Class XII Session 2026-27
Subject - Physics
Sample Question Paper - 1

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. The cations and anions are arranged in alternate form in **[1]**

   a) ionic crystal b) covalent crystal

   c) semiconductor crystal d) metallic crystal

2. If 2% of the main current is to be passed through the galvanometer of resistance G, the resistance of shunt required is **[1]**

   a) 50G b) $\frac{G}{49}$

   c) $\frac{G}{50}$ d) 49G

3. Magnifying power of a compound microscope is high if **[1]**

   a) both objective and eye-piece have long focal lengths

   b) the objective has a long focal length and eye-piece has a short focal

   c) the objective has a short focal length and the eye-piece has a long focal

   d) both objective and eye-piece have short focal lengths

4. A frog can be levitated in a magnetic field produced by a current in a vertical solenoid placed below the frog. This is possible, because the body of the frog behaves as **[1]**

   a) anti-ferromagnetic b) diamagnetic

c) ferromagnetic
d) paramagnetic

5. When a negative charge is taken at a height from earth's surface, then its potential energy **[1]**

a) increases
b) decreases
c) remains unchanged
d) will become infinity

6. A piece of wire bent in the form of a circular loop A carries a current I. The wire is then bent into a circular loop B of two turns and carries the same current. The ratio of magnetic fields at the centre of loop A to that of loop B will be: **[1]**

a) 16
b) $\frac{1}{4}$
c) $\frac{1}{16}$
d) 4

7. The SI unit of magnetic flux is: **[1]**

a) Gauss
b) Weber
c) Oersted
d) Tesla

8. The universal property among all substances is **[1]**

a) diamagnetism
b) ferromagnetism
c) non-magnetism
d) paramagnetism

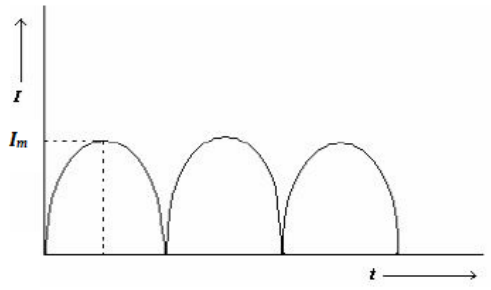
9. The main condition for diffraction to be observed is **[1]**

a) for any size of obstacle
b) size of obstacle should be comparable to the wavelength of the wave
c) size of obstacle should be much smaller than the wavelength of the wave
d) size of obstacle should be much larger than the wavelength of the wave

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

a) newton per coulomb
b) volt $\times$ meter
c) weber
d) joule per coulomb

11. The output current I versus time (t) curve of a full wave rectifier is shown in the figure. The average value of the output current in this case is **[1]**



a) I_m
b) Zero
c) $\frac{2I_m}{\pi}$
d) $\frac{I_m}{\pi}$

12. Which of the following is used in optical fibers? **[1]**

a) Refraction
b) Scattering

c) Total internal reflection d) Diffraction

13. **Assertion (A):** The minimum negative potential applied to the anode in a photoelectric experiment at which photoelectric current becomes zero, is called cut-off voltage. **[1]**

Reason (R)**:** The threshold frequency for a metal is the minimum frequency of incident radiation below which emission of photoelectrons does not take place.

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):** If two protons are brought near one another, the potential energy of the system will increase. **[1]**

Reason (R): The charge on the proton is $+1.6 \times 10^{-19}$ C.

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):** Thin film such as soap bubbles or a thin layer of oil on water show beautiful colors when illuminated by white light. **[1]**

Reason (R): It happens due to the interference of light reflected from the upper and lower face of the thin film.

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):** We use a thick wire in the secondary of a step-down transformer to reduce the production of heat. **[1]**

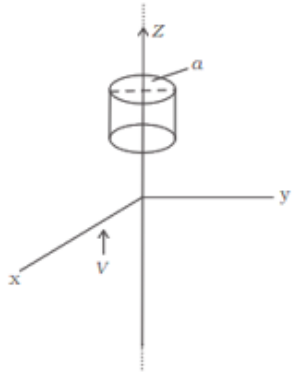
Reason (R): When the plane of the armature is parallel to the lines of force of the magnetic field, the magnitude of induced emf is maximum.

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. An infinitely long thin wire carrying a uniform linear static charge density λ is placed along the z-axis (Fig). The wire is set into motion along its length with a **[2]**

uniform velocity $\vec{v} = v\vec{k}_z$. Calculate the Poynting vector $\vec{S} = \frac{1}{\mu_0}(\vec{E} \times \vec{B})$.



18. A semiconductor has equal electron and hole concentration of 2×10^8 m^{-3}. On doping with a certain impurity, the hole concentration increases to 4×10^{10} m^{-3}. **[2]**

i. What type of semiconductor is obtained on doping?

ii. Calculate the new electron concentration of the semiconductor.

iii. How does the energy gap vary with doping?

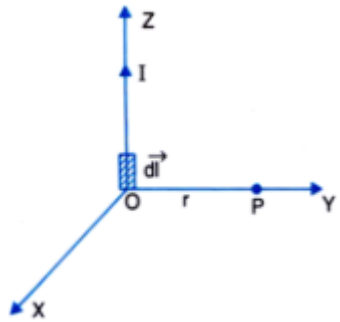
19. When an electron in hydrogen atom jumps from the third excited state to the ground state, how would the de-Broglie wavelength associate with the electron change? Justify your answer. **[2]**

20. 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? **[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.

21. State Biot Savart law. A current I flows in a conductor placed perpendicular to the plane of the paper. Indicate the direction of the magnetic field due to a small element $\overrightarrow{dl}$ at point P situated at a distance $\overrightarrow{r}$ from the element as shown in the figure. **[2]**



OR

State the condition under which a charged particle moving with velocity v goes undeflected in a magnetic field B.

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. Red light, however bright it is, cannot produce the emission of electrons from a clean zinc surface. But even weak ultraviolet radiation can do so. Why? **[3]**

Electrons are emitted from the cathode of negligible work function, when photons of wavelength λ are incident on it. Derive the expression for the de Broglie wavelength of the electrons emitted in terms of the wavelength of the incident light.

24. a. Explain how a potential barrier is developed in a p-n junction diode. **[3]**

b. Draw the circuit arrangement for studying the V-I characteristics of a p-n junction diode in reverse bias. Plot the V-I characteristics in this case.

25. How the size of a nucleus is experimentally determined? Write the relation between the radius and mass number of the nucleus. Show that the density of the nucleus is independent of its mass number. **[3]**

26. An electron in a hydrogen atom makes transitions from orbits of higher energies to orbits of lower energies. **[3]**

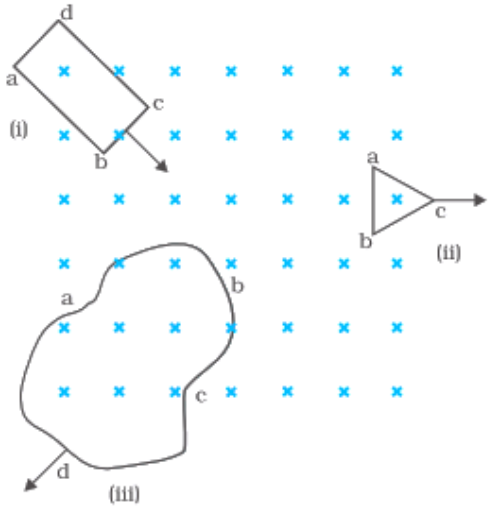
a. When will such transitions result in (a) Lyman (b) Balmer series?

b. Find the ratio of the longest wavelength in Lyman series to the shortest wavelength in Balmer series.

27. Define self-inductance of a coil. Obtain the expression for the energy stored in an inductor L connected across a source of emf. **[3]**

OR

In Figure, shows planar loops of different shapes moving out of or into a region of a magnetic field which is directed normal to the plane of the loop away from the reader. Determine the direction of induced current in each loop using Lenz's law.



28. i. Define wavefront. Use Huygens' principle to verify the laws of refraction. **[3]**

ii. In a single slit diffraction experiment, the width of the slit is made double of the original width. How does this affect the size and intensity of the central diffraction band? Explain.

iii. When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the center of obstacle. Explain why?

Section D

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

An electromagnetic wave transports linear momentum as it travels through space. If an electromagnetic wave transfers a total energy U to a surface in time t, then total linear momentum delivered to the surface is p = $\frac{U}{c}$. When an electromagnetic wave falls on a surface, it exerts pressure on the surface. In 1903, the American scientists Nichols and Hull succeeded in measuring radiation pressures of visible light where other had failed, by making a detailed empirical analysis of the ubiquitous gas heating and ballistic effects.

(a) The pressure exerted by an electromagnetic wave of intensity I(W m^{-2}) on a non-reflecting surface is (c is the velocity of light)

a) $\frac{I}{c}$ b) Ic^2

c) Ic d) $\frac{I}{c^2}$

(b) Light with an energy flux of 18 W/cm^2 falls on a non-reflecting surface at normal incidence. The pressure exerted on the surface is:

a) 6×10^{-4} N/m^2 b) 2 N/m^2

c) 6 N/m^2 d) 2×10^{-4} N/m^2

(c) Radiation of intensity 0.5 W m^{-2} are striking a metal plate. The pressure on the plate is

a) 0.083×10^{-8} N m^{-2} b) 0.212×10^{-8} N m^{-2}

c) 0.166×10^{-8} N m^{-2} d) 0.132×10^{-8} N m^{-2}

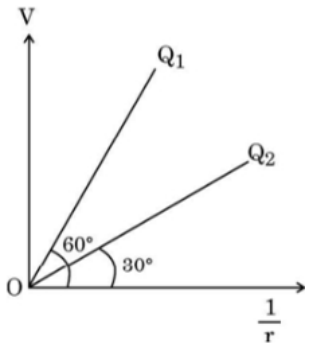
(d) A point source of electromagnetic radiation has an average power output of 1500 W. The maximum value of electric field at a distance of 3 m from this source (in V m^{-1}) is

a) $\frac{250}{3}$ b) 100

c) 500 d) $\frac{500}{3}$

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

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



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

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

Section E

31. i. Draw a ray diagram to show the formation of image by a concave mirror when the object is placed between f and 2f. Using this diagram, derive the mirror equation. **[5]**

ii. An object is kept 30 cm in front of a convex mirror of focal length 12 cm. Find the nature and position of the image formed.

OR

a. Derive the relation $a \sin \theta = \lambda$ for the first minimum of the diffraction pattern produced due to a single slit of width **a** using light of wavelength λ.

b. State with reason, how the linear width of central maximum will be affected if (i) monochromatic yellow light is replaced with red light, and (ii) distance between the slit and the screen is increased.

c. Using the monochromatic light of same wavelength in the experimental set-up of the diffraction pattern as well as in the interference pattern where the slit separation is 1 mm, 10 interference fringes are found to be within the central maximum of the diffraction pattern. Determine the width of the single slit, if the screen is kept at the same distance from the slit in the two cases.

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

i. A. Why does the electric field inside a dielectric slab decrease when kept in an external electric field?

B. Derive an expression for the capacitance of a parallel plate capacitor filled with a medium of dielectric constant K.

ii. A charge q = 2 μC is placed at the centre of a sphere of radius 20 cm. What is the amount of work done in moving 4 μC from one point to another point on its surface?

iii. Write a relation for polarisation $\vec{P}$ of a dielectric material in the presence of an external electric field.

33. i. Draw a labelled diagram of a step-down transformer. State the principle of its working. **[5]**

ii. Express the turn ratio in terms of voltages.

iii. Find the ratio of primary and secondary currents in terms of turn ratio in an ideal transformer.

iv. How much current is drawn by the primary of a transformer connected to 220 V supply when it delivers power to a 110 V - 550 W refrigerator?

OR

An emf ε = 100 sin 314 t is applied across a pure capacitor of 637 μF. Find

i. the instantaneous current I

ii. instantaneous power P

iii. the frequency of power and

iv. the maximum energy stored in the capacitor.

Solution

Section A

1. **(a)** ionic crystal
   Explanation:
   In an ionic crystal, cations and anions are arranged in alternate form.

2. **(b)** $\frac{G}{49}$
   Explanation:
   The current I_g through a galvanometer of resistance G is 0.02 I where I is the main current.
   The shunt resistance S is calculated as follows.
   $G = \left(\frac{I}{I_g} - 1\right) \times S$
   where G is galvanometer resistance,I is main current and S is Shunt resistance.
   $\Rightarrow \frac{G}{S} = \left(\frac{I}{I_g} - 1\right)$
   $\Rightarrow \frac{G}{S} = \left(\frac{I}{0.02I} - 1\right) = \frac{0.98}{0.02}$
   $\therefore S = \frac{G}{49}$

3. **(d)** both objective and eye-piece have short focal lengths
   Explanation:
   Angular magnification or magnifying power of compound microscope is defined as ratio of angle made at eye by image formed at infinity to the angle made by object, if placed at distance of distinct vision from an unaided eye.
   Magnification = $\frac{LD}{f_o f_e}$
   where, L- length of the tube of microscope, D = 25 cm
   Now as, m $\propto$ $1/f_o$
   and m $\propto$ $1/f_e$
   $\therefore$ both eye piece and objective must be of smaller focal lengths, so, that magnification is higher.

4. **(b)** diamagnetic
   Explanation:
   To levitate a body, a force must be applied on it which at least balances the body's weight. Since weight will always pull the frog down, the magnetic force on the frog due to the vertical solenoid placed below it must act in the upward direction. Thus, the frog is repelled by the magnetic field. Diamagnetic substances are the only substances which are repelled by a magnetic field. This shows that the body of the frog behaves diamagnetically.

5. **(a)** increases
   Explanation:
   The potential energy of a charge in an electric field depends on its position relative to other charges. When a negative charge is moved away from the Earth's surface, which is positively charged, it is moving to a position of higher potential energy. This is because the negative charge is moving against the electric field created by the positive charge of the Earth. Therefore, as the negative charge is raised, its potential energy increases.

6.

(b) $\frac{1}{4}$

Explanation:

The magnetic field at the center of loop A is $B_A = \frac{\mu_0 I}{2R_A}$ and for loop $B_1 B_B = \frac{\mu_0 I}{R_B}$. The ratio $\frac{B_A}{B_B} = \frac{1}{4}$. Thus, the answer is $\frac{1}{4}$.

7.

(b) Weber

Explanation:

Weber

8. **(a)** diamagnetism

Explanation:

Diamagnetism is a universal property among all substances.

9.

(b) size of obstacle should be comparable to the wavelength of the wave

Explanation:

size of obstacle should be comparable to the wavelength of the wave

10.

(b) volt $\times$ meter

Explanation:

SI unit of electric flux is

$\frac{\mathrm{N} \times \mathrm{m}^2}{\mathrm{C}} = \frac{\mathrm{J} \times \mathrm{m}}{\mathrm{C}}$ = volt $\times$ m

11.

(c) $\frac{2I_m}{\pi}$

Explanation:

Current waveform can be represented as, $I = I_m sin\omega t$ for $0 \leq \omega t \leq 2\pi$, where I_m = max load current

Average current, $I_{DC} = \frac{I_m}{\pi} \int_0^{\pi} \sin(\omega t)\, \mathrm{d}(\omega t)$

$= \frac{I_m}{\pi}[-cos(\omega t)]_0^{\pi} = \frac{2I_m}{\pi}$

12.

(c) Total internal reflection

Explanation:

When light travelling in an optically dense medium hits a boundary at a steep angle, the light is completely reflected. This is called total internal reflection. This effect is used in optical fibres to confine light in the core.

13.

(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.

14.

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

Explanation:

If two protons are brought near one another, work has to be done against electrostatic force ($\because$ the same charge repels each other). This work done is stored as potential energy in the system.

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

16. **(b)** Both A and R are true but R is not the correct explanation of A.
Explanation:
The assertion is true. Heat loss can be reduced by using thick wire in the secondary.
The reason is also true. When the plane of the armature is parallel to the magnetic field, the rate of change of flux is maximum. Hence induced emf is maximum. But the reason is not the correct explanation of the assertion.

Section B

17. The electric field due to infinitely long thin wire
$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 a}\hat{j}$
Magnetic field due to the wire, $\vec{B} = \frac{\mu_0 i}{2\pi a}\hat{i}$
Equivalent current flowing through the wire, i = λv
Hence $\vec{B} = \frac{\mu_0 \lambda v}{2\pi a}\hat{i}$, poynting vector is given by :-
$\therefore \vec{S} = \frac{1}{\mu_0}[\vec{E} \times \vec{B}] = \frac{1}{\mu_0}\left[\frac{\lambda}{2\pi\varepsilon_0 a}\hat{j} \times \frac{\mu_0 \lambda v}{2\pi a}\hat{i}\right]$
$\Rightarrow \vec{S} = \frac{\lambda^2 v}{4\pi^2 \varepsilon_0 a^2}(\hat{j} \times \hat{i}) = -\frac{\lambda^2 v}{4\pi^2 \varepsilon_0 a^2}\hat{k}$

18. i. As the hole concentration increases, the p-type semi-conductor is obtained after doping.
ii. As $n_e\, n_h = n_i^2$
$\therefore n_e = \frac{n_i^2}{n_h} = \frac{(2\times10^8)^2}{4\times10^{10}} = 10^6\ m^{-3}$
iii. Energy gap decreases with doping.

19. de Broglie wavelength associated with a moving charge particle having a KE 'K' can be given as
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}\left[K = \frac{1}{2}mv^2 = \frac{p^2}{2m}\right]$ ...(i)
The kinetic energy of the electron in any orbit of hydrogen atom can be given as
$K = -E = -\left(\frac{13.6}{n^2}eV\right) = \frac{13.6}{n^2}eV$ ...(ii)
Let K_1 and K_4 be the KE of the electron in ground state and third excited state, where $n_1 = 1$ shows ground state and $n_2 = 4$ shows third excited state.
Using the concept of equation (i) & (ii), we have
$\frac{\lambda_1}{\lambda_4} = \sqrt{\frac{K_4}{K_1}} = \sqrt{\frac{n_1'^2}{n_2^2}}$
$\Rightarrow \frac{\lambda_1}{\lambda_4} = \sqrt{\frac{1^2}{4^2}} = \frac{1}{4}$
$\lambda_1 = \frac{\lambda_4}{4}$
i.e., the wavelength in the ground state will decrease.

20. 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, τ = Fr = mB sin θ
$\therefore F = \frac{mB\sin\theta}{r} = \frac{3.6\times0.25\times\sin 60°}{0.12}$

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

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

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,

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

$M = \frac{(15 \times 10^{-2})^3 H}{2 \times 10^{-7}} = \frac{3375 \times 10^{-6} \times 0{\cdot}3 \times 10^{-4}}{2 \times 10^{-7}}$

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

21. Biot Savart law states that the magnitude of magnetic field induction at a point due to a current element of length dl, carrying I, at a point r from the element is given by

$dB = \frac{\mu_0}{4\pi} \cdot \frac{I\ dl \sin\theta}{r^2}$

Vector form: $|\overrightarrow{dB}| = \frac{\mu_0}{4\pi} \cdot \frac{|dl \times I|}{r^3}$

The direction of magnitude field $\overrightarrow{dB}$ is perpendicular to the plane containing $\overrightarrow{dl}$ and $\overrightarrow{r}$ and is directed inward.

OR

Force on a charge moving parallel or antiparallel to the direction of the magnetic field is zero

$F = qvB \sin\theta$

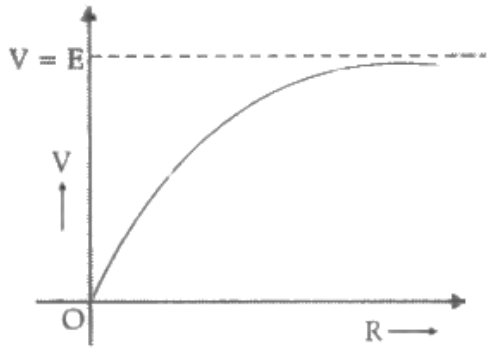
for (0° or 180°)

$\sin\theta = 0$

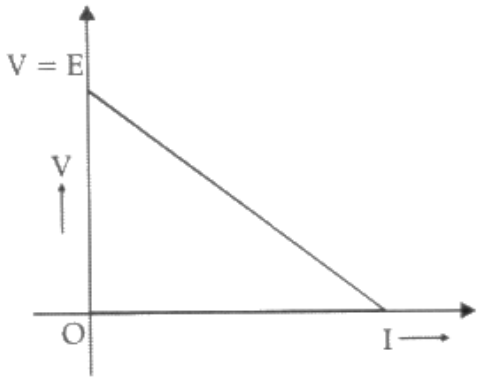
So Force =0

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)

From equation (i) and (ii),

4 + r = 4.5 + 0.5r

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

Using this value of r, we get,

E = 5V

23. The frequency of ultraviolet radiations is more while that of red light is less than the threshold frequency for a zinc surface, so ultraviolet radiations can cause the emission of electrons and red light cannot.

From Einstein's photoelectric equation, K.E. of a photoelectron is

$\frac{1}{2}mv^2 = h\nu - W_0 = h\nu - 0 = \frac{hc}{\lambda}$

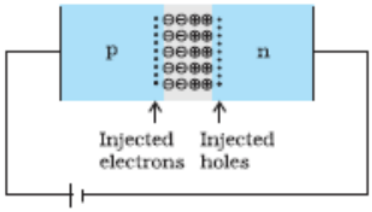
or $v = \sqrt{\frac{2hc}{m\lambda}}$

de Broglie wavelength of electrons,

$\lambda_e = \frac{h}{mv}$

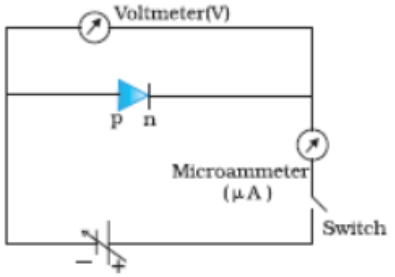
$= \frac{h}{m}\sqrt{\frac{m\lambda}{2hc}} = \sqrt{\frac{h\lambda}{2mc}}$

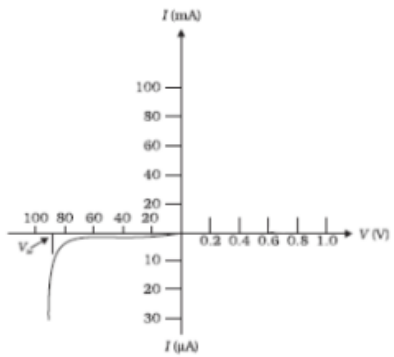
24. a.



During the formation of p - n junction diode; due to the concentration gradient across p and n sides of a diode, holes diffuse from p side to n side and electrons diffuse from n side to p side giving rise to development of immobile positive charges on the n side and the negative charges on the p side across the junction. Thus a potential barrier is formed at the junction.

b. The VI characteristics are obtained by connecting the battery, to the diode, through a potentiometer the battery, to the diode, through a (or, rheostat). The applied voltage to the diode is changed. The applied voltage to the diode is changed. The values of current, for different values of voltage, are noted and a graph between V and I is plotted. The V-I characteristics of a diode, have the form the form shown here.





25. Radius of nucleus is determined by Rutherford α–particle scattering experiment by using the concept of distance of closest approach.

The relation between radius and mass number of the nucleus is $R = R_0 A^{1/3}$

where, $R_0 = 1.1 \times 10^{-15}$ is the range of nuclear force, R = radius of nucleus and A = mass number

The expression for radius of nucleus can be used to compute the density of the nucleus. Let us find the density of the nucleus of an atom, whose mass number is A.

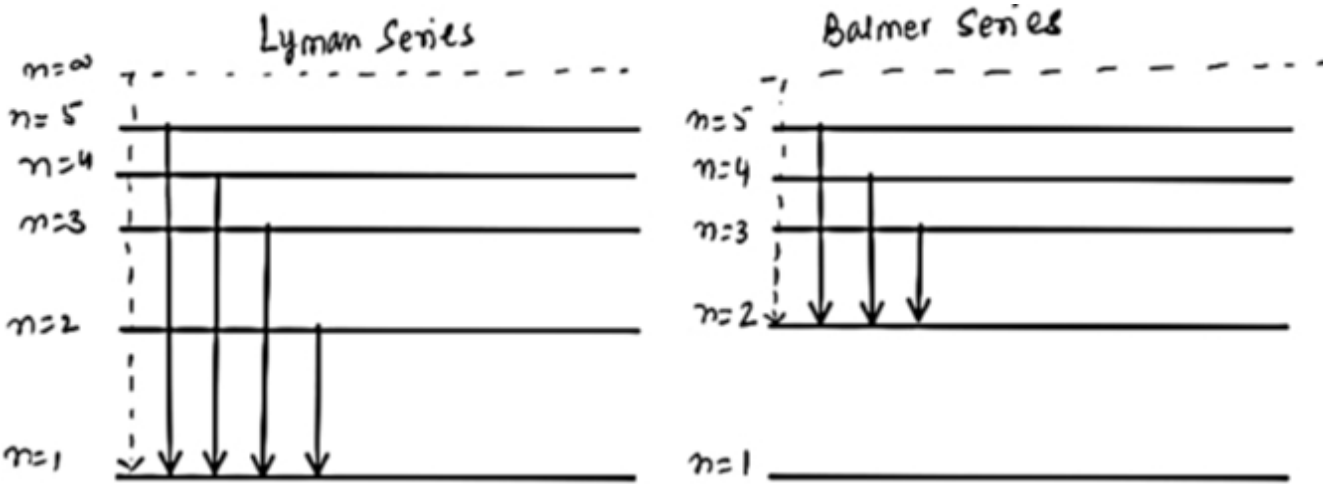
Now, Density of the nucleus, $\rho = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}} = \frac{mA}{\frac{4}{3}\pi\left(R_0 A^{1/3}\right)^3}$

$\rho = \frac{mA}{\frac{4}{3}\pi R_0^3 A} \Rightarrow \rho = \frac{m}{\frac{4}{3}\pi R_0^3}$

So as per above formula, density of nucleus does not depend on mass number of nucleus rather it is same for all the atoms and it is roughly in the order of 10^{17} kg/m^3 which is very large as compared to our everyday observed densities.

26. a. Transition result in Lyman series if electron will jump from a higher energy orbit to n = 1 orbit

Transition result in Balmer series if electron will jump from a higher energy orbit to n = 2 orbit



b. Longest wavelength in Lyman Series

$\frac{1}{\lambda_L} = R \cdot \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3R}{4}$

Shorted wavelength in Balmer Series

$\frac{1}{\lambda_S} = R\left[\frac{1}{{n_1}^2} - \frac{1}{n_2^2}\right] = R\left[\frac{1}{2^2} - \frac{1}{\infty}\right] = \frac{R}{4}$

Ratio $\frac{\lambda_2}{\lambda_S} = \frac{4}{3R} \times \frac{R}{4} = \frac{1}{3}$

27. 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

$\phi = \frac{\mu_0 NI}{l} \times$ 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 = $\frac{1}{2}LI_0^2$

OR

i. The magnetic flux through the rectangular loop abcd increases, due to the motion of the loop into the region of a magnetic field According to Lenz's law, this increase in flux is opposed by the induced current. The induced current must flow along the path bcdab so that it opposes the increasing flux.

ii. Due to the outward motion, magnetic flux through the triangular loop abc decreases due to which the induced current flows along bacd, so as to oppose the change in flux.

iii. As the magnetic flux decreases due to motion of the irregularly shaped loop abcd out of the region of the magnetic field, the induced current flows along cdabc, so as to oppose change in flux. Note that there is no induced current as long as the loops are completely inside or outside the region of the magnetic field.

28. i. Wavefront is the locus of all points in which light waves are in the same phase. The propagation of wave energy is perpendicular to the wavefront. Or A wavefront is defined as the continuous locus of all the particles which are vibrating in the same phase.

ii. The angular width of the central fringe = $\frac{2D\lambda}{a}$ where, a is the width of the slit. Hence if the width of the slit is made double, then fringe width becomes half. The intensity of the central fringe becomes four times. This is because the area of central diffraction band would become ($\frac{1}{4}$)th.

iii. This is because of diffraction. The diffraction of waves from the edges of the circular obstacle interferes constructively at the center of the shadow. It results in the formation of a bright spot at the center of the obstacle.

Section D

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

An electromagnetic wave transports linear momentum as it travels through space. If an electromagnetic wave transfers a total energy U to a surface in time t, then total linear momentum delivered to the surface is p = $\frac{U}{c}$. When an electromagnetic wave falls on a surface, it

exerts pressure on the surface. In 1903, the American scientists Nichols and Hull succeeded in measuring radiation pressures of visible light where other had failed, by making a detailed empirical analysis of the ubiquitous gas heating and ballistic effects.

(a) **(a)** $\frac{I}{c}$

Explanation:

Pressure exerted by an electromagnetic radiation, $P = \frac{I}{c}$

(b) **(a)** 6×10^{-4} N/m^2

Explanation:

$P_{\text{rad}} = \frac{\text{Energy flux}}{\text{Speed of light}} = \frac{18 \text{ W/cm}^2}{3 \times 10^8 \text{ m/s}}$

$= \frac{18 \times 10^4 \text{ W/m}^2}{3 \times 10^8 \text{ m/s}} = 6 \times 10^{-4}$ N/m^2

(c) **(c)** 0.166×10^{-8} N m^{-2}

Explanation:

$P = \frac{I}{c} = \frac{0.5}{3 \times 10^8} = 0.166 \times 10^{-8}$ N m^{-2}

(d) **(b)** 100

Explanation:

Intensity of EM wave is given by $I = \frac{P}{4\pi R^2}$ $V_{av} = \frac{1}{2}\varepsilon_0 E_0^2 \times c$

$\Rightarrow E_0 = \sqrt{\frac{P}{2\pi R^2 \varepsilon_0 c}} = \sqrt{\frac{1500}{2 \times 3.14 (3)^2 \times 8.85 \times 10^{-12} \times 3 \times 10^8}}$

$= \sqrt{10,000} = 100$ V m^{-1}

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

Slope of graph is proportional to Q

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

ii. U = - p E cosθ

$\theta = 0^o$

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

U = -6×10^{-3} J

iii. $\because$ Work done W= - p E (cosθ_2 - cosθ_1)

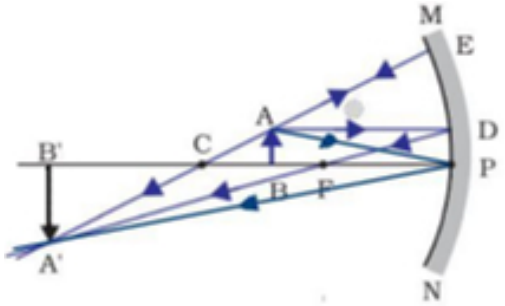
where $\theta_2 = 180^o$, $\theta_1 = 90^o$

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

W = +p E

Section E

31. i.



From $\triangle A'B'C' \sim \triangle DPF$

$\frac{B'A}{BA} = \frac{B'F}{FP}$ ($\because$ PD = AB) ...(i)

From $\triangle A'B'P \sim \triangle ABP$

$\frac{B'A'}{BA} = \frac{B'P}{BP}$ ...(ii)

Comparing equation (i) and (ii)

$\frac{B'F}{FP} = \frac{B'P-FP}{FP} = \frac{B'P}{BP}$

Here B'P = -v

FP = -f

BP = -u

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

$\frac{v-f}{f} = \frac{v}{u}$

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

On solving we get

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

ii. u = -30 cm

f = +12 cm

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

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

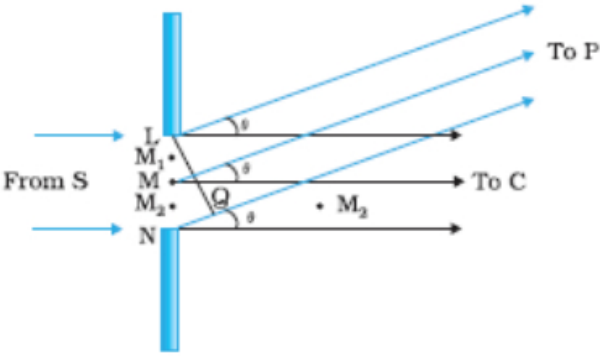
$\frac{1}{v} = \frac{1}{12} + \frac{1}{30} = \frac{7}{60}$

v = $\frac{60}{7}$ cm

Since v is positive image is virtual and erect and the position of is at $\frac{60}{7}$ cm in front of the mirror.

OR

a.



From diagram path difference between the waves from L and N = a sinθ

When first minimum is obtained at P then path difference = λ

[imagine the slit be divided into two halves, for each wavelets from first half of the slit has a corresponding wavelet from second half of the slit differing by a path of $\frac{\lambda}{2}$ and cancel each other]

Condition for first minimum

$\therefore \lambda = a \sin\theta$

b. $\beta_{cm} = \frac{2\lambda D}{d}$

i. As we know that wave length (λ) of red light is more than yellow light.

$\therefore \lambda_{red} > \lambda_{yellow}$

So, $\therefore \beta_{red} > \beta_{yellow}$

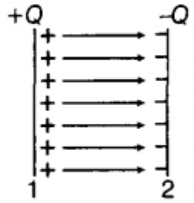
Hence, the linear width of the central maximum will increase if monochromatic yellow light is replaced with the red light.

ii. If the distance between the slit and screen (d) is increased then also the linear width of the central maximum will increase.

c. $10\frac{\lambda}{\mathrm{d}} = 2\frac{\lambda}{a}$

$\mathrm{a} = \frac{\mathrm{d}}{5}$ = 0.2 mm

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

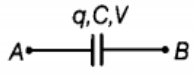
Using, $C = \frac{\varepsilon_0 A}{d}$ and V = Ed (Where V is the potential difference and E is the Electric field existing between the plates)

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 :

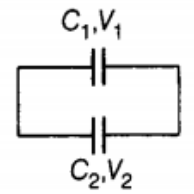
If we consider a charged capacitor of capacitance C with potential difference V, then its charge would be given, q = CV



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.

$\Rightarrow Q_1 = CV_1$ 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

i. A. A dielectric material gets polarized when it is placed in an external electric field. The field produced due to the polarization of material reduces the effect of external electric field. Hence, the electric field inside a dielectric decreases.

B. Electric field in vacuum between the plates = $E0 = \frac{\sigma}{\varepsilon_o}$

Electric field in dielectric between the plates, $E = \frac{E_0}{K}$

Potential difference between the capacitor plates

$V = Et + E_0(d - t)$

where 't' is the thickness of dielectric slab.

$V = \frac{E_0}{K}t + E_0(d - t)$

$V = \frac{\sigma}{\varepsilon_o}\left[\frac{t}{K} + (d - t)\right]$

$V = \frac{\sigma}{\varepsilon_o}\left[\frac{t + K(d-t)}{K}\right]$

As $C = \frac{Q}{V}$

$\Rightarrow C = \frac{\varepsilon_0 AK}{t + K(d-t)}$

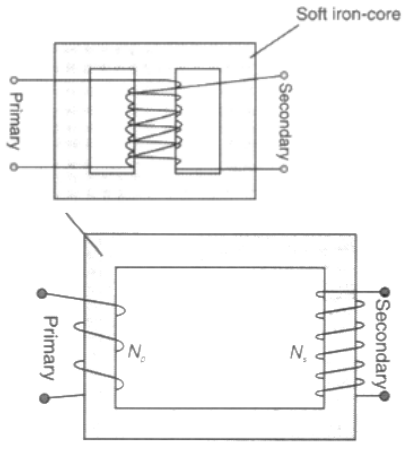
ii. The surface of the sphere is equipotential. So, the work done in moving the charge from one point to the other is zero.

$W = q\,\Delta V$ ($\because \Delta V = 0$)

$= 0$

iii. $P = \chi E$

33. i.



Principle: Step-down transformer is made up of two or more coil wound on the iron core of the transformer. It works on the principle of magnetic induction between the coils. When the current flowing through the primary coil changes, an emf is induced in the secondary coil due to the change in magnetic flux linked with it.

ii. $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

iii. For an ideal transformer,

$i_p V_p = i_s V_s$

$\therefore \frac{i_p}{i_s} = \frac{V_s}{V_p} = \frac{N_s}{N_p}$

iv. We have

$i_p V_p = i_s V_s = 550$ W

$V_p = 220$ V

$i_p = \frac{550}{220} = \frac{5}{2} = 2.5$ A

OR

i. Given $\varepsilon = 100 \sin 314$ t volt

As the current in a capacitor leads the voltage by 90°, so the instantaneous current is given by

$I = I_0 \sin(314t + 90^\circ) = I_0 \cos 314t$

where $I_0 = \frac{\varepsilon_0}{X_C} = \frac{\varepsilon_0}{1/\omega C} = \varepsilon_0 \omega C$

But $\varepsilon_0 = 100$ V, $\omega = 314$ rads^{-1}, C $= 637 \times 10^{-6}$ F

$\therefore I_0 = 100 \times 314 \times 637 \times 10^{-6} = 20$ A

Where $I_0 = \frac{\varepsilon_0}{X_C} = \frac{\varepsilon_0}{1/\omega C} = \varepsilon_0 \omega C$

But $\varepsilon_0 = 100$ V, $\omega = 314$ rad s^{-1}, $C = 637 \times 10^{-6}$ F

$\therefore I_0 = 100 \times 314 \times 637 \times 10^{-6} = 20$ A

Hence I = 20 cos 314 t ampere

ii. Instantaneous power,

$P = \varepsilon I = 100 \sin 314t \times 20 \cos 314t$

$= 1000 \sin 628$ t watt

iii. Angular frequency of power, $\omega_p = 628$ rads^{-1}

$\therefore$ Frequency of power, $f_p = \frac{\omega_p}{2\pi} = \frac{628}{2\pi} = 100$ Hz

iv. The maximum energy stored in the capacitor is

$U_0 = \frac{1}{2} C E_0^2 = \frac{1}{2} \times 637 \times 10^{-6} \times (100)^2$ = 3.185 J