Class XII Session 2025-26
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.

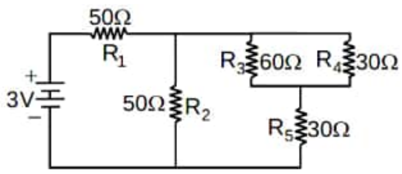
Section A

1. At which temperature, a pure semiconductor behaves slightly as a conductor? **[1]**

a) room temp. b) both low and room temp.

c) high temp. d) low temp.

2. In circuit shown below, the resistance are given in ohms and the battery is assumed ideal with emf equal to 3 volt. The voltage across the resistance R_4 is: **[1]**



a) 1.2 V b) 0.6 V

c) 0.4 V d) 1.5 V

3. Reflecting telescope utilizes **[1]**

a) Prism b) Convex mirror

c) Both Convex mirror and Concave mirror d) Concave mirror

4. A magnet is cut in three equal parts by cutting it perpendicular to its length. The time period of original magnet is T0 in a uniform magnetic field B. Then, the time period of each part in the same magnetic field is **[1]**

a) None of these | b) $\frac{T_o}{2}$
c) $\frac{T_o}{3}$ | d) $\frac{T_o}{4}$

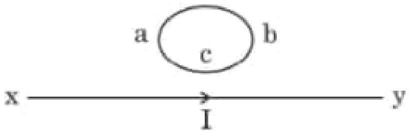
5. Capacitance of a conductor is $1\mu F$. What charge is required to raise its potential to 100 V? **[1]**

a) $200\mu C$
b) $50\mu C$
c) $100\mu C$
d) $150\mu C$

6. The magnetic force on a point charge is $\vec{F} = q(\vec{v} \times \vec{B})$, The dimensions of $\vec{B}$are: **[1]**
(Here q = electric charge, $\vec{v}$ = velocity of point charge, $\vec{B}$ = magnetic field)

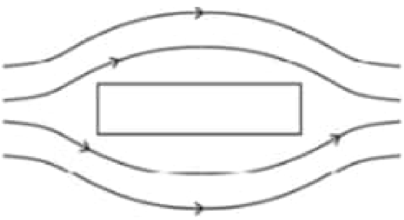
a) $[MT^{-2} A^{-1}]$
b) $[MLT^{-1}A]$
c) $[M^1L^2T^{-1}A^{-2}]$
d) $[M^2LT^{-2}A^{-1}]$

7. The direction of induced current in the loop abc is: **[1]**



a) along abc if I increases
b) along acb if I increases
c) along abc if I is constant
d) along abc if I decreases

8. The magnetic field lines near a substance are as shown in the figure. The substance is: **[1]**



a) Copper
b) Sodium
c) Iron
d) Aluminium

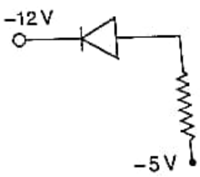
9. The intensity ratio of the maxima and minima in an interference pattern produced by two coherent sources of light is 9 : 1. The intensities of the used light sources are in the ratio: **[1]**

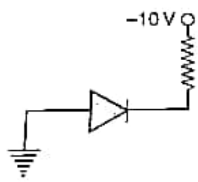
a) 3 : 1
b) 9 : 1
c) 10 : 1
d) 4 : 1

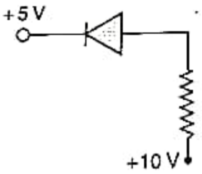
10. Consider a neutral conducting sphere. A positive point charge is placed outside the sphere. Then the net charge on the sphere is - **[1]**

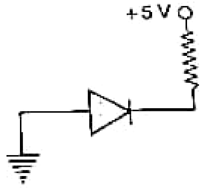
a) Negative and distributed non–uniformly over the entire surface of the sphere
b) Negative and appears only at the point on the sphere closest to the point charge
c) Negative and distributed uniformly over the surface of the sphere
d) Zero

11. In the following figures, which one of the diodes is reverse biased? **[1]**

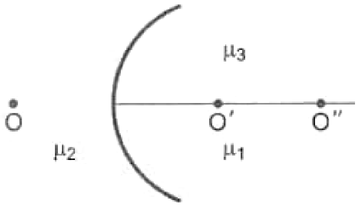
a) 

b) 

c) 

d) 

12. Figure shows three transparent media of refractive indices μ_1, μ_2 and μ_3. A point object O is placed in the medium μ_2. If the entire medium on the right of the spherical surface has refractive index μ_1, the image forms at O'. If this entire medium has refractive index μ_3, the image forms at O''. In the situation shown in the figure given ahead: **[1]**



a) the image forms to the right of O''

b) the image forms to the left of O'

c) the image forms between O' and O''

d) two images form, one at O' and the other at O''

13. **Assertion (A):** The de Broglie equation has significance for any microscopic or sub-microscopic particle. **[1]**
Reason (R): The de Broglie wavelength is inversely proportional to the mass of the object if velocity is constant.

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:** 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):** Thin films such as soap bubble or a thin layer of oil on water show beautiful colours when illuminated by monochromatic light. **[1]**
Reason (R): The colours are obtained by dispersion 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 but R is true.

16. **Assertion (A):** At resonance, the current becomes minimum in a series LCR circuit. **[1]**
Reason (R): At resonance, voltage and current are phase in a series LCR circuit.

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. Given: Wavelength of light in mercury is $5.5 \times 10^{-5} cm$. **[2]**

i. Calculate its frequency and period.

ii. What is the wavelength of the light in the glass, if the refractive index of glass is 1.5?

18. Find the percent increase in the magnetic field B when the space within a current-carrying toroid is filled with aluminium. The susceptibility of aluminium is 2.1×10^{-5}. **[2]**

OR

A magnetising field of 1500 A/m produces a magnetic flux of 2.4×10^{-5} weber in a bar of iron of crosssection 0.5 cm^2. Calculate permeability and susceptibility of the iron-bar used.

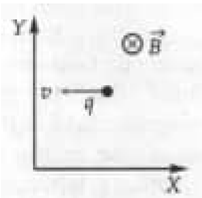
19. A potential barrier of 0.60 V exists across a p-n junction, **[2]**

i. If the depletion region is 6.0×10^{-7} m thick, what is the intensity of the electric field in this region?

ii. If an electron with speed 5.0×10^{5} ms^{-1} approaches the p-n junction from the n-side, with what speed will it enter the p-side?

20. Suppose you are given a chance to repeat the alpha particle scattering experiment using a thin sheet of solid hydrogen in place of the gold foil. (Hydrogen is a solid at temperatures below 14 K). What results do you expect? **[2]**

21. a. A point charge q moving with speed v v enters a uniform magnetic field B that is acting into the plane of the paper as shown. What is the path followed by the charge q and in which plane does it move? **[2]**

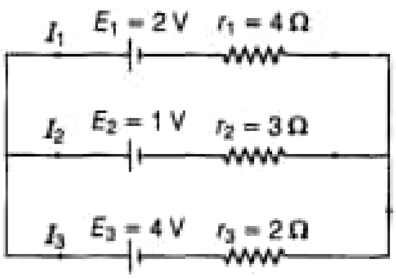


b. How does the path followed by the charge get affected if its velocity has a component parallel to B?

c. If an electric $\vec{E}$ is also applied such that the particle continues moving along the original straight line path, what would be the magnitude and direction of the electric field $\vec{E}$?

Section C

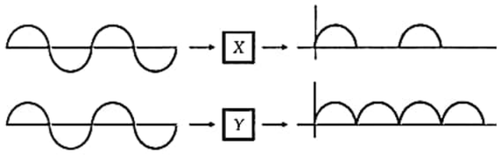
22. State Kirchhoff's rules. Use these rules to write the expressions for the currents I_1, I_2 and I_3 in the circuit diagram shown in figure below. **[3]**



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

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

24. An a.c. the signal is fed into two circuits X and Y and the corresponding output in the two cases have the waveforms shown in the figure. Name the circuits X and Y. Also draw their detailed circuit diagrams. **[3]**



25. Describe how Chadwick discovered neutrons. Is neutron a stable particle when isolated? **[3]**

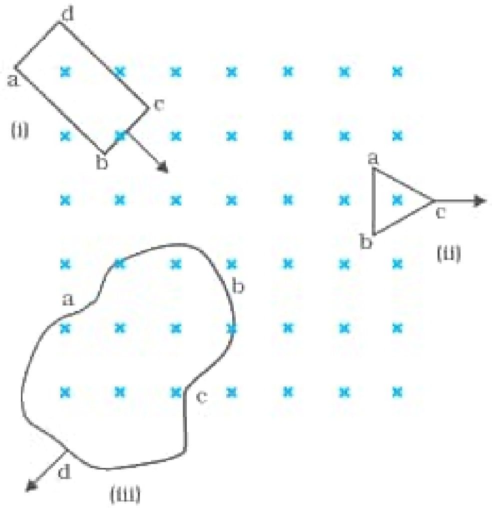
26. The energy of a hydrogen atom in the first excited state is -3.4 eV. Find: **[3]**

a. the radius of this orbit. (Take Bohr radius = 0.53 $\overset{\circ}{A}$)
b. the angular momentum of the electron in the orbit.
c. the kinetic and potential energy of the electron in the orbit.

27. Answer the following questions: **[3]**

a. In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band?
b. How is the width of the central maximum changed when red light is replaced by blue?
c. In what way is diffraction from each slit related to the interference pattern in a double slit experiment?

28. 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. **[3]**



OR

Define the term mutual inductance between the two coils. Obtain the expression for mutual inductance of a pair of long co-axial solenoids each of length l and radii r_1 and r_2 ($r_2 >> r_1$). The total number of turns in the two solenoids are N_1 and N_2 respectively.

Section D

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

All the known radiations from a big family of electromagnetic waves which stretch over a large range of wavelengths. Electromagnetic wave include radio waves, microwaves, visible light waves, infrared rays, UV rays, X-rays and gamma rays. The orderly distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum.

(a) Which wavelength of the Sun is used finally as electric energy?
radio waves, infrared waves, visible light, microwaves

a) infrared waves
b) radio waves
c) microwaves
d) visible light

(b) Which of the following electromagnetic radiations have the longest wavelength?

X-rays, γ-rays, microwaves, radiowaves

a) γ-rays
b) X-rays
c) microwaves
d) radiowaves

(c) Which one of the following is not electromagnetic in nature?

X-rays, gamma rays, cathode rays, infrared rays

a) infrared rays
b) gamma rays
c) cathode rays
d) X-rays

OR

The decreasing order of wavelength of infrared, microwave, ultraviolet and gamma rays is

a) microwave, gamma rays, infrared, ultraviolet
b) infrared, microwave, ultraviolet, gamma rays.
c) gamma rays, ultraviolet, infrared, microwave
d) microwave, infrared, ultraviolet, gamma rays

(d) Which of the following has minimum wavelength?

X-rays, ultraviolet rays, γ-rays, cosmic rays

a) ultraviolet rays
b) X-rays
c) cosmic rays
d) γ-rays

30. The smallest charge that can exist in nature is the charge of an electron. During friction, it is only the transfer of electrons that makes the body charged. Hence net charge on anybody is an integral multiple of the charge of an electron [1.6×10^{-19} C] i.e. **[4]**

q = $\pm$ne

where n = 1, 2, 3, 4,...

Hence nobody can have a charge represented as 1.1e, 2.7e, $\frac{3}{5}$e, etc.

Recently, it has been discovered that elementary particles such as protons or neutrons are composed of more elemental units called quarks.

i. Find the number of electrons if the body has 3.2×10^{-18} C of charge.
ii. If a charge on a body is 1 nC, then how many electrons are present on the body?
iii. If a body gives out 10^9 electrons every second, how much time is required to get a total charge of 1 C from it?
iv. A polythene piece rubbed with wool is found to have a negative charge of 3.2×10^{-7} C. Calculate the number of electrons transferred.

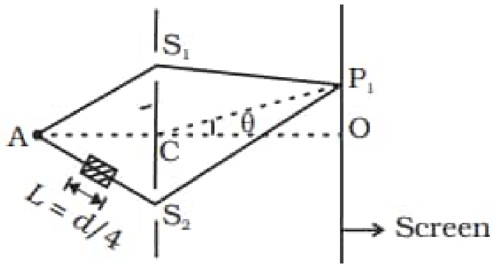
Section E

31. i. A coin is placed inside a denser medium. Why does it appear to be raised? Obtain an expression for the height through which the object appears to be raised in terms of refractive index of the medium and real depth. **[5]**

ii. A compound microscope consists of an objective lens of focal length 2 cm and an eyepiece of focal length 6.25 cm separated by a distance of 15 cm. How far from the objective should an object be placed in order to obtain the final image at the least distance of distinct vision (25 cm)? Calculate the magnifying power of the microscope.

OR

A small transparent slab containing material of μ = 1.5 is placed along AS_2 (Figure). What will be the distance from O of the principal maxima and of the first minima on either side of the principal maxima obtained in the absence of the glass slab?



AC = CO = D, $S_1C = S_2C = d << D$

32. i. Obtain an expression for the potential energy of an electric dipole placed in a uniform electric field. **[5]**

ii. Three capacitors of capacitance C_1, C_2 and C_3 are connected in series to a source of V volt. Show that the total energy stored in the combination of capacitors is equal to sum of the energy stored in individual capacitors.

iii. A capacitor of capacitance C is connected across a battery. After charging, the battery is disconnected and the separation between the plates is doubled. How will (i) the capacitance of the capacitor, and (ii) the electric field between the plates be affected? Justify your answer.

OR

a. Derive the expression for the electric potential due to an electric dipole at a point on its axial line.

b. Depict the equipotential surfaces due to an electric dipole.

33. A small town with a demand of 800 kW of electric power at 220 V is situated 15 km away from an electric plant generating power at 440 V. The resistance of the two wirelines carrying power is 0.5 Ω per km. The town gets power from the line through a 4000 - 220 V step-down transformer at a sub-station in the town. **[5]**

a. Estimate the line power loss in the form of heat.

b. How much power must the plant supply, assuming there is negligible power loss due to leakage?

c. Characterize the step-up transformer at the plant.

OR

i. With the help of a labelled diagram, describe the principle and working of an ac generator. Hence, obtain an expression for the instantaneous value of the emf generated.

ii. The coil of an ac generator consists of 100 turns of wire, each of area 0.5 m^2. The resistance of the wire is 100 Ω. The coil is rotating in a magnetic field of 0.8 T perpendicular to its axis of rotation, at a constant angular speed of 60 radian per second. Calculate the maximum emf generated and power dissipated in the coil.

Solution

Section A

1.

(c) high temp.

Explanation:

A pure semiconductor behaves slightly as a conductor at high temperatures.

2.

(c) 0.4 V

Explanation:

To find the voltage across the resistor R_4, we need to analyze the circuit using Ohm's Law and the principles of series and parallel circuits. Assuming the resistors are arranged in a way that allows us to calculate the total resistance and the current flowing through the circuit, we can determine the voltage drop across R_4. If the total current flowing through the circuit is calculated, we can then use the formula $V = I \times R$ to find the voltage across R_4. Given the options, if the calculations lead to a voltage of 0.4 V across R_4, it indicates that the current and resistance values were correctly applied in the calculations. Thus, the solution provided is correct based on the analysis of the circuit.

3.

(d) Concave mirror

Explanation:

Concave mirror

4.

(c) $\frac{T_o}{3}$

Explanation:

Initial time period of magnet

$T_0 \ = 2\pi\sqrt{\frac{\mathrm{I}}{\mathrm{MB}}}$

I - moment of inertia of bar magnet

M- magnetic moment of bar magnet

when the magnet is cut into three equal pieces the magnetic moment of each piece of magnet becomes =$M' = \frac{\mathrm{M}}{3}$

New moment of inertia of each magnet = $I' = \frac{\mathrm{I}}{3^3} = \frac{I}{27}$

New time period of magnet is

$T' = 2\pi\sqrt{\frac{\mathrm{I}'}{\mathrm{M}'\mathrm{B}}} = 2\pi\sqrt{\frac{\mathrm{I}/27}{(\mathrm{M}/3)\mathrm{B}}}$

$T' = \frac{T_0}{3}$

5.

(c) $100\mu C$

Explanation:

The capacitance C of a conductor is given as $1\mu F$ (microfarad), which is equal to $1 \times 10^{-6} F$. The potential V is given as $100V$. The relationship between charge Q, capacitance C, and potential V is described by the formula: $Q = C \times V$

Substituting the values: $Q = (1 \times 10^{-6} F) \times (100V) = 1 \times 10^{-4} C$ Converting $1 \times 10^{-4} C$ to microcoulombs:

$1 \times 10^{-4} C = 100\mu C$

Thus, the charge required to raise the potential to 100 V is $100\mu C$.

6. **(a)** $[MT^{-2} A^{-1}]$

Explanation:

$F = qvB\sin\theta$ or $B = \frac{F}{qv\sin\theta}$

$\therefore \quad [B] = \frac{MLT^{-2}}{AT \cdot LT^{-1}} = \left[MT^{-2}A^{-1}\right]$

7. **(a)** along abc if I increases

Explanation:

In accordance with Lenz law.

8. **(a)** Copper

Explanation:

Magnetic field lines are repelled by diamagnetic substances and Copper is diamagnetic substance.

9.

(d) 4 : 1

Explanation:

$\frac{I_{\max}}{I_{\min}} = \left(\frac{r+1}{r-1}\right)^2 = \frac{9}{1}$

$\Rightarrow \frac{r+1}{r-1}$ = 3

$\Rightarrow$ r + 1 = 3r - 3

$\Rightarrow$ r = 2

$\therefore \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$ = r^2 = 4 : 1

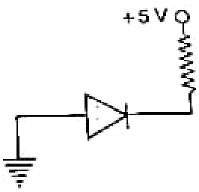
10.

(d) Zero

Explanation:

If a charge +q is placed outside, then the electric field lines incident on the conducting sphere induces -q charge on one surface whereas the opposite surface becomes oppositely charged (i.e. +q) and the total charge becomes zero.

11.

(d) 

Explanation:

The p-n junction is said to be reverse biased, when the positive terminal of the external battery in the circuit is connected to n-section and the negative terminal to p-section of the junction diode.

12.

(d) two images form, one at O' and the other at O''

Explanation:

two images form, one at O' and the other at O''

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

Explanation:

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

For constant v, $\lambda \propto \frac{1}{m}$

λ is significantly measurable only in case of microscopic or sub-microscopic particles.

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.

(d) A is false but R is true.

Explanation:

The beautiful colours are seen on account of interference of light reflected from the upper and lower surfaces of the thin film. As the conditions for constructive and destructive interference are dependent on wavelength of light, therefore, coloured interference fringes are observed.

16.

(d) A is false but R is true.

Explanation:

At resonance, $X_L = X_C$, so the circuit impedance becomes minimum and resistive and hence the current becomes maximum. So, the assertion is false.

At resonance, $X_L = X_C$, so the circuit impedance becomes resistive. In resistive circuit voltage and current are always in same phase. Hence, reason is true.

Section B

17. Given: Wavelength, $\lambda = 5.5\times10^{-5}$ cm = 5.5×10^{-7} m

1. Frequency, $\nu = \frac{c}{\lambda} = \frac{3\times10^8 m/s}{5.5\times10^{-7} m}$ = 5.45×10^{14} Hz $= 5.45 \times 10^8 MHz$

   Time period, $T = \frac{1}{\nu}$ = $\frac{1}{5.45\times10^8} = 1.83 \times 10^{-9} \mu s$
2. Wavelength of the light in the glass, λ_g = $\frac{\lambda}{\mu}$ = $\frac{5.5\times10^{-7}}{1.5}$ = 3.67×10^{-7} m

18. In the absence of aluminium,

$B_0 = \mu_0 H$

In the presence of aluminium,

$B = \mu H = \mu_0 (1 + \chi_m) H$

Increase in magnetic field induction

$= B - B_0 = \mu_0 \chi_m H$

Percentage increase = $\frac{B-B_0}{B_0} \times 100$

$= \frac{\mu_0 \chi_m H}{\mu_0 H} \times 100$

$= 2.1 \times 10^{-5} \times 100 = 2.1 \times 10^{-3}$

OR

Here $H = 1500$ Am^{-1}, $\phi = 2.4 \times 10^{-5}$ Wb, $A = 0.5 \times 10^{-4}$ m^2

Magnetic induction,

$B = \frac{\phi}{A} = \frac{2.4\times10^{-5}}{0.5\times10^{-4}}$ = 0.48 Wbm^{-2}

Permeability,

$\mu = \frac{B}{H} = \frac{0.48}{1500}$ = 3.2×10^{-4} TmA^{-1}

As $\mu = \mu_0 (1 + \chi_m)$

$\therefore$ Susceptibility,

$\chi_m = \frac{\mu}{\mu_0} - 1 = \frac{3.2\times10^{-4}}{4\times3.14\times10^{-7}} - 1$

= 254.77 - 1 = 253.77

19. Electric field, $E = \frac{v}{d} = \frac{0.60}{6.0\times10^{-7}}$

$= 1.0 \times 10^6$ Vm^{-1}

Let v_1 = velocity of the electron when enters the depletion layer. V_2 be the velocity of the electron emerging out of the depletion layer. Barrier voltage,

V = 0.60V, $v_1 = 5.0 \times 10^5$ m/s According to Principle of conservation of energy

$\frac{1}{2} m v_1^2 = eV + \frac{1}{2} m v_2^2$

or $\frac{1}{2} \times \left(9.1 \times 10^{-31}\right) \times \left(5.0 \times 10^5\right)^2$

$= (1.6 \times 10^{-19}) \times 0.6 + \frac{1}{2} \times \left(9.1 \times 10^{-31}\right) \times v_2^2$

or $1.375 \times 10^{-19} = 0.96 \times 10^{-19} + 4.55 \times 10^{-31} v_2^2$

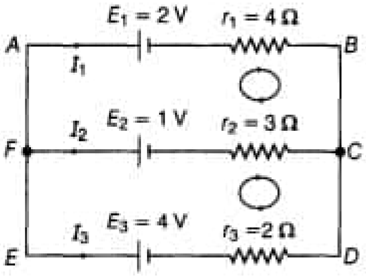
On solving, we get,

$v^2 = 1.975 \times 10^5$ ms^{-1}

20. The nucleus of a hydrogen atom is a proton (mass $1.67 \times 10^{-27} kg$) which has only about one-fourth of the mass of an alpha particle $(6.64 \times 10^{-27} kg)$. Because the alpha particle is more massive, it won't bounce back in even a head on collision with a proton. It is like a bowling ball colliding with a ping pong ball at rest. Thus, there would be no large angle scattering in this case. In Rutherford's experiment, by contrast, there was large angle scattering because a gold nucleus is more massive than an alpha particle. The analogy there is a ping pong ball hitting a bowling ball at rest.
21. a. The charge q moves in the XY plane describing a circular path in the anticlockwise sense.
    b. The path of the charged particle will become helical.
    c. By Fleming's left hand rule, the magnetic Lorentz force acts on charge q in -Y direction
    ∴Applied electric field should be in the + Y direction to make the charged particle move along the original straight line path.
    $F_e = F_m$
    $qE = qvB \sin 90°$ or $E = vB$

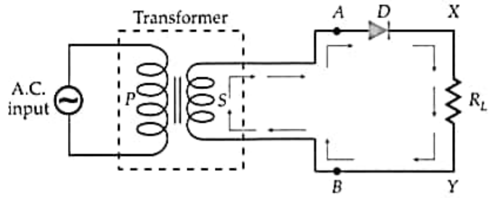
Section C

22. **Kirchhoff's first rule:** The algebraic sum of the electric currents at any junction of electric circuit is equal to zero, i.e. the sum of current entering into a junction is equal to the sum of current leaving the junction.
    $\Rightarrow \quad \Sigma I = 0$
    Kirchhoffs second rule or loop rule In any closed mesh of electrical circuit, the algebraic sum of emfs of cells and the product of currents and resistances is always equal to zero.
    i.e. $\Sigma E + \Sigma IR = 0$

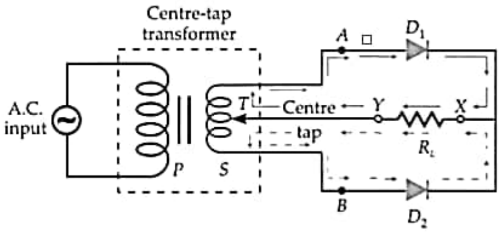
    For given circuit,
    

    At, F, applying junction rule,
    $I_3 = I_1 + I_2$ ...(i)
    In mesh ABCFA,
    $-2 - 4I_1 + 3I_2 + 1 = 0$
    $4I_1 - 3I_2 = -1$ ...(ii)
    In mesh FCDEF,
    $-1 - 3I_2 - 2I_3 + 4 = 0$
    $3I_2 + 2I_3 = 3$
    On solving, I_1, I_2 and I_3, we get
    $I_1 = \frac{2}{13} A, \quad I_2 = \frac{7}{13} A$
    and $I_3 = \frac{9}{13} A$
    Thus by using KCL & KVL, we can calculate the values of current flowing in each branch.
23. a. Purpose of Davisson Germer Experiment was to verify the wave nature of electron. It confirms the de Broglie relations for matter waves / Diffraction effect of electron beams from crystal
    b. de Broglie wavelength
    $\lambda = \frac{\mathrm{h}}{\sqrt{2\mathrm{mqV}}}$
    $\therefore \frac{\mathrm{h}}{\sqrt{2\,\mathrm{m}_p \mathrm{eV_p}}} = \frac{\mathrm{h}}{\sqrt{2\,\mathrm{m}_\alpha \mathrm{eV}_\alpha}}$
    $\therefore \frac{\mathrm{V_p}}{\mathrm{V\alpha}} = \frac{8}{1}$
24. we know that A half-wave rectifier **converts an AC signal to DC by passing either the negative or positive half-cycle of the waveform and blocking the other**. A *full wave rectifier* is defined as a rectifier that converts the complete cycle of alternating current into pulsating DC

Here, X, is a half-wave rectifier and Y is a full-wave rectifier.

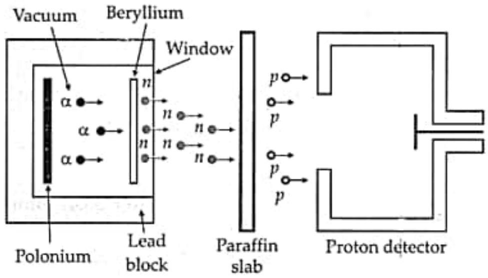


Half-wave rectifier circuit.



Full wave rectifier circuit.

25. The neutrons were discovered by James Chadwick in 1932. He was awarded the 1935 Nobel prize for physics for this discovery.



Experimental set up used by Chadwick to discover neutrons.

In 1932, Chadwick performed an experiment in which α -particles from a radioactive Polonium source were used to bombard beryllium nuclei. Highly penetrating rays were found to come out of the beryllium metal, which could not be deflected by electric and magnetic fields. These radiations were used to bombard hydrocarbons like paraffin wax. High energy protons were knocked out from the paraffin wax. The energy of the ejected protons was found to be too high to be accounted for y-ray photons By using the laws of conservation of energy and momentum, Chadwick concluded that the penetrating radiation consisted of neutral particles, each having a mass nearly that of a proton. These particles were called neutrons.

A free or isolated neutron is unstable because A free neutron spontaneously decays into a proton, electron and antineutron.

26. Energy E = -3.4eV
    a. $r = \frac{ke^2}{2E}$ as PE = 2 × E
    $r = \frac{9\times10^9\times(1.6\times10^{-19})^2}{2\times3.4\times1.6\times10^{-19}}$
    r = 2.11 × 10^{-10} m
    b. $L = \frac{nh}{2\pi}$
    $E = -\frac{13.6}{n^2}$
    $-3.4 = \frac{-13.6}{n^2}$
    n = 2
    $L = \frac{2\times6.63\times10^{-34}}{2\times\pi}$
    L = 2.11 × 10^{-34} js
    c. KE = -E = 3.4 eV
    PE = 2 × E = -2 × 3.4
    = -6.8 eV
27. a. When width is doubled, then $\frac{\lambda}{a}$ reduces to half hence size of the central maximum will get halved and intensity of central maximum will become 4 times.
    b. For red light width will be maximum because
    $\beta = \frac{2\lambda D}{a}$
    Wave length of blue is small as compared to red so width will be less when red is replaced by blue.

c. Interference pattern is observed by superposing two waves originating from the two narrow slits. The diffraction pattern is a superposition of a continuous family of waves originating from each point on a single slit.

28. 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.

OR

A coil B kept near another coil A has magnetic flux passing through it when kept near coil A. The ratio of magnetic flux through the coil B to the current in the coil A is called as mutual inductance of coils. or **Mutual Inductance** is the interaction of one coils magnetic field on another coil as it induces a voltage in the adjacent coil

$M_{12} = \frac{\phi_2}{i}$

Let S_1 carries a current i.

Magnetic field inside S_1 will be $B = \frac{\mu_o N_1 i}{l}$

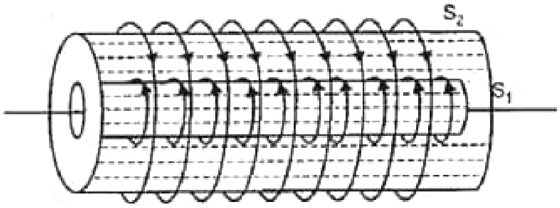
Flux through each turn of S_2 is $\phi = B \times \pi r_2^2$

$\phi = \frac{\mu_o N_1 \pi r_2^2 i N_2}{l}$

Flux through each turn of S_2 is $\phi_B = \phi N_2$

$\phi_B = \frac{\mu_o N_1 \pi r_2^2 i N_2}{l}$

$M = \frac{\phi_B}{i} = \frac{\mu_o N_1 N_2 \pi r_2^2}{l}$



Section D

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

All the known radiations from a big family of electromagnetic waves which stretch over a large range of wavelengths. Electromagnetic wave include radio waves, microwaves, visible light waves, infrared rays, UV rays, X-rays and gamma rays. The orderly distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum.

(i) **(a)** infrared waves

Explanation:

Infrared rays can be converted into electric energy as in solar cell.

(ii) **(d)** radiowaves

Explanation:

Radiowaves have longest wavelength.

(iii) **(c)** cathode rays

Explanation:

Cathode rays are invisible fast moving streams of electrons emitted by the cathode of a discharge tube which is maintained at a pressure of about 0.01 mm of mercury.

OR

(d) microwave, infrared, ultraviolet, gamma rays

Explanation:

$\lambda_{micro} > \lambda_{infra} > \lambda_{ultra} > \lambda_{gamma}$

(iv) **(d)** γ-rays

Explanation:

γ-rays have minimum wavelength.

30. i. From, q = ne, n = $\frac{q}{e} = \frac{3.2\times10^{-18}}{1.6\times10^{-19}}$ = 20

Hence, the number of electrons on the body is 20.

ii. Charge on the body is q = ne

$\therefore$ No. of electrons present on the body is n = $\frac{q}{e} = \frac{1\times10^{-9}\text{C}}{1.6\times10^{-19}\text{C}}$ = 6.25 $\times$ 10^9

iii. Here, n = 10^9 electrons per second

The charge given per second, q = ne = $10^9 \times 1.6 \times 10^{-19}$ C

q = 1.6 $\times$ 19^{-10} C

Total charge, Q = 1 C ...(given)

$\therefore$ Time required = $\frac{Q}{q} = \frac{1}{1.6\times10^{-10}}s$ = 6.25 $\times$ 10^9 s

$\therefore \frac{6.25\times10^{9}}{3600\times24\times365}$year = 198.19 years

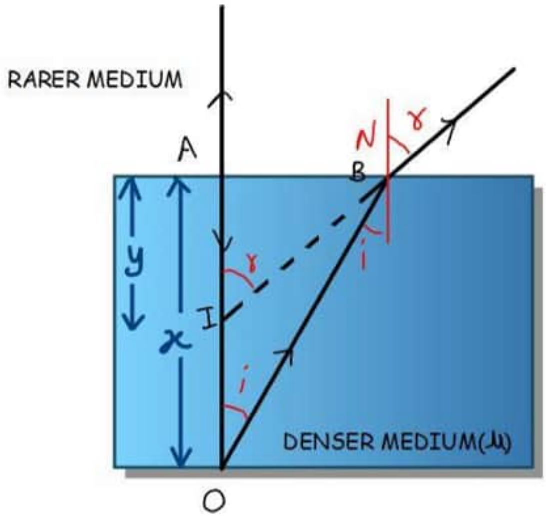
iv. As q = ne, n = $\frac{3.2\times10^{-7}}{1.6\times10^{-19}}$

$\Rightarrow$ n = 2 $\times$ 10^{12} electrons

$\therefore$ the number of electrons transferred will be 2 $\times$ 10^{12}

Section E

31. i. Due to refraction of light



In $\triangle$OAB,

sin i = $\frac{AB}{OB}$

In $\triangle$IAB, sin r = $\frac{AB}{IB}$

According to Snell's law

$\frac{1}{\mu}$ = $\frac{\sin i}{\sin r}$ = $\frac{IB}{OB}$ When angles are small, OB $\approx$ OA and IB $\approx$ IA

μ = $\frac{OA}{IA}$ = $\frac{x}{y}$

Height through which object is raised = x - y

= x - $\frac{x}{\mu}$

= x $\left(1-\frac{1}{\mu}\right)$

ii. f_0 = 2 cm

f_e = 6.25 cm

L = v_0 + $|u_e|$ = 15 cm

v_e = -25 cm

$\frac{1}{V_e} - \frac{1}{u_e} = \frac{1}{f_e}$;

$\frac{1}{-25}$ - $\frac{1}{u_e}$ = $\frac{1}{6.25}$

u_e = -5 cm

Now, L = v_0 + |-5| = 15 cm

V_o = 10 cm

Now, $\frac{1}{f_o} = \frac{1}{V_o} - \frac{1}{u_o}$

u_0 = 2.5 cm

MP = $\frac{V_o}{u_o}\left[1+\frac{D}{f_o}\right]$

= -20

OR

As is clear from figure and difference between waves reaching P_1 from A is

$= 2d\sin\theta + (u-1)l$

For principal maximum, path difference = 0

i.e., $2d\sin\theta + (\mu-1)l = 0$

2d $= \sin\theta + (1.5-1)\frac{d}{4} = 0, \sin\theta = \frac{-1}{16}$

$\therefore OP_1 = (CO)\tan\theta \cong D\left(-\frac{1}{16}\right)$

For the first minimum, an angle θ_1, say,

path difference $= 2d\sin\theta_1 + 0.5l = \pm\lambda/2$

$\sin\theta_1 = \frac{\pm\lambda/2-0.5l}{2d}$

As diffraction occurs when d = λ,

$\therefore \sin\theta_1 = \frac{\pm\lambda/2-\lambda/8}{2\lambda} = \pm\frac{1}{4} - \frac{1}{16}$

on the positive side, $\sin\theta_1 = +\frac{1}{4} - \frac{1}{16} = \frac{3}{16}$, on the negative side,

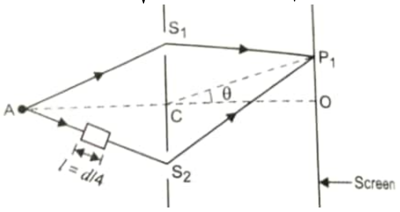
$\sin\theta_1' = -\frac{1}{4} - \frac{1}{16} = \frac{-5}{16}$

The first principal maximum on the positive side is at distance (above O)

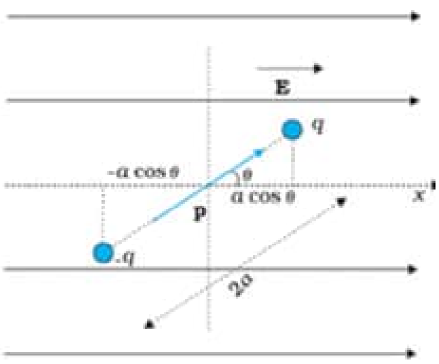
= D than $\theta_1 = D\frac{\sin\theta_1}{\sqrt{1-\sin^2\theta_1}} = \frac{D.3/16}{\sqrt{1-9/256}} = \frac{3D}{\sqrt{16^2-3^2}}$

On the negative side, the distance of first principal maximum (below O) will be

$= D\theta_1' = D\frac{\sin\theta_1'}{\sqrt{1-\sin^2\theta_1}} = \frac{D(-5/16)}{\sqrt{1-(5/16)^2}} = \frac{-5D}{\sqrt{16^2-5^2}}$



32. i.



Consider a dipole with charges q1 = +q and q2 = -q is placed in a uniform electric field E, as shown in Fig The dipole experiences no net force; but experiences a torque $\boldsymbol{\tau}$ given by $\boldsymbol{\tau}$ = p × E

which will tend to rotate it (unless p is parallel or antiparallel to E). Suppose an external torque $\boldsymbol{\tau}_{ext}$ is applied in such a manner that it just neutralizes this torque and rotates it in the plane of paper from angle θ_o to angle θ_1 at an infinitesimal angular speed and without angular acceleration. The amount of work done by the external torque will be given by

W = $\int_{\theta_0}^{\theta_1} \tau_{\text{ext}}(\theta)d\theta$ = $\int_{\theta_0}^{\theta_1} pE\sin\theta d\theta$

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

ii. U = $\frac{1}{2}\frac{Q^2}{C_{\text{eff}}}$

$\frac{1}{C_{\text{eff}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

$U = \frac{1}{2}\frac{Q^2}{C_1} + \frac{1}{2}\frac{Q^2}{C_2} + \frac{1}{2}\frac{Q^2}{C_3}$

$U = U_1 + U_2 + U_3$

iii. When battery is disconnected then charge (q) remains constant.

Capacitance is halved

$C' = \frac{\varepsilon_o A}{2d} = \frac{C}{2}$

Electric field (E) is unaffected.

$E = \frac{\sigma}{\varepsilon} = \frac{q}{\varepsilon_o A}$

Alternatively for effect on electric field.

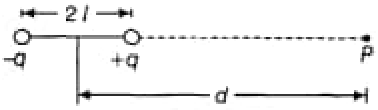
$E = \frac{V}{d}$

$V' = \frac{Q}{C'} = \frac{Q}{\frac{C}{2}} = 2V$

$E' = \frac{V'}{d'} = \frac{2V}{2d} = \frac{V}{d} = E$

OR

a. Let electric potential is to be determined at a point P lying on the axis of an electric dipole of dipole length 2l at a distance d from the centre of the dipole as shown in the figure.



Potential at P due to +q charge of the dipole $= \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(d-l)}$

Potential at P due to -q charge of the dipole

$= \frac{1}{4\pi\varepsilon_0}\frac{-q}{(d+l)}$

Total potential at P due to both the charges of the dipole

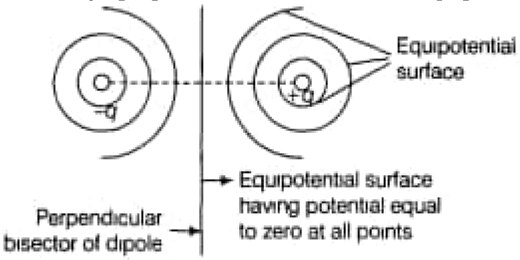
$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(d-l)} - \frac{1}{(d+l)}\right]$

$= q \times \frac{2l}{4\pi\varepsilon_0} \times \frac{1}{\left(d^2-l^2\right)} = \frac{p}{4\pi\varepsilon_0} \times \frac{1}{\left(d^2-l^2\right)}$

where, the scalar value of dipole moment (p) = q × 2l

If l << d, then neglecting l^2 we get, the final value of the electric potential to be, $V = \frac{1}{4\pi\varepsilon_0}\frac{p}{d^2}$

b. An electric dipole consists of two equal and opposite charges separated by some distance. Equipotential lines and electric field are always perpendicular to each other. Equipotential surfaces of a dipole are as shown below:



Potential of points lying on the perpendicular bisector surface will be zero.

33. Total electric power required,

Supply voltage, V = 220 V

The voltage at which electric plant is generating power, V' = 440 V

Distance between the town and power generating station, d = 15 km

The resistance of the two-wire lines carrying power = 0.5 Ω/km

Total resistance of the wires, R = (15 + 15) 0.5 = 15 Ω

A step-down transformer of rating 4000 - 220 V is used in the sub-station.

Input voltage is , V_1 = 4000 V

Output voltage is, V_2 = 220 V

Rms current in the wire lines is given as:

$I = \frac{P}{V_1}$

$= \frac{800 \times 10^3}{4000}$ = 200 A

a. Line power loss in the form of heat is given by = I^2R

= $(200)^2 \times 15$

= 600×10^3 W

= 600 KW

b. Assuming that the power loss is negligible due to the leakage of the current:

hence Total power supplied by the plant = 800 KW + 600 KW

= 1400 KW

c. Voltage drop in the power line is given by = IR = 200×15 = 3000 V

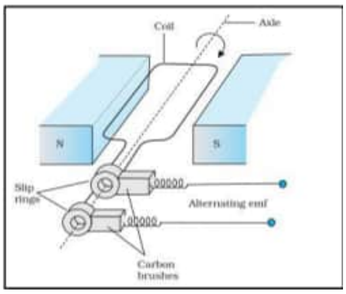
Hence, total voltage transmitted by the plant = 3000 + 4000

= 7000 V

Hence, the rating of the step-up transformer situated at the power plant is 440 V - 7000 V.

OR

i. Diagram



Principle - It is based on the principle of electromagnetic induction. Whenever there is a change in magnetic flux linked with a coil , an emf is induced in the coil.

Working - When a rectangular coil is rotated in a magnetic field, the magnetic flux changes continuously which induces an emf and the direction of current changes periodically.

$\varepsilon = \frac{-Nd\phi}{dt}$

$= -NBA\frac{d}{dt}(\cos\omega t)$

$\varepsilon = NBA\omega\sin\omega t$

ii. $\varepsilon = NBA\omega$

= $100 \times 0.8 \times 0.5 \times 60$

= 2400 V

hence, the maximum emf generated will be 2400 V.

Power dissipated, P = $\frac{\varepsilon_{rms}^2}{R}$

$= \frac{\left(\frac{2400}{\sqrt{2}}\right)^2}{100}$

= 28.8 kW