emitted only during the day.
iii. The radiation is emitted during the summers and absorbed during the winters.
iv. The radiation emitted lies in the ultraviolet region and hence it is not visible.

a) Option (iv)

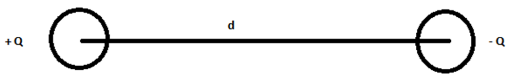
b) Option (ii)

c) Option (iii)

d) Option (i)

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

Electric dipole consist of a pair of equal and opposite point charges separated by a small distance and its strength is measured by the dipole moment. The field around the dipole in which the electric effect of the dipole can be experienced is called the dipole field.



(i) The electric dipole moment is:

a) a scalar quantity

b) neither scalar nor vector quantity

c) a vector quantity

d) none of these

(ii) Electric field due to the electric dipole is

a) cylindrically symmetric

b) spherically symmetric

c) none of these

d) asymmetric

(iii) The SI unit of dipole moment is:

a) C/m

b) C-m

c) c/m^2

d) $C\text{-}m^2$

(iv) Charges ± 20 nC are separated by 5mm. calculate the magnitude of dipole moment:-

a) 10^{-7} C-m

b) 10^{10} C-m

c) 10^{-10} C-m

d) 10^{-8} C-m

OR

When an electric dipole is placed in a uniform electric field, it experiences

a) Neither any force nor any torque

b) Force but no torque

c) Force as well as torque

d) Torque but no net force

Section E

31. i. Draw the ray diagram of an astronomical telescope when the final image is formed at infinity. Write the expression for the resolving power of the telescope. **[5]**

ii. An astronomical telescope has an objective lens of focal length 20 m and eyepiece of focal length 1 cm.

a. Find the angular magnification of the telescope.

b. If this telescope is used to view the Moon, find the diameter of the image formed by the objective lens.

Given the diameter of the Moon is 3.5×10^6 m and radius of the lunar orbit is 3.8×10^8 m.

OR

i. How does an unpolarized light incident on a Polaroid get polarized? Describe briefly, with the help of a necessary diagram, the polarization of light by reflection from a transparent medium.

ii. Two polaroids A and B are kept in a crossed position. How should a third polaroid C be placed between them so that the intensity of polarized light transmitted by polaroid B reduces to $\frac{1}{8}^{th}$ of the intensity of unpolarised light incident on A?

32. A parallel plate capacitor is charged by a battery. After some time the battery is disconnected and a dielectric slab with its thickness equal to the plate separation is inserted between the plates. What change, in any will take place in **[5]**

i. charge on the plates

ii. electric field intensity between the plates

iii. the capacitance of the capacitor,

iv. a potential difference between the plates and

v. the energy stored in the capacitor? Justify your answer in each case.

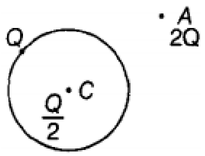
OR

i. Explain using suitable diagrams, the difference in the behaviour of a

a. conductor and

b. dielectric in the presence of external electric field. Define the terms polarisation of a dielectric and write its relation with susceptibility.

ii. A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge Q/2 is placed at its centre C and another charge + 2Q is placed outside the shell at a distance x from the centre as shown in the figure. Find



a. the force on the charge at the centre of shell and at the point A,

b. the electric flux through the shell.

33. A series LCR circuit with L = 0.12 H, C = 480 nF, R = 23 Ω is connected to a 230 V variable frequency supply. **[5]**

a. What is the source frequency for which the current amplitude is maximum? Obtain this maximum value

b. What is the source frequency for which average power absorbed by the circuit is maximum? Obtain the value of this maximum power.

c. For which frequencies of the source is the power transferred to the circuit half the power at resonant frequency? What is the current amplitude at these frequencies?

d. What is the Q-factor of the given circuit?

OR

a. Derive an expression for the impedance of a series L-C-R circuit connected to an AC supply of variable frequency.

b. Explain briefly how the phenomenon of resonance in the circuit can be used in the tuning mechanism of a radio or a TV set?

Solution

Section A

1.

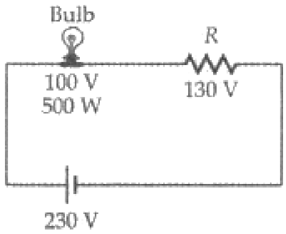
(b) the depletion region is increased

Explanation: When a p-n junction is reverse biased, its depletion region is widened.

2.

(b) 26 Ω

Explanation:



I = $\frac{P}{V} = \frac{500\text{ W}}{100\text{ V}}$ = 5 A

$\therefore$ 5 R = 130 V

R = 26 Ω

3.

(b) $\frac{5}{3}$

Explanation: f = $\frac{1}{P}$ = $\frac{1}{5}$ m = 20 cm

Now, $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

In air, $\frac{1}{20} = \left(\frac{1.5}{1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = 0.5\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ....(i)

In liquid, $\frac{1}{-100} = \left(\frac{1.5}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ....(ii)

Dividing (i) by (ii), we get

$-5 = \frac{0.5}{\left(\frac{1.5}{\mu_1} - 1\right)}$

On solving we get, $\mu_1 = \frac{5}{3} = 1.67$

4. **(a)** 20 cm

Explanation: $\tau = q_m \times 2l \times B \sin\theta$

$\therefore$ 2l = $\frac{\tau}{q_m \times B \sin\theta}$

= $\frac{80 \times 10^{-7}}{2 \times 4 \times 10^{-5} \times \sin 30^\circ}$ = 0.20 m = 20 cm

5. **(a)** 500 μF

Explanation: Given that , voltage = 200V and Specific Heat is =250J/Kg-K and mass= 100g = 0.1 kg

Energy stored in the capacitor, $U = \frac{1}{2}CV^2 = \frac{1}{2}(200)^2 C\ = 2 \times 10^4 C$ J

This is released as heat when the capacitor discharges through the metal block.

The quantity of heat = mass × sp.heat × rise in temperature.

$Q = m \times s \times \Delta\theta = 0.1 \times 2.5 \times 10^2 \times 0.4 = 10J$

$U = Q \Rightarrow 2 \times 10^4 C = 10$

or $C = 5 \times 10^{-4} F = 500 \mu F$

6.

(d) path will change

Explanation: As magnetic force always act perpendicular to the direction of motion, so path or direction will change without any change in speed.

7. **(a)** $\frac{\mu_0 q f}{2R}$

Explanation: Field at the centre of the ring,

$B=\frac{\mu_0 I}{2R}=\frac{\mu_0 q}{2RT}=\frac{\mu_0 q f}{2R}$

8.

(b) potential is zero at all points on the right bisector

Explanation: The magnetic potential at any point is the amount of work done in bringing a unit north pole from infinity to that point. At any point on the right bisector, the potentials due to the two poles are equal and opposite.

9.

(c) $\Delta x=\left(\frac{\lambda}{2\pi}\right)\Delta\phi$

Explanation: Phase difference $=\frac{2\pi}{\lambda}\times$ Path difference

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

or $\Delta x=\left(\frac{\lambda}{2\pi}\right)\Delta\phi$

10.

(d) 10^{-12} m

Explanation: The distance must be greater than the nuclear size ($\approx 10^{-15}$m). For r $\leq 10^{-15}$m, the much stronger nuclear force makes the coulombic force ineffective.

11.

(c) C and A

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

12. **(a)** its wavelength decreases

Explanation: The energy of the light is related to the frequency. When the light enters the medium, the apparent speed of light changes. If the frequency changed, the energy would not be conserved. The wavelength changes to balance the change in speed. When light enters from air to glass (from rarer to denser medium), its speed decreases as a consequence its wavelength also decreases.

13.

(d) A is false and R is also false

Explanation: On increasing the intensity of incident light, the number of photons incident on the metal per sec per unit area (and hence the current in the photoelectric cell) will increase. The energy of photons will however not increase with the increase in intensity and hence the kinetic energy of emitted electrons will not increase.

14. **(a)** Assertion and reason both are correct statements and reason is correct explanation for assertion.

Explanation: Assertion and reason both are correct statements and reason is correct explanation for assertion.

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.

(d) A is false and R is also false

Explanation: Resistance offered by an inductor is a DC circuit at t = 0 is infinity, which decreases to zero at steady state.

Section B

17. i. X-rays/γ-rays
ii. infra-red radiation
iii. microwaves

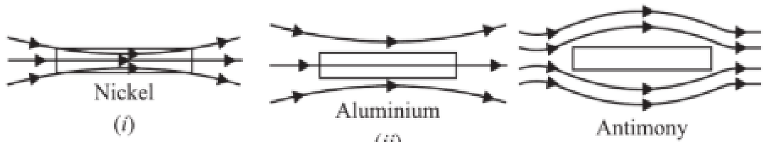
18. 

Fig shows the modified field lines. The magnetic field lines become more crowded in nickel (ferromagnetic material) and less crowded in aluminium (paramagnetic material). However, in case of antimony (diamagnetic material), the magnetic field lines are repelled and the field inside the material is reduced.

19. i. The p-n junction is reverse biased.

ii. The p-n junction is forward biased.

20. $E_n - E_1 = hv$

or $E_n = hv + E_1 = 12.09 - 13.6 = -1.51$ eV

As $E_n = \frac{E_1}{n^2}$

$\therefore \quad n^2 = \frac{E_1}{E_n} = \frac{-13.6}{-1.51} = 9$ or n = 3.

21. τ & = NIBA sin θ = 40 $\times$ 10 $\times$ 0.2 $\times$ 100 $\times$ 10^{-4} sin 90°

& = 0.8 Nm .

OR

Any element $\vec{dl}$ on the arc will be perpendicular to the position vector $\vec{r}$, so the field due to one such element at the centre O will be:

dB = $\frac{\mu_0}{4\pi} \cdot \frac{Idl \sin \pi/2}{r^2}$ = $\frac{\mu_0}{4\pi} \cdot \frac{Idl}{r^2}$

Magnetic field due to the entire arc at the centre O,

B = $\int dB = \frac{\mu_0 I}{4\pi r^2} \int dl = \frac{\mu_0 I}{4\pi r^2} \cdot l$

But l = length of arc = αr

$\therefore$ B = $\frac{\mu_0 I}{4\pi r^2} \cdot \alpha r$ = $\frac{\mu_0 I\alpha}{4\pi r}$

Section C

22. Let R_Q be the resistance of the conductor A at 0°C.

Then the resistance of conductor B at 0°C = nR_0

Resistance of conductor A at 0°C will be R = R_0 (1 + $\alpha_1\theta$) ...(i)

Resistance of conductor B at 0°C will be R' = nR_0 (1 + $\alpha_2\theta$)

Thus the resistance of the series combination at 0°C will be

R_s = R + R' = R_0(1 + $\alpha_1\theta$) + nR_0 (1 + $\alpha_2\theta$)

= R_0[(1 + n) + (α_1 + n α_2) θ]

= (1 + n)$R_0\left[1 + \frac{\alpha_1 + n\alpha_2}{1+n}\theta\right]$ ..(ii)

Comparing equation (ii) with equation (i), we get

i. Resistance of the series combination at 0°C = (1 + n) R_0.

ii. Temperature coefficient of resistance of the series combination = $\frac{\alpha_1 + n\alpha_2}{1+n}$

23. **Diode B is reverse biased.**

Justification: When the diode is reverse biased, the barrier height increases as the direction of applied voltage (V) and the direction of barrier potential (V_0) is the same. The effective barrier height under reverse biased is (V_0 + V).

Diode C is forward biased.

Justification: As the direction of the applied voltage is opposite to the barrier potential, therefore, the effective barrier height is reduced to (V_0 - V).

24. Given that

Initial kinetic energy of photoelectrons is given by = K_1

Final kinetic energy of photoelectrons is given by $K_2 = 2K_1$

Wavelength of light changes from λ_1 to λ_2

Let the threshold frequency is ν_0 and work function is ϕ_0

Now, we know that:-

$\frac{hc}{\lambda}$ = ϕ_0 + KE

$\frac{hc}{\lambda_1}$ = ϕ_0 + K_1 ...(i)

$\frac{hc}{\lambda_2}$ = ϕ_0 + K_2 ...(ii)

$K_2 = 2K_1$

$\frac{hc}{\lambda_2}$ = ϕ_0 + $2K_1$ ...(iii)

$\frac{2hc}{\lambda_1}$ = $2\phi_0$ + $2K_1$ (eq (i) $\times$ 2)

$\frac{2hc}{\lambda_1} - \frac{hc}{\lambda_2} = \phi_0$

$\Rightarrow \phi_0 = \mathrm{hc}\left(\frac{2\lambda_2 - \lambda_1}{\lambda_1\lambda_2}\right)$

We know

work function is given by $\phi_0 = \frac{\mathrm{hc}}{\lambda_0}$

$\frac{\mathrm{hc}}{\lambda_0} = \mathrm{hc}\left(\frac{2\lambda_2 - \lambda_1}{\lambda_1\lambda_2}\right)$

$\frac{1}{\lambda_0} = \frac{2\lambda_2 - \lambda_1}{\lambda_1\lambda_2}$

$\lambda_0 = \frac{\lambda_1\lambda_2}{2\lambda_2 - \lambda_1}$

25. i. Let there be N_0 radioactive nuclei at t = 0

If N is the number of nuclei leftover at t = t, we get

$\frac{-dN}{dt} \propto N$

or $\frac{-dN}{dt} \propto N$

(λ = decay constant)

$\therefore \frac{dN}{N} = -\lambda \mathrm{dt}$

or In N = $-\lambda t$ + constant

$\therefore$ At t = 0 we have

In N_0 = constant

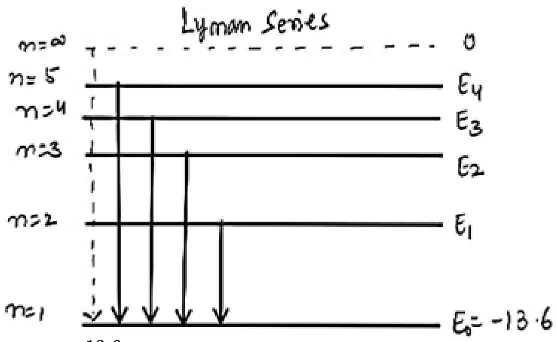
In N = $-\lambda t$ + In N_0

or In$\left(\frac{N}{N_0}\right) = -\lambda t$

$\therefore$ N = $N_0 e^{-\lambda t}$

ii. Mean life = $\frac{1}{\text{decay constant}}$

26.



$E = -\frac{13\cdot 6}{n^2}$

$\frac{1}{\lambda} = R\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)$

$\frac{1}{\lambda_{\min}} = R\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = R$

$\frac{1}{\lambda_{\max}} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3R}{4}$

$\frac{\lambda_{\max}}{\lambda_{\min}} = \frac{4}{3R} \times R = \frac{4}{3}$

27. i. In single slit diffraction pattern, first minimum occurs at $d \sin\theta = \lambda$ [θ and λ are diffraction angle and wavelength of the light used]

$\therefore$ Slit width, $d = \frac{\lambda}{\sin\theta}$ ....(a)

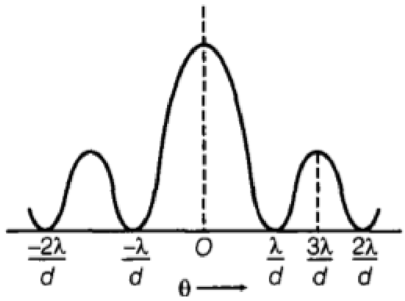
Given, $\lambda = 650 \times 10^{-9}\mathrm{m}\; and\; \theta = 30^\circ$

Now from equation (a) we get slit width, $d = \frac{650\times10^{-9}}{\sin 30^\circ} = \frac{650}{(1/2)} \times 10^{-9}$

$= 1300 \times 10^{-9}$ m

$\therefore d = 1.3 \times 10^{-6}\mathrm{m} = 1.3\ \mu m$

ii. In single slit diffraction pattern, maximum and minima occurs as per the below diagram -



Now for first maximum,

$d \sin\theta = \frac{3\lambda}{2} \left[using,\ d\sin\theta = (2n+1)\frac{\lambda}{2}\right]$

where, n = 1(for first maximum)

$\Rightarrow \quad d = \frac{3\lambda}{2\sin\theta}$

where, $\theta = 30^\circ, \lambda = 650 \times 10^{-9}\mathrm{m}$

$\therefore d = \frac{3\lambda}{2\sin\theta}$

$= \frac{3 \times 650 \times 10^{-9}}{2 \times \sin 30^\circ}$

$= 1950 \times 10^{-9}\mathrm{m}$

$\therefore d = 1.95 \times 10^{-6}\mathrm{m} = 1.95\ \mu m$

28. $\varepsilon = -\frac{d\phi}{dt}$

$= -\pi R^2 \times \frac{dB}{dt}$

$= -\frac{22}{7} \times (0.12)^2 \times \frac{1}{2}$

ε = -0.023 V,

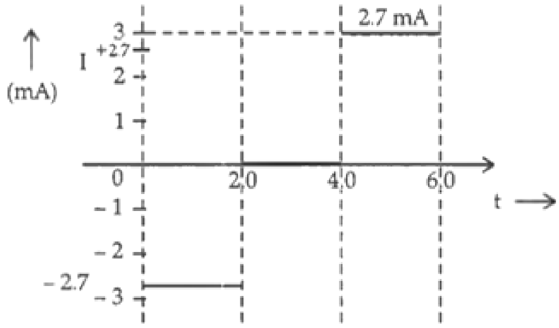
I = $\frac{\varepsilon}{R}$

= - 2.7 mA for 0 < t < 2s.

Similarly,

	0 < t < 2s	2 < t < 4 s	4 < t < 6 s
ε(V)	-0.023	0	+0.023
I (mA)	-2.7	0	+2.7

The graphical variation of induced current with time is shown in fig. From t = 0 to t = 2s, magnetic field is increasing. Therefore, induced current opposes the increase. From t = 2s to t = 4s induced current is zero. From t = 4s to t = 6s magnetic field is decreasing. Therefore, induced current opposes the decrease and flow in the same direction.



OR

i. For rotation from 0^o to 90^o

ϕ_1 = BA cos 0^o = BA, ϕ_2 = BA cos 90^o = 0, t = $\frac{T}{4}$

$\therefore$ Average induced emf,

$\varepsilon = -\frac{\phi_2 - \phi_1}{t} = -\frac{0 - BA}{T/4} = \frac{4BA}{T}$.

ii. For rotation from 90^o to 180^o

ϕ_1 = BA cos 90^o = 0, ϕ_2 = BA cos 180^o = -BA, t = $\frac{T}{4}$

$\therefore \varepsilon = -\frac{-BA - 0}{T/4} = \frac{4BA}{T}$

iii. For rotation from 180^o to 270^o

ϕ_1 = BA cos180^o = -BA, ϕ_2 = BA cos 270^o = 0, t = $\frac{T}{4}$

$\therefore \varepsilon = -\frac{0+BA}{T/4} = -\frac{4BA}{T}$

iv. For rotation from 270^o + 360^o

ϕ_1 = BA cos 270^o = 0, ϕ_2 = BA cos 360^o = BA, t = $\frac{T}{4}$

$\therefore \varepsilon = -\frac{BA-0}{T/4} = -\frac{4BA}{T}$

As the sense of the induced emf in the second half rotation is opposite to that in the first half rotation, the induced current will change its direction after first-half rotation.

Section D

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

Electrons oscillating in a circuit give rise to radiowaves. A transmitting antenna radiates most effectively the radiowaves of wavelength equal to the size of the antenna. The infrared waves incident on a substance set into oscillation all its electrons, atoms and molecules. This increases the internal energy and hence the temperature of the substance.

(i) **(d)** $v_g = v_X = v_m$

Explanation: All electromagnetic waves travel in vacuum with the same speed.

(ii) **(d)** cathode rays

Explanation: Cathode rays (beam of electrons) get deflected in an electric field.

(iii) **(b)** ionization chamber

Explanation: γ-rays are detected by ionization chamber.

OR

(a) 10^{14} Hz

Explanation: Size of particle = $\lambda = \frac{c}{v}$

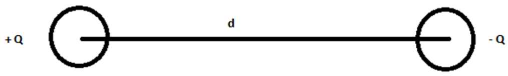
$\nu = \frac{c}{\lambda} = \frac{3\times10^{10}\text{ cm s}^{-1}}{3\times10^{-4}\text{ cm}}$ = 3 × 10^{14} Hz

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

Explanation: Everybody at a temperature T > 0 K emits radiation in the infrared region.

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

Electric dipole consist of a pair of equal and opposite point charges separated by a small distance and its strength is measured by the dipole moment. The field around the dipole in which the electric effect of the dipole can be experienced is called the dipole field.



(i) **(c)** a vector quantity

Explanation: a vector quantity

(ii) **(a)** cylindrically symmetric

Explanation: cylindricaly symmetric

(iii) **(b)** C-m

Explanation: C-m

(iv) **(c)** 10^{-10} C-m

Explanation: 10^{-10} C-m

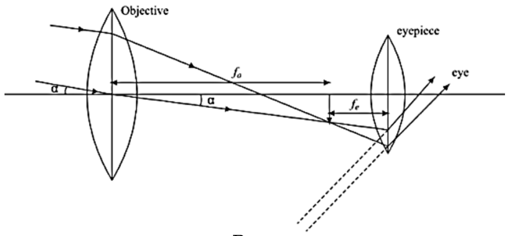
OR

(d) Torque but no net force

Explanation: Torque but no net force

Section E

31. i.



Resolving power = $\frac{D}{1.22\lambda}$

ii. a. Angular magnification f_0 = 20 m , f_e= 1 cm = 0.01 m

m = $\frac{f_0}{f_e}$

m = $\frac{20}{0.01}$ = 2000

b. Diameter of moon = 3.5 $\times$ 10^6 m and radius of lunar orbit = 3.8 $\times$ 10^8m. Let d be the diameter of the image in metres.

Then angle subtended by the moon will be

$\alpha = \frac{\text{Diameter at moon}}{\text{Radius of lunar orbit}}$

$= \frac{3.5\times10^6}{3.8\times10^8}$

Angle subtended by the image formed by the objective will also be equal to α and is given by

$\alpha = \frac{\text{Diameter of image of moon}}{f_o}$

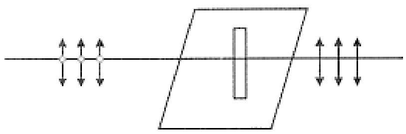
$\alpha = \frac{d}{20}$

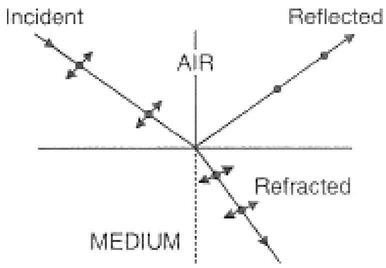
$\therefore \frac{d}{20} = \frac{3.5\times10^6}{3.8\times10^8}$

d = 0.18 m

OR

i. When an unpolarized light falls on a polaroid, it lets only those of the electric vectors that are oscillating along a direction perpendicular to its aligned molecules to pass through it. The incident light thus gets linearly polarized.





Whenever an unpolarized light is an incident on boundary two transparent surface, the reflected light gets completely polarized or partially polarized. when the reflected and refracted light are perpendicular to each other, the reflected light is completely polarized.

ii. Let θ be the angle between the pass-axis of A and C.

The intensity of light passing through A = $\frac{I_0}{2}$

The intensity of light passing through B = $(\frac{I_0}{2})\cos^2\theta$

The Intensity of light passing through C = $(\frac{I_0}{2})\cos^2\theta[\cos^2(90° - \theta)]$=$\frac{I_0}{2}(cos\theta sin\theta)^2$=$\frac{I_0}{2}\frac{(2sin\theta cos\theta)^2}{4}$

$Acccording\ to\ question \Rightarrow$ $\frac{I_0}{2} \times \frac{\sin^2 2\theta}{4} = \frac{I_0}{8}$ (By comparing these equations, we get)

$\therefore$ sin 2θ = 1

2θ = 90°

The third polaroid is placed at θ = 45°

32. i. The charge q_0 on the capacitor plates remains the same because the battery has been disconnected, before placing the dielectric slab.

ii. The surface charges induced on the dielectric slab reduce electric field intensity to a new value given by $E = \frac{E_0}{\kappa}$

iii. The reduction in the electric field induces the potential difference $V = Ed = \frac{E_0 d}{k} = \frac{V_0}{k}$

iv. Due to the decrease in p.d., the capacitance increases k times $C = \frac{q_0}{V} = \frac{q_0}{V_0/\mathrm{k}} = \mathrm{K}\frac{q_0}{V_0} = \kappa \mathrm{C}_0$

v. Energy stored decreases by a factor of κ:

$U = \frac{1}{2}CV^2 = \frac{1}{2}(\kappa C_0)\left(\frac{V_0}{K}\right)^2 = \frac{1}{\kappa}\cdot\frac{1}{2}C_0V_0^2 = \frac{U_0}{\kappa}$

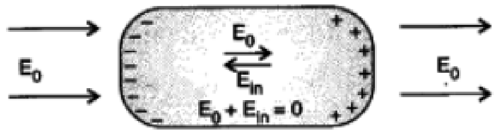
OR

i. a. In the presence of electric field, the free charge carriers, in a conductor, move the charge distribution in the conductor re-adjusting itself so that the net electric field within the conductor becomes zero.

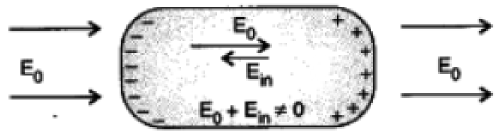
b. In a dielectric, the external electric field induces a net dipole moment, by stretching/reorienting the molecules. The electric field, due to this induced dipole moment, opposes, but does not exactly cancel, the external electric field.

Polarisation: Induced dipole moment, per unit volume, is called the polarization. For linear isotropic dielectrics having a susceptibility χ_c, we have

P = χ_c E



Conductor



Dielectric

ii. a. Net force on the charge $\frac{Q}{2}$, placed at the centre of the shell is zero.

Force on charge 2Q kept at point A

F = E $\times$ 2Q

$= \frac{1\left(\frac{3Q}{2}\right)2Q}{4\pi\varepsilon_0 r^2} = \frac{3Q^2}{4\pi r^2\varepsilon_0}$

b. Electric flux through the shell,

$\phi = \frac{Q}{2\varepsilon_0}$ (because charge enclosed is Q/2)

33. Inductance, L = 0.12 H

Capacitance, C = 480 nF = 480 $\times$ 10^{-9} F

Resistance, R = 23 Ω

Supply voltage, V = 230 V

Peak voltage is given as:

$V_0 = \sqrt{2} \times 230$ = 352.22 V

a. the source frequency for which the current amplitude is maximum is given by:-Current flowing in the circuit is given by the relation, $I_0 = \frac{V_0}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$

Where,

I_0 = maximum at resonance

At resonance, we have

$\omega_R L - \frac{1}{\omega_R C} = 0$

Where,

ω_R = Resonance angular frequency

$\therefore \omega_R = \frac{1}{\sqrt{LC}}$

$= \frac{1}{\sqrt{0.12 \times 480 \times 10^{-9}}}$ = 4166.67 rad/s

$\therefore$ Resonant frequency, $\upsilon_R = \frac{\omega_R}{2\pi} = \frac{4166.67}{2\times 3.14}$ = 663.48 Hz

And, maximum current in he given circuit $(I_0)_{Max} = \frac{V_0}{R} = \frac{325.22}{23}$ = 14.14 A

b. Maximum average power absorbed by the circuit is given as:

$(P_{av})_{Max} = \frac{1}{2}(I_0)^2_{Max} R$

$= \frac{1}{2} \times (14.14)^2 \times 23$ = 2299.3 W

Also ,the resonant frequency (ν_R) is 663.48 Hz.

c. The power transferred to the circuit is half the power at resonant frequency.

Frequencies at which power transferred is half, $= \omega_r \pm \triangle\omega$

$= 2\pi\left(v_R \pm \triangle v\right)$

where,

$\triangle\omega = \frac{R}{2L}$

$= \frac{23}{2\times0.12}$ = 95.83 rad/s

Hence, change in frequency, $\triangle v = \frac{1}{2\pi}\triangle\omega = \frac{95.83}{2\pi}$ = 15.26 Hz

$\therefore \nu_R$ + △v = 663.48 + 15.26 = 678.74 Hz

And, ν_R - △v = 663.48 - 15.26 = 648.22 Hz

Hence, at 648.22 Hz and 678.74 Hz frequencies, the power transferred is half.

At these frequencies, the current amplitude can be given as:

$I' = \frac{1}{\sqrt{2}} \times (I_0)_{Max}$

$= \frac{14.14}{\sqrt{2}} = 10\text{A}$

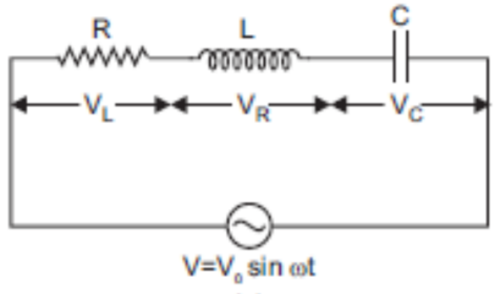
d. Q -factor of the given circuit can be obtained using the relation, $Q = \frac{\omega_R L}{R}$

$= \frac{4166.67\times0.12}{23}$ = 21.74

Hence, the Q -factor of the given circuit is = 21.74

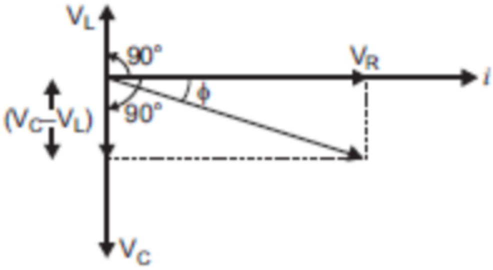
OR

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



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

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



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

So,

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

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

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

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

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

Therefore, impendance of the circuit is given by, Z = $\frac{V}{i}$ = $\sqrt{(R)^2 + (X_c - X_L)^2}$

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

This is the impedance of the LCR series circuit.

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