Class XII Session 2025-26
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. C and Si both have the same lattice structure, having 4 bonding electrons in each. However, C is an insulator whereas Si is an intrinsic semiconductor. This is because **[1]**

A. In case of C the valence band is not completely filled at absolute zero temperature.
B. In case of C the conduction band is partly filled even at absolute zero temperature.
C. The four bonding electrons in the case of C lie in the second orbit, whereas in the case of Si they lie in the third.
D. The four bonding electrons in the case of C lie in the third orbit, whereas for Si they lie in the fourth orbit.

a) Option D
b) Option B
c) Option A
d) Option C

2. An electron beam has an aperture 1.0 mm^2. A total of 6.0×10^{16} electrons go through any unit square meter perpendicular cross section per second. Find the current density in the beam: **[1]**

a) $9.6 \times 10^{-5}\ A\,m^{-2}$
b) $9.2 \times 10^{+6}\ A\,m^{-2}$
c) $9.2 \times 10^{-3}\ A\,m^{-2}$
d) $9.6 \times 10^{+3}\ A\,m^{-2}$

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. A bar magnet has magnetic dipole moment $\vec{M}$. Its initial position is parallel to the direction of uniform magnetic field $\vec{B}$. In this position, the magnitudes of torque and force acting on it respectively are **[1]**

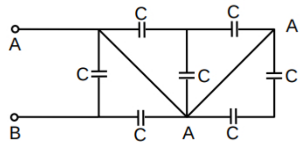
a) MB and MB

b) 0 and 0

c) $|\vec{M} \times \vec{B}|$ and 0

d) 0 and MB

5. Find equivalent capacitance between A and B. **[1]**



a) 4 C

b) 2 C

c) 6 C

d) 8 C

6. A current carrying wire kept in a uniform magnetic field, will experience a maximum force when it is **[1]**

a) perpendicular to the magnetic field

b) at an angle of 60^o to the magnetic field

c) parallel to the magnetic field

d) at an angle of 45^o to the magnetic field

7. Two ends of a horizontal conducting rod of length l are joined to a voltmeter. The whole arrangement moves with a horizontal velocity v, the direction of motion being perpendicular to the rod. Vertical component of the earth's magnetic field is B. The voltmeter reads **[1]**

a) Blv if the rod moves in any direction

b) Blv only if the rod moves eastward

c) Blv only if the rod moves westward

d) Zero

8. The μ_0 is also known as : **[1]**

a) Magnetic dipole moment

b) Magnetic flux

c) magnetic dipole

d) Absolute Permittivity

9. Interference was observed in interference chamber, when air was present. Now, the chamber is evacuated and if the same light is used, a careful observer will see **[1]**

a) no interference

b) interference, in which width of the fringe will be slightly increased

c) interference with bright bands

d) interference with dark bands

10. Gauss' law of electrostatics would be invalid if: **[1]**

a) the inverse square law was not exactly true

b) there were magnetic monopoles

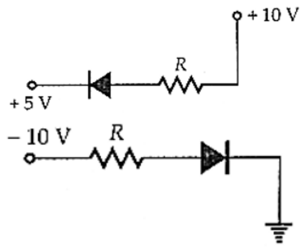
c) the electrical charge was not quantized

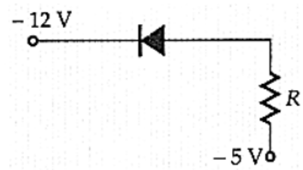
d) the speed of light was not a universal constant

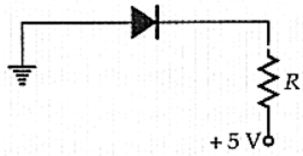
11. In the following figure, the diodes which are forward biased, are **[1]**

A.

B.



C. 

D. 

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

12. A beam of monochromatic light is refracted from vacuum into a medium of refractive index $1 \cdot 5$. The wavelength of refracted light will be **[1]**

a) dependent on intensity of refracted light
b) same
c) larger
d) smaller

13. **Assertion (A):** A photocell is called an electric eye. **[1]**
Reason (R): When light is incident on some semiconductor, its electrical resistance is reduced.

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.

14. **Assertion (A):** Two adjacent conductors of unequal dimensions, carrying the same positive charge have a potential difference between them. **[1]**
Reason (R): The potential of a conductor depends upon the charge given to it.

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 light wave travels from a rarer to denser medium, it loses speed. The reduction in speed imply a reduction in energy carried by the light wave. **[1]**
Reason (R): The energy of a wave is proportional to velocity of wave.

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) Both A and R are false.

16. **Assertion (A):** Ac is more dangerous than dc. **[1]**
Reason (R): The frequency of ac is dangerous for the human body.

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

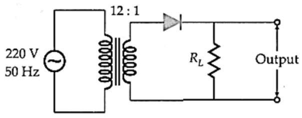
17. The charge on a parallel plate capacitor varies as $q = q_0 \cos 2\pi\nu t$. The plates are very large and close together (area = A, separation = d). Neglecting the edge effects, find the displacement current through the capacitor? **[2]**

18. A magnetised steel wire 31.4 cm long has a pole strength of 0.2 Am. It is bent in the form of a semicircle. Calculate the magnetic moment of the steel wire. **[2]**

OR

A bar magnet with poles 25 cm apart and of pole strength 14.4 Am rests with its centre on a frictionless pivot. It is held in equilibrium at 60° to a uniform magnetic field of induction 0.25 T by applying a force F, at right angles to its axis, 12 cm from its pivot. Calculate F. What will happen if the force F is removed?

19. Find the average value of dc voltage that can be obtained from the half-wave rectifier of Figure. Assume the diode to be ideal one. **[2]**



20. Monochromatic radiation of wavelength 975 $\overset{o}{A}$ excites the hydrogen atom from its ground state to a higher state. How many different spectral lines are possible in the resulting spectrum? Which transition corresponds to the longest wavelength amongst them. **[2]**

21. What information would you wish to know about the galvanometer before converting it into an ammeter or voltmeter? **[2]**

Section C

22. **[3]**
    a. Use Kirchhoff's rules to obtain the balance condition in Wheatstone bridge.
    b. Give one practical application that is based on this principle.

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?

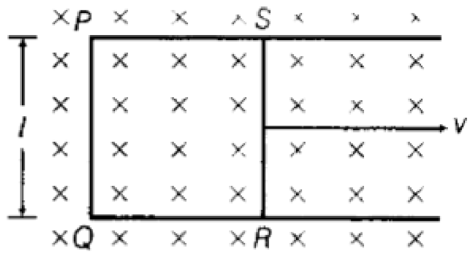
24. Explain briefly with the help of necessary diagrams, the forward and the reverse biasing of a p-n junction diode. Also, draw their characteristic curves in the two cases. **[3]**

25. **[3]**
    i. Write three characteristic properties of nuclear force.
    ii. Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions that can be drawn from the graph.

26. The total energy of an electron in the first excited state of the hydrogen atom is about –3.4 eV. **[3]**
    a. What is the kinetic energy of the electron in this state?
    b. What is the potential energy of the electron in this state?
    c. Which of the answers above would change if the choice of the zero of potential energy is changed?

27. Two narrow slits are illuminated by a single monochromatic source. Name the pattern obtained on the screen. One of the slits is now completely covered. What is the name of the pattern now obtained on the screen? Draw intensity pattern obtained in the two cases. Also, write two differences between the patterns obtained in the above two cases. **[3]**

28. Figure shows a rectangular conducting loop PQRS in which arm RS of length I is movable. The loop is kept in a uniform magnetic field B directed downward perpendicular to the plane of the loop. The arm RS is moved with a uniform speed v. **[3]**



Deduce an expression for

i. the emf induced across the arm RS

ii. the external force required to move the arm and

iii. the power dissipated as heat.

OR

Define self-inductance of a coil. Obtain the expression for the energy stored in an inductor L connected across a source of emf.

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

OR

The electric and magnetic fields of an electromagnetic waves are

a) in phase and parallel to each other. b) in phase and perpendicular to each other

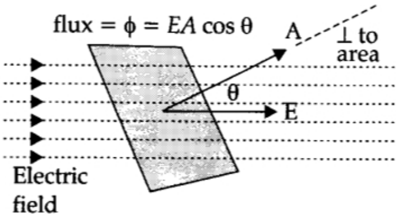
c) in opposite phase and parallel to each other d) in opposite phase and perpendicular to each other

(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. The total number of electric field lines passing a given area in a unit time is defined as the electric flux. **[4]**



If the plane is normal to the flow of the electric field, the total flux is given as:

ϕ = EA

When the same plane is tilted at an angle θ, the projected area is given as A cos θ and the total flux through this surface is given as:

ϕ = EA cos θ

where, E is the magnitude of the electric field. A is the area of the surface through which the electric flux is to be calculated.

i. If a unit positive charge is kept in the air, then what is the total flux coming out of unit charge?

ii. What is the value of electric flux (φ) on a plane of area 1 m^2 on which an electric field of 2 V/m crosses with an angle of 30^o.

iii. When is the flux through a surface taken as positive?

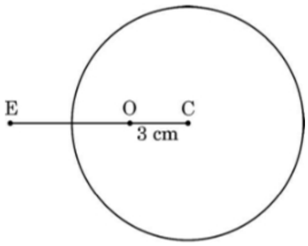
iv. On which factor the net flux through a closed surface in a given medium depends?

v. A plane surface is rotated in a uniform electric field. When is the flux of the electric field through the surface maximum?

Section E

31. i. A spherical surface of radius of curvature R separates two media of refractive indices n_1 and n_2. A point object is placed in front of the surface at distance u in medium of refractive index n_1 and its image is formed by the surface at distance v, in the medium of refractive index n_2. Derive a relation between u and v. **[5]**

ii. A solid glass sphere of radius 6.0 cm has a small air bubble trapped at a distance 3.0 cm from its centre C as shown in the figure. The refractive index of the material of the sphere is 1.5. Find the apparent position of this bubble when seen through the surface of the sphere from an outside point E in air.



OR

i. State Huygen's principle. With the help of a diagram, show how a plane wave is reflected from a surface. Hence verify the law of reflection.

ii. A concave mirror of focal length 12 cm forms a three times magnified virtual image of an object. Find the distance of the object from the mirror.

32. i. Derive the expression for the energy stored in parallel plate capacitor. Hence, obtain the expression for the energy density of the electric field. **[5]**

ii. A fully charged parallel plate capacitor is connected across an uncharged identical capacitor. Show that the energy stored in the combination is less than the energy stored initially in the single capacitor.

OR

a. If two similar large plates, each of area A having surface charge densities +σ and - σ are separated by a distance d in air, then find the expression for

i. the field at points between the two plates and on the outer side of the plates. Specify the direction of the field in each case.

ii. the potential difference between the plates.

iii. the capacitance of the capacitor so formed.

b. Two metallic spheres of radii R and 2R are charged so that both of these have the same surface charge density σ. If they are connected to each other with a conducting wire, in which direction will the charge flow and why?

33. A circuit containing a 80 mH inductor and a 60 μF capacitor in series is connected to a 230 V, 50 Hz supply. The resistance of the circuit is negligible. **[5]**

a. Obtain the current amplitude and rms values.

b. Obtain the rms values of potential drops across each element.

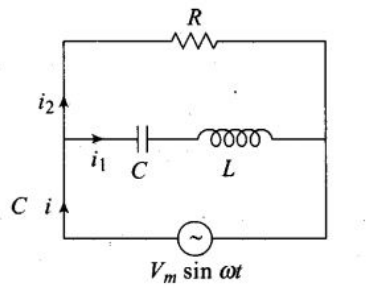
c. What is the average power transferred to the inductor?

d. What is the average power transferred to the capacitor?

e. What is the total average power absorbed by the circuit? [‘Average’ implies ‘averaged over one cycle’.]

OR

Consider the LCR circuit shown in Figure. Find the net current i and the phase of i. Show that $i = \frac{v}{Z}$. Find the impedance Z for this circuit.



Solution

Section A

1.

(d) Option C

Explanation:

$^{6}C: 1s^2\ 2s^2\ 2p^2$

$^{14}Si: 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

The energy required to take out an electron from the 3rd orbit of Si is much smaller than to take out an electron from the 2nd orbit of C. So, Si has a significant number of free electrons while C has a negligibly small number of free electrons.

2.

(d) $9.6 \times 10^{+3}\ A\,m^{-2}$

Explanation:

To find the current density in the electron beam, we first need to calculate the current (I) flowing through the beam. The current can be determined using the formula: $I = n \cdot e$ where n is the number of electrons passing through per second per unit area, and e is the charge of an electron (approximately 1.6×10^{-19} coulombs).

Given that $n = 6.0 \times 10^{16}$ electrons/m²/s, we can calculate the current for the given aperture area of $1.0\ \text{mm}^2$ (which is $1.0 \times 10^{-6}\ \text{m}^2$):

i. Calculate the total number of electrons passing through the aperture per second:
   Total electrons $= n \cdot \text{Area} = 6.0 \times 10^{16}\ \text{electrons/m}^2/\text{s} \times 1.0 \times 10^{-6}\ \text{m}^2 = 6.0 \times 10^{10}\ \text{electrons/s}$

ii. Now, calculate the current: $I = 6.0 \times 10^{10}\ \text{electrons/s} \times 1.6 \times 10^{-19}\ \text{C/electron} = 9.6 \times 10^{-9}\ \text{A}$

iii. Finally, to find the current density J, we use the formula: $J = \frac{I}{\text{Area}} = \frac{9.6 \times 10^{-9}\ \text{A}}{1.0 \times 10^{-6}\ \text{m}^2} = 9.6 \times 10^3\ \text{A/m}^2$

This calculation confirms that the current density in the beam is $9.6 \times 10^3\ \text{A/m}^2$, which matches option ($9.6 \times 10^{+3}\ A\,m^{-2}$).

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.

(b) 0 and 0

Explanation:

Torque = τ = MBsin θ

Since, M and B are parallel, then θ = 0 and hence,

τ = 0

Torque is 0. So, in this case force is also zero since the distance is not equal to zero.

5.

(b) 2 C

Explanation:

The equivalent capacitance between points A and B is calculated based on the configuration of the capacitors in the circuit. If the capacitors are in series, the formula for equivalent capacitance is given by: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$ If they are in parallel, the formula is: $C_{eq} = C_1 + C_2 + \ldots$ The solution indicates that the equivalent capacitance is 2 C, which suggests that the combination of capacitors results in this value based on the above formulas. The specific arrangement and values of the capacitors lead to this final result.

6. **(a)** perpendicular to the magnetic field

Explanation:

F = Bilsin θ

θ is the angle between the direction of current and the direction of magnetic field.

So, when $\theta = 90^{o}$, the force is maximum.

7.

(d) Zero

Explanation:

Induced EMF is zero because flux linked with it remains constant.

8.

(d) Absolute Permittivity

Explanation:

Absolute Permittivity

9.

(b) interference, in which width of the fringe will be slightly increased

Explanation:

Strictly speaking, the refractive index of air is $1 \cdot 00029$ and that of vacuum is 1. Therefore, on evacuating the chamber, the wavelength of the light used will increase slightly. Since $\beta \propto \lambda$, the fringe width will increase slightly.

10. **(a)** the inverse square law was not exactly true

Explanation:

Gauss's law is based on the inverse square dependence of distance contained in the Coulomb's law. Any violation of Gauss's law will indicate departure from the inverse square law.

11.

(d) C and A

Explanation:

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

12.

(d) smaller

Explanation:

When light travels from air to a medium of refractive index μ, its wavelength decreases by a factor μ i.e. becomes $1/\mu$.

13.

(c) A is true but R is false.

Explanation:

A photocell works on the principle of photoelectric emission. It is also called an electric eye.

14.

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

Explanation:

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

15.

(d) Both A and R are false.

Explanation:

When a light wave travel from a rarer to a denser medium it loses speed, but energy carried by the wave does not depend on its speed. Instead, it depends on the amplitude of wave The frequency also remain constant.

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

Explanation:

The effect of ac on the body depends largely on the frequency. Low-frequency currents of 50 to 60 Hz (cycles/sec), which are commonly used, are usually more dangerous than high-frequency currents and are 3 to 5 times more dangerous than dc of the same voltage and amperage (current). The usual frequency of 50 cps (or 60 cps) is extremely dangerous as it corresponds to the fibrillation frequency of the myocardium. This results in ventricular fibrillation and instant death.

Section B

17. The displacement current in a capacitor is equal to the conduction current of the capacitor.

Displacement current, $I_d = I_c$

The displacement current through the capacitor is given by

$I_d = I_c = \frac{dq}{dt}$ ....(i)

Here we are given, $q = q_0 \cos 2\pi\nu t$

Putting this value in Eq (i), we get

$I_d = I_c = - q_0 \sin 2\pi\nu t \times 2\pi\nu$

$I_d = I_c = -2\pi\nu q_0 \sin 2\pi\nu t$

18. Given length of wire l = 31.4 cm = 0.314 m

Pole strength m = 0.2 Am

Magnetic moment = m $\times$ r = 0.2 $\times$ 0.314 = 0.628 Am^2

For semicircle, $l = \pi r \Rightarrow r' = \frac{1}{\pi}$ and $M' = m \times 2r'$

$= m \times \frac{2 \times l}{\pi}$

$= \frac{M \times 2}{\pi}$

$= \frac{0.628}{3.14} \times 2$

= 0.04 Am^2

OR

Here $m = q_m \times 2l = 14.4 \times 0.25 = 3.6\ Am^2$, $\theta = 60°$, B = 0.25 T, r = 12 cm = 0.12 m

Torque, $\tau = Fr = mB \sin\theta$

$\therefore F = \frac{mB \sin\theta}{r} = \frac{3.6 \times 0.25 \times \sin 60^\circ}{0.12}$

$= \frac{3.6 \times 0.25 \times 0.866}{0.12}$ = 6.5 N

When the force F is removed, the magnet aligns itself in the direction of field B.

19. The peak value of primary voltage is

$V_0^P = \sqrt{2} V_{rms}^P = \sqrt{2} \times 220$ = 311 V

$\therefore$ The peak value of secondary voltage is

$V_0^S = \frac{N_2}{N_1} \cdot V_0^P = \frac{1}{12} \times 311$ = 25.9 V

The d.c. voltage across the load is

$V_{dc} = \frac{V_0^S}{\pi} = 0.637 \times 25.9$ = 8.24 V

20. Energy corresponding to the given wavelength

E (in eV) = $\frac{12400}{\lambda(\text{in } \mathring{A})}$ = 12.71 eV

The excited state :

$E_n - E_1 = 12.71$

$\frac{-13.6}{n^2} + 13.6 = 12.71$

$\therefore$ n = 3.9 = 4

Total no. of spectral lines possible in the resultant spectrum is given by :- $\frac{n(n-1)}{2} = 6$

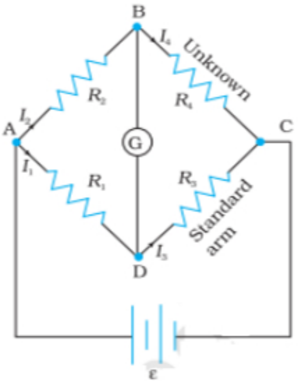
Longest wavelength will correspond to the transition from n = 4 to n = 3

21. For converting galvanometer into ammeter or voltmeter, we must know:

i. Resistance of the galvanometer (R_g)

ii. Current (I_g) required to produce full scale deflection in the galvanometer.

Section C

22. a. 

Applying kirchoff's loop rule to ADBA and CBDC

$-I_1R_1 + 0 + I_2R_2 = 0$

$I_2R_4 + 0 - I_1R_3 = 0$

Since, $I_g = 0$, $I_3 = I_1$, $I_4 = I_2$

$\frac{I_1}{I_2} = \frac{R_4}{R_3}$ and $\frac{I_1}{I_2} = \frac{R_2}{R_1}$

$\therefore \frac{R_4}{R_3} = \frac{R_2}{R_1}$ (Balance Condition)

b. A practical device using the principle of wheatstone bridge is meter bridge.

23. a. λ = 200 nm, stopping potential = -2.5 V

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

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

$= \frac{6.63\times10^{-34}\times3\times10^{8}}{200\times10^{-9}}$

$= 9.945 \times 10^{-19}$ 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 = hv = $h\frac{c}{\lambda}$

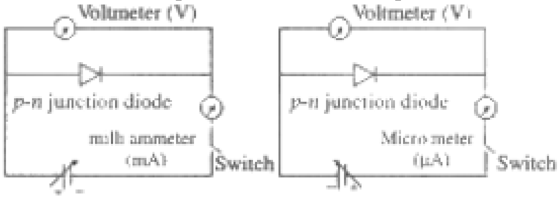
$= \frac{6.63\times10^{-34}\times3\times10^{8}}{6328\times10^{-10}}$

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

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

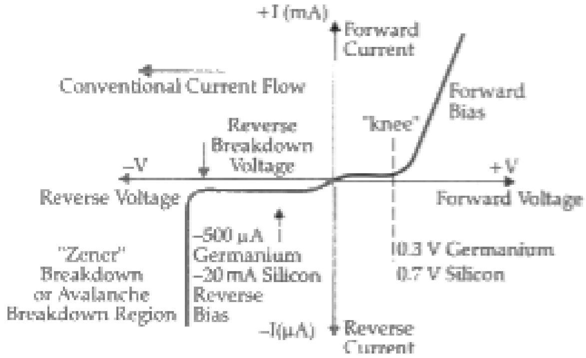
Energy of red light < work function of metal surface

$\therefore$ No emission of photoelectrons takes place.

24. 

In forward bias, the applied voltage does not support potential barriers. As a result, the depletion layer width decreases, and the barrier height is reduced. Due to the applied voltage, electrons from n side cross the depletion region and reach p side. Similarly, holes from p side cross the junction and reach the n side. The motion of charge carriers, on either side, give rise to current. In reverse bias, applied voltage support potential barrier. As a result, the barrier height is increased, depletion layer widens. This suppresses the flow of electrons from n $\rightarrow$ p and holes from p $\rightarrow$ n, thereby decrease the diffusion current. The electric field direction of the junction is such that if electrons on p side or holes on n side in their random motion come close to the junction. They will be swept to its majority zone. This drift of carriers give rise to the current called reverse current .Also ,Resistance of P-n

Junction in reverse bias is high.



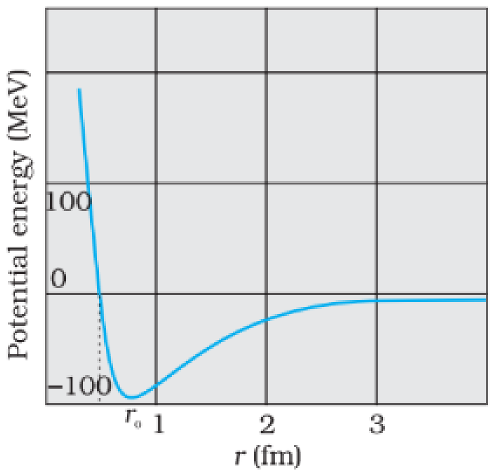
25. i. The nuclear force binds nucleons into atomic nuclei. Characteristics properties of nuclear force are:

a. Nuclear forces act between a pair of neutrons, a pair of protons and also between a neutron-proton pair, with the same strength. This shows that nuclear forces are independent of charge.

b. The nuclear forces are dependent on spin or angular momentum of nuclei.

c. Nuclear forces are non-central forces. This shows that the distribution of nucleons in a nucleus is not spherically symmetric.

ii. A plot of potential energy of a pair of nucleons as a function of their separation is shown below:



From the plot, it is concluded that

i. The potential energy is minimum at a distance $r_0 (\approx 0.8\text{fm})$ which means that the force is attractive for distances larger than 0.8 fm and repulsive for the distance less than 0.8 fm between the nucleons

ii. Nuclear forces are negligible when the distances between the nucleons is more than 10 fm.

26. a. Given: The total energy of an electron in the first excited state of the hydrogen atom is about –3.4 eV.

The kinetic energy of the electron in this state = negative of the total energy = -E

Kinetic energy of the electron in this state = -(-3.4)eV = + 3.4 eV

b. Potential energy is given as the negative of the twice of the kinetic energy U = -2 × (3.4) eV

U = -6.8eV

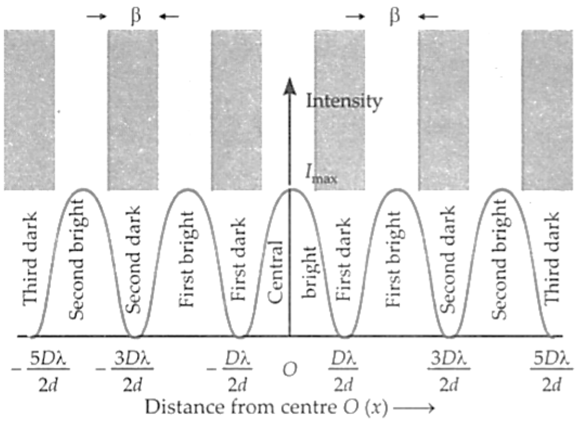
Hence the potential energy of the electron in the given state is − 6.8 eV.

c. If the choice of the zero of potential energy is changed, then the value of potential energy of the system also changes and as we know the total energy is the sum of kinetic energy as well as potential energy. Therefore, the potential energy will also change.

27. With two narrow slits, an interference pattern is obtained.

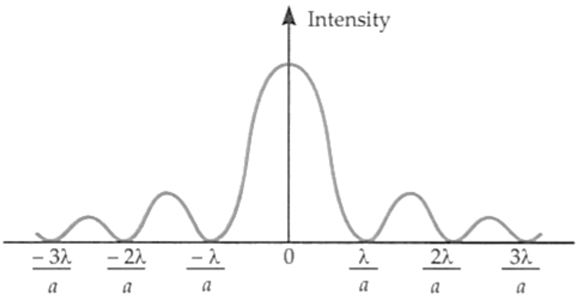
When one slit is completely covered, the diffraction pattern is obtained.

For intensity distribution curve for interference, see Fig.



Intensity distribution curve.

For intensity distribution curve for diffraction, see Fig.



Interference	Diffraction
1. All the bright fringes are of same intensity.	Intensity of bright fringes decreases with the increasing order.
2. All the bright fringes are of equal width.	Central bright fringe is twice as wide as any secondary bright fringe.
3. Regions of dark fringes are perfectly dark.	Regions of dark fringes are not perfectly dark.
4. Maxima occur at $\theta = n\frac{\lambda}{d}$	Minima occur at $\theta = n\frac{\lambda}{a}$

28. i. Let RS moves with speed v rightward and also RS is at distances x_1 and x_2 from PQ at instants t_1 and t_2, respectively.

Change in flux, $d\phi = \phi_2 - \phi_1 = Bl(x_2 - x_1)$ [$\because$ magnetic flux, $\phi = \vec{B}.\vec{A} = BAcos0^0 = Blx$]

$\Rightarrow$ dϕ = Bldx$\Rightarrow$ $\frac{d\phi}{dt} = Bl\frac{dx}{dt} = Blv$ $\left[\because v = \frac{dx}{dt}\right]$

If resistance of loop is R, then $I = \frac{vBl}{R}$

ii. Magnetic force = BIl sin 90°

$= \left(\frac{vBl}{R}\right) Bl = \frac{vB^2l^2}{R}$

Now, External force must be equal to magnetic force

$\therefore$ External force $= \frac{vB^2l^2}{R}$

iii. As, $P = I^2R = \left(\frac{vBl}{R}\right)^2 \times R = \frac{v^2B^2l^2}{R^2} \times R$

$\therefore P = \frac{v^2B^2l^2}{R}$

OR

Self-inductance of a coil is the property of the coil in which it opposes the change of current flowing through it. Inductance is attained by a coil due to the self-induced emf produced in the coil itself by changing the current flowing through it.

Self-induction of the long solenoid of inductance L, (A long solenoid is one which length is very large as compared to its cross-section area.) the magnetic field inside such a solenoid is constant at any point and given by

B = $\frac{\mu_0 NI}{l}$

Magnetic flux through each turn of solenoid

ϕ = B $\times$ area of each turn

ϕ = $\frac{\mu_0 NI}{l}$ $\times$ A

total flux = flux $\times$ total number of turns

$N\phi = N\left(\frac{\mu_0 NI}{l} \times A\right)$ ... (i)

If L is the coefficient of inductance of solenoid

$N\phi$ = LI ... (ii)

from equation (i) and (ii)

LI = $N\left(\frac{\mu_0 NI}{l} \times A\right)$

L = $\frac{\mu_0 N^2 A}{l}$ ... (iii)

The magnitude of emf is given by

|e| or e = $L\frac{dI}{dt}$ ... (iv)

multiplying I to both sides

eIdt = LIdI

but I = $\frac{dq}{dt}$

Idt = dq

Also work done (dW)= voltage $\times$ Charge(dq)

or dW = e$\times$dq = eIdt

substituting the values in equation (iv)

dW = LIdt

By integrating both sides

$\int_0^w dW = \int_0^{I_0} LIdt$

W = $\frac{1}{2}LI_0^2$

this work done is in increasing the current flow through inductor is stored as potential energy (U) in the magnetic field of inductor

U = $\frac{1}{2}LI_0^2$

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.

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

Explanation:

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

(ii) **(b)** photon

Explanation:

Photon is the fundamental particle in an electromagnetic wave.

(iii) **(a)** polarisation

Explanation:

Polarisation establishes the wave nature of electromagnetic waves.

OR

(b) in phase and perpendicular to each other

Explanation:

The electric and magnetic fields of an electromagnetic wave are in phase and perpendicular to each other.

(iv) **(d)** frequency

Explanation:

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

30. i. The total flux corning out is ε_0^{-1}.

ii. ϕ = EA cos θ

= (2)(1)(cos 90^{o} - 30^{o})

= (2)(1) (cos 60^{o})

= (2)(1)($\frac{1}{2}$)

= 1 Vm

iii. It will be positive when the flux lines are directed outwards.
iv. It depends on the net charge enclosed.
v. It is when the surface is perpendicular to the field.

Section E

31. i. Assuming the aperture of the surface is small as compared to other distance involved, so that small angle approximation can be taken under consideration. For small angles in $\triangle$NOC, i is the exterior angle.

By exterior angle theorem;

$\therefore$ i = $\angle$NOM + $\angle$NCM

$i = \frac{MN}{OM} + \frac{MN}{MC}$ ...(i)

Similarly r = $\angle$NCM - $\angle$NIM

$= \frac{MN}{MC} - \frac{MN}{MI}$ ...(ii)

By Snell's law

$n_1 \sin i = n_2 \sin r$

for small angles

$n_1 i = n_2 r$

substituting i and r from (i) and (ii) we get

$\frac{n_1}{OM} + \frac{n_2}{MI} = \frac{n_2 - n_1}{MC}$

Applying Cartesian coordinates

OM = -u, MI = +v, MC = +R

$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

ii. $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

R= -6 cm, u = -3cm , $n_1 = 1.5$ $n_2 = 1$

$\frac{1}{v} + \frac{1.5}{3} = \frac{1-1.5}{-6}$

$\frac{1}{v} = \frac{0.5}{6} - \frac{1.5}{3}$

$\frac{1}{v} = \frac{0.5-3}{6}$

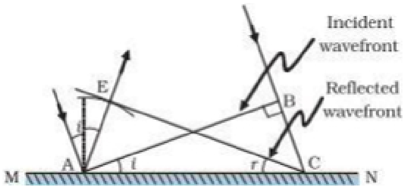
$\frac{1}{v} = \frac{-2.5}{6}$

v = -2.4 cm

from the left surface inside the sphere

OR

i. **Huygen's principle** 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, a common tangent to all these spheres gives the new position of the wavefront at a later time.



Verification of law of reflection

In $\triangle$AEC & $\triangle$CBA

EC = AB (c x t each)

$\angle$AEC = $\angle$CBA (90^o each)

AC = AC (common side)

By RHS congruency $\triangle \text{AEC} \cong \Delta \text{CBA}$

$\Rightarrow \angle i = \angle r$

Hence the law of reflection is verified.

ii. m = +3, f = -12 cm, u = ?

m = $-\frac{v}{u}$ = 3 $\Rightarrow$ v = -3u

using mirror formula

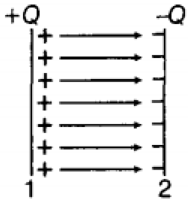
$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{-3u} + \frac{1}{u} = \frac{1}{-12}$

u = -8 cm

Hence the distance of the object from the mirror is 8 cm

32. i. Let the total charge on the plates of the below capacitor is +Q and -Q respectively.



∴The potential difference between the plates of the above capacitor of capacitance C for an infinitesimal charge q is q/C.

∴ Potential of condenser = q/C

Small amount of work done in giving an additional charge dq to the condenser,

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

∴Total work done in giving a charge Q to the condenser,

$W = \int_{q=0}^{q=Q} \frac{q}{C} dq = \frac{1}{C}\left[\frac{q^2}{2}\right]_{q=0}^{q=Q} \Rightarrow W = \frac{1}{C}\frac{Q^2}{2}$

As, an electrostatic force is conservative, this work is stored in the form of potential energy (U) of the condenser.

$U = W = \frac{1}{2}\frac{Q^2}{C}$

$\because \quad Q = CV \Rightarrow U = \frac{1}{2}\frac{(CV)^2}{C} = \frac{1}{2}CV^2$

$\because \quad CV = Q \Rightarrow U = \frac{1}{2}QV$

Hence, $U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$

Energy density (u) is defined as the total energy per unit volume of the condenser.

i.e., $u = \frac{\text{Total energy } (U)}{\text{Volume } (V)} = \frac{\frac{1}{2}CV^2}{Ad}$

Using, $C = \frac{\varepsilon_0 A}{d}$ and V = Ed (Where V is the potential difference and E is the Electric field existing between the plates)

We get, $u = \frac{1}{2}\left(\frac{\varepsilon_0 A}{d}\right)\left(\frac{E^2 d^2}{Ad}\right) = \frac{1}{2}\varepsilon_0 E^2$

Here, Energy density between plates of capacitors is directly proportional to electric field that exists between the plates of capacitor.

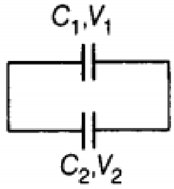
ii. Initial condition :

If we consider a charged capacitor of capacitance C with potential difference V, then its charge would be given, q = CV

and energy stored in it is given by

$U_1 = \frac{1}{2}CV^2$ .....(i)

When this charged capacitor is connected to uncharged capacitor,



Let the common potential be V_1, the charge flow from first capacitor to the other capacitor unless both the capacitor attains the common potential.

⇒ $Q_1 = CV_1$ and $Q_2 = CV_2$

Applying conservation of charge,

$Q = Q_1 + Q_2 \Rightarrow CV = CV_1 + CV_2$

$\Rightarrow V = V_1 + V_2 \Rightarrow V_1 = \frac{V}{2}$ [hence voltage will be equally divided between the capacitors]

Total energy stored in both the capacitor is

$U_2 = \frac{1}{2}CV_1^2 + \frac{1}{2}CV_1^2 \Rightarrow U_2 = \frac{1}{2}C\left(\frac{V}{2}\right)^2 + \frac{1}{2}C\left(\frac{V}{2}\right)^2$

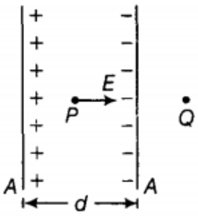
$U_2 = \frac{2CV^2}{8} = \frac{1}{4}CV^2$

From Eqs. (i) and (ii), we get, $U_2 < U_1$

It means that energy stored in the combination is less than that stored initially in the single capacitor. It is due to the fact that when the charge is transferred from one capacitor to another capacitor energy is wasted in transferring the charge.

OR

a. Consider the figure shown below:



i. Electric field due to the plate of the positive charge of charge density $+\sigma$ at point P, is given by

$E_1 = \sigma/2\varepsilon_0$

Magnitude of electric field due to the other plate of negative charge density $-\sigma$,is given by

$E_2 = -\sigma/2\varepsilon_0$

In , the inner region between the plates 1 and 2 , electric field due to the two charged plates add up, is given by

$E_{\text{net}} = E_1 + E_2 = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$

Outside the plate, electric field will be equal to zero because of the opposite directions of the electric fields E_1 and E_2 there.

ii. Potential difference between the plates of the capacitor is given by

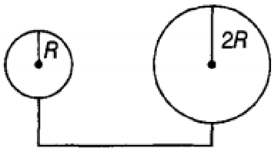
V = Ed = $\sigma d/\varepsilon_0$ ($\because E = \sigma/\varepsilon_0$)

iii. Capacitance of the capacitor is given by

($\because$ Q = CV)

$C = \frac{Q}{V} = \frac{\sigma A}{\sigma d}\varepsilon_0 = \frac{\varepsilon_0 A}{d}$

b. Consider the figure shown below:



Potential at the surface of the sphere of radius R,

{tex}= \frac { k q } { R } \quad \left[\because q = \sigma \times 4πR ^ { 2 } \right]{/tex}

$= \frac{k\sigma 4\pi R^2}{R} = \sigma k 4\pi R = 4k\sigma\pi R$

Potential at the surface of the second sphere of radius twice the previous one i.e. 2R,

$= \frac{kq}{2R} \quad [\because q = \sigma \times 4\pi(2R)^2 = 16\sigma\pi R^2]$

$= \frac{k16\sigma\pi R^2}{2R} = 8k\sigma\pi R$

We know that charge always flows from the higher potential surface to lower potential surface. Since the potential of the bigger sphere is more, so charge will flow from sphere of radius 2R to the sphere of radius R after connecting both the spheres by a conducting wire

33. Inductance, L = 80 mH = 80 $\times$ 10^{-3} H

Capacitance, C = 60 μF = 60 $\times$ 10^{-6} F

Supply voltage, V = 230 V

Frequency, ν = 50 Hz

Angular frequency, ω = $2\pi\nu$= 100 π rad/s

Peak voltage, $V_0 = V\sqrt{2} = 230\sqrt{2}$V

a. Maximum current is given as:

$I_0 = \frac{V_0}{\left(\omega L - \frac{1}{\omega C}\right)}$

$= \frac{230\sqrt{2}}{\left(100\pi \times 80 \times 10^{-3} - \frac{1}{100\pi \times 60 \times 10^{-6}}\right)}$

$= \frac{230\sqrt{2}}{\left(8\pi - \frac{1000}{6\pi}\right)}$ = -11.63 A

The negative sign appears because $\omega L < \frac{1}{\omega C}$

Amplitude of maximum current, $|I_0| = 11.63\text{A}$

Hence, rms value of current. $I = \frac{I_0}{\sqrt{2}} = \frac{-11.63}{\sqrt{2}}$ =- 8.22 A

b. Potential difference across the inductor.

$v_L = I \times \omega L$

$= 8.22 \times 100\,\pi \times 80 \times 10^{-3}$

= 206.61 V

Potential difference across the capacitor,

$V_c = I \times \frac{1}{\omega C}$

$= 8.22 \times \frac{1}{100\pi \times 60 \times 10^{-6}} = 436.84\text{V}$

c. Average power consumed over a **complete cycle by the source** to the inductor is zero as actual voltage leads the current by $\frac{\pi}{2}$.

d. Average power consumed over a complete cycle by the source to the capacitor is zero as voltage lags current by $\frac{\pi}{2}$.

e. The total power absorbed (averaged over one cycle) is zero.

OR

According to the above figure, the total current 'i' is divided into two parts i_2 through R and i_1 through a series combination of C and L.

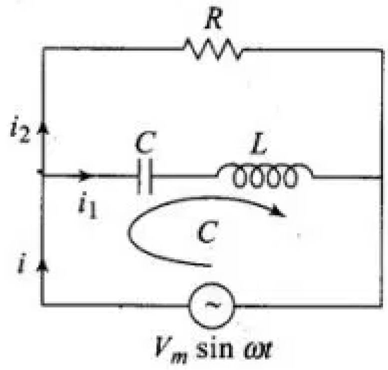
So, we get $i = i_1 + i_2$

As, $V_m \sin \omega t = Ri_2$, [from the circuit diagram, we find that]

$\Rightarrow \quad i_2 = \frac{V_m \sin \omega t}{R}$ .... (i)

Let q_1 is charge on the capacitor at any time t, i_1 is the current in the lower circuit.

thus, by Applying KVL in the lower circuit as shown in the figure,



$V_m \sin \omega t - \frac{q_1}{C} - \frac{Ldi_1}{dt} = 0$

$\Rightarrow \quad \frac{q_1}{C} + \frac{Ld^2 q_1}{dt^2} = V_m \sin \omega t$ ..... (ii)

Let $q_1 = q_m \sin(\omega t + \phi)$ .... (iii)

$\therefore \quad i_1 = \frac{dq_1}{dt} = q_m \omega \cos(\omega t + \phi)$

$\Rightarrow \quad \frac{d(i_1)}{dt} = \frac{d^2 q_1}{dt^2} = -q_m \omega^2 \sin(\omega t + \phi)$

Now putting these values in eq. (ii), we get

$q_m \left[\frac{1}{C} + L\left(-\omega^2\right)\right] \sin(\omega t + \phi) = V_m \sin \omega t$

If $\phi = 0$ and $\left(\frac{1}{C} - L\omega^2\right) > 0$

then $q_m = \frac{V_m}{\left(\frac{1}{C} - L\omega^2\right)}$ .... (iv)

From Eq. (iii), $i_1 = \frac{dq_1}{dt} = \omega q_m \cos(\omega t + \phi)$

Using eq. (iv), $i_1 = \frac{\omega V_m \cos(\omega t + \phi)}{\frac{1}{C} - L\omega^2}$

Taking $\phi = 0$; $i_1 = \frac{V_m \cos(\omega t)}{\left(\frac{1}{\omega C} - L\omega\right)}$ .... (v)

From Eqs. (i) and (v), we find that i_1 and i_2 are out of phase by $\frac{\pi}{2}$

Now, $i_2 + i_1 = \frac{V_m \sin \omega t}{R} + \frac{V_m \cos \omega t}{\left(\frac{1}{\omega C} - L\omega\right)}$

Let $\frac{V_m}{R} = A\cos\phi$ and $\frac{V_m}{\left(\frac{1}{\omega C} - L\omega\right)} = A\sin\phi$

$\therefore \quad i_1 + i_2 = A\cos\phi\sin\omega t + A\sin\phi\cos\omega t$

$= A\sin(\omega t + \phi)$

Where $A = \sqrt{(A\cos\phi)^2 + (A\sin\phi)^2}$

and $\phi = \tan^{-1}\frac{B}{A}C = \left[\frac{V_m^2}{R^2} + \frac{V_m^2}{\left(\frac{1}{\omega C} - L\omega\right)}\right]^{1/2}$

and $\phi = \tan^{-1}\frac{R}{\left(\frac{1}{\omega C} - L\omega\right)}$

Hence, i = i_1 + i_2 $= \left[\frac{V_m^2}{R^2} + \frac{V_m^2}{\left(\frac{1}{\omega C} - L\omega\right)^2}\right]^{1/2} \sin(\omega t + \phi)$

or $\frac{i}{V_m} = \frac{1}{Z} = \left[\frac{1}{R^2} + \frac{1}{\left(\frac{1}{\omega C} - L\omega\right)^2}\right]^{1/2}$

This is the expression for impedance Z of the circuit. Hence these are the required results.