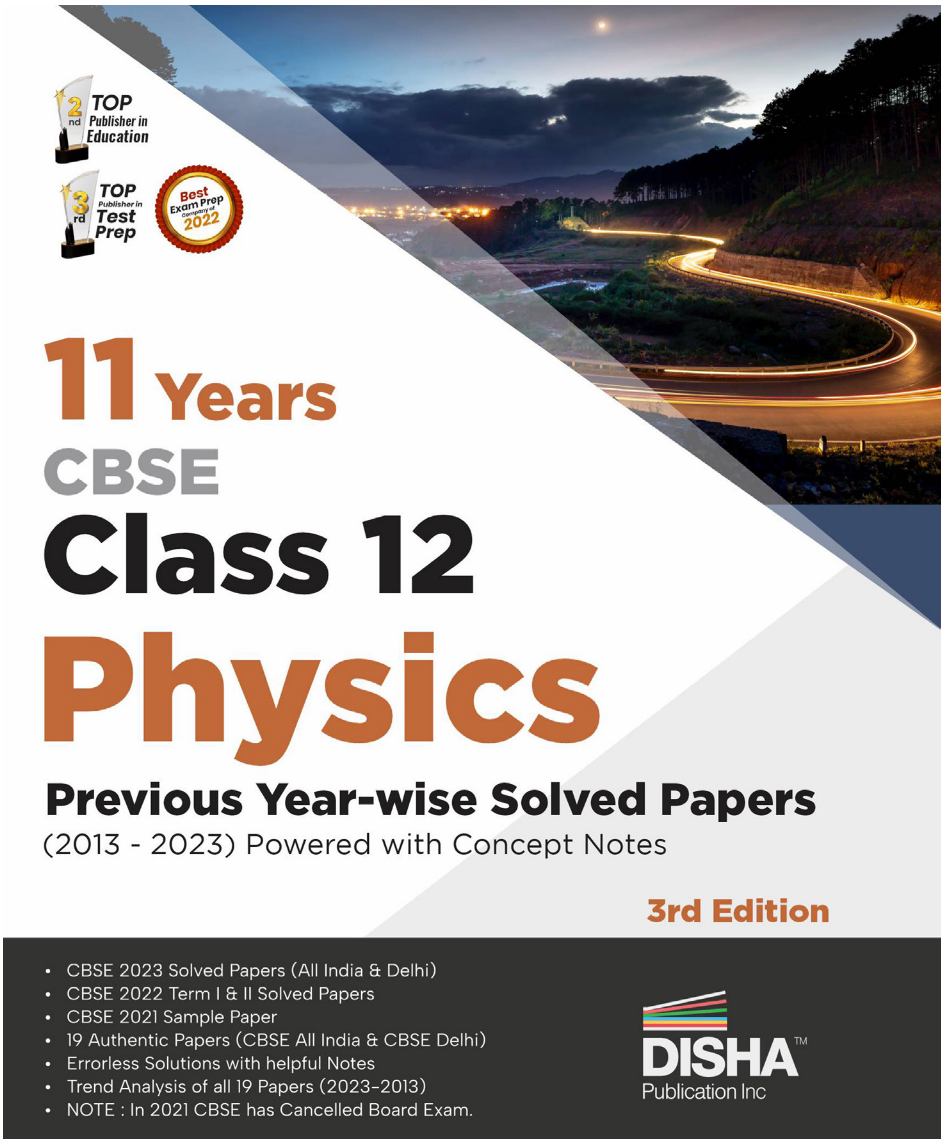
DISHA™
Publication Inc

All India 2023 Solved Paper

This sample is taken from the **"11 Years CBSE Class 12 Physics Previous Year-wise Solved Papers (2013 - 2023) powered with Concept Notes 3rd Edition | Previous Year Questions PYQs"**



ISBN - 978-8119181162

All India 2023

CBSE Board Solved Paper

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

General Instructions:

Read the following instructions very carefully and follow them :

(i) *This question paper contains **35** questions. **All** questions are compulsory.*
(ii) *Question paper is divided into **FIVE** sections – Section **A, B, C, D** and **E**.*
(iii) ***In section – A :** question number **1** to **18** are Multiple Choice (MCQ) type questions carrying **1** mark each.*
(iv) ***In section – B :** question number **19** to **25** are Short Answer-1 (SA-1) type questions carrying **2** marks each.*
(v) ***In section – C :** question number **26** to **30** are Short Answer-2 (SA-2) type questions carrying **3** marks each.*
(vi) ***In section – D :** question number **31** to **33** are Long Answer (LA) type questions carrying **5** marks each.*
(vii) ***In section – E :** question number **34** and **35** are case-based questions carrying **4** marks each.*
(viii) *There is no overall choice. However, an internal choice has been provided in 2 questions in Section – **B**, **2** questions in Section – **C**, **3** questions in Section – **D** and **2** questions in Section – **E**.*
(ix) *Use of calculators is NOT allowed.*

$c = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$ Js
$e = 1.6 \times 10^{-19}$ C
$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}
$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ Nm}^2 \text{C}^{-2}$$

Mass of electron (m_e) = 9.1×10^{-31} kg
Mass of neutron = 1.675×10^{-27} kg
Mass of proton = 1.673×10^{-27} kg
Avogadro's number = 6.023×10^{23} per gram mole
Boltzmann constant = 1.38×10^{-23} JK^{-1}

SECTION - A

1. The ratio of the magnitudes of the electric field and magnetic field of a plane electromagnetic wave is

(a) 1 (b) $\frac{1}{c}$ (c) c (d) $\frac{1}{c^2}$

2. Specify the transition of electron in the wavelength of the line in the Bohr model of hydrogen atom which gives rise to the spectral line of highest wavelength.

(a) n = 3 to n = 1 (b) n = 3 to n = 2
(c) n = 4 to n = 1 (d) n = 4 to n = 2

3. A ray of monochromatic light propagating in air, is incident on the surface of water. Which of the following will be the same for the reflected and refracted rays ?

(a) Energy carried (b) Speed
(c) Frequency (d) Wavelength

4. The formation of depletion region in a p-n junction diode is due to

(a) movement of dopant atoms
(b) diffusion of both electrons and holes
(c) drift of electrons only
(d) drift of holes only

5. An isolated point charge particle produces an electric field $\vec{E}$ at a point 3 m away from it. The distance of the point at which the field is $\frac{\vec{E}}{4}$ will be

(a) 2m (b) 3m (c) 4m (d) 6m

6. The curve of binding energy per nucleon as a function of atomic mass number has a sharp peak for helium nucleus. This implies that helium nucleus is

(a) radioactive
(b) unstable
(c) easily fissionable
(d) more stable nucleus than its neighbours

7. A steady current of 8 mA flows through a wire. The number of electrons passing through a cross-section of the wire in 10 s is

(a) 4.0×10^{16} (b) 5.0×10^{17}
(c) 1.6×10^{16} (d) 1.0×10^{17}

8. Which one of the following elements will require the highest energy to take out an electron from them ?
Pb, Ge, C and Si

(a) Ge (b) C (c) Si (d) Pb

9. A conductor of 10 Ω is connected across a 6 V ideal source. The power supplied by the source to the conductor is

(a) 1.8 W (b) 2.4 W (c) 3.6 W (d) 7.2 W

10. In an extrinsic semiconductor, the number density of holes is $4 \times 10^{20}\ m^{-3}$. If the number density of intrinsic carriers is $1.2 \times 10^{15}\ m^{-3}$, the number density of electrons in it is

(a) $1.8 \times 10^{9}\ m^{-3}$ (b) $2.4 \times 10^{10}\ m^{-3}$
(c) $3.6 \times 10^{9}\ m^{-3}$ (d) $3.2 \times 10^{10}\ m^{-3}$

11. A cell of emf E is connected across an external resistance R. When current 'I' is drawn from the cell, the potential difference across the electrodes of the cell drops to V. The internal resistance 'r' of the cell is

(a) $\left(\frac{E-V}{E}\right)R$ (b) $\left(\frac{E-V}{R}\right)$

(c) $\frac{(E-V)R}{I}$ (d) $\left(\frac{E-V}{V}\right)R$

12. A photon of wavelength 663 nm is incident on a metal surface. The work function of the metal is 1.50 eV. The maximum kinetic energy of the emitted photo electrons is

(a) 3.0×10^{-20} J (b) 6.0×10^{-20} J
(c) 4.5×10^{-20} J (d) 9.0×10^{-20} J

13. Beams of electrons and protons move parallel to each other in the same direction. They

(a) attract each other
(b) repel each other
(c) neither attract nor repel
(d) force of attraction or repulsion depends upon speed of beams

14. A ray of light of wavelength 600 nm propagates from air into a medium. If its wavelength in the medium becomes 400 nm, the refractive index of the medium is

(a) 1.4 (b) 1.5 (c) 1.6 (d) 1.8

15. A long straight wire of radius 'a' carries a steady current 'I'. The current is uniformly distributed across its area of cross-section. The ratio of magnitude of magnetic field $\vec{B}_1$ at $\frac{a}{2}$ and $\vec{B}_2$ at distance 2a is

(a) $\frac{1}{2}$ (b) 1 (c) 2 (d) 4

Note: In question number **16** to **18** two statements are given – one labelled **Assertion (A)** and the other labelled **Reason (R)**. Select the correct answer to these questions from the codes **(a)**, **(b)**, **(c)** and **(d)** as given below :

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b) Both Assertion (A) and Reason (R) are true and Reason (R) is NOT the correct explanation of Assertion (A).
(c) Assertion (A) is true and Reason (R) is false.
(d) Assertion (A) is false and Reason (R) is also false.

16. **Assertion (A) :** Work done in moving a charge around a closed path, in an electric field is always zero.
Reason (R) : Electrostatic force is a conservative force.

17. **Assertion (A) :** In Young's double slit experiment all fringes are of equal width.
Reason (R) : The fringe width depends upon wavelength of light (λ) used, distance of screen from plane of slits (D) and slits separation (d).

18. **Assertion (A) :** Diamagnetic substances exhibit magnetism.
Reason (R) : Diamagnetic materials do not have permanent magnetic dipole moment.

SECTION - B

19. In a Young's double slit experiment, the separation between the two slits is d and distance of the screen from the slits is 1000 d. If the first minima falls at a distance d from the central maximum, obtain the relation between d and λ.

20. Draw energy band diagram for an n-type and p-type semiconductor at T > 0 K.

21. Answer the following giving reasons :
(i) A p-n junction diode is damaged by a strong current.
(ii) Impurities are added in intrinsic semiconductors.

22. (a) How are infrared waves produced ? Why are these waves referred to as heat waves ? Give any two uses of infrared waves.

OR

(b) How are X-rays produced ? Give any two uses of these.

23. Briefly explain why and how a galvanometer is converted into an ammeter.

24. (a) What is meant by ionisation energy ? Write its value for hydrogen atom ?

OR

(b) Define the term, mass defect. How is it related to stability of the nucleus ?

25. A point object in air is placed symmetrically at a distance of 60 cm in front of a concave spherical surface of refractive index 1.5. If the radius of curvature of the surface is 20 cm, find the position of the image formed.

SECTION - C

26. A series RL circuit with R = 10 Ω and $L = \left(\frac{100}{\pi}\right)$ mH is connected to an ac source of voltage V = 141 sin (100 πt), where V is in volts and t is in seconds. Calculate

(a) impedence of the circuit

(b) phase angle, and

(c) voltage drop across the inductor

27. A ray of light is incident on a glass prism of refractive index μ and refracting angle A. If it just suffers total internal reflection at the other face, obtain a relation between the angle of incidence, angle of prism and critical angle.

28. (a) (i) Distinguish between nuclear fission and fusion giving an example of each.

(ii) Explain the release of energy in nuclear fission and fusion on the basis of binding energy per nucleon curve.

OR

(b) (i) How is the size of a nucleus found experimentally ? Write the relation between the radius and mass number of a nucleus.

(ii) Prove that the density of a nucleus is independent of its mass number.

29. Two cells of emf E_1 and E_2 and internal resistances r_1 and r_2 are connected in parallel, with their terminals of the same polarity connected together. Obtain an expression for the equivalent emf of the combination.

30. (a) Two charged conducting spheres of radii a and b are connected to each other by a wire. Find the ratio of the electric fields at their surfaces.

OR

(b) A parallel plate capacitor (A) of capacitance C is charged by a battery to voltage V. The battery is disconnected and an uncharged capacitor (B) of capacitance 2C is connected across A. Find the ratio of

(i) final charges on A and B.

(ii) total electrostatic energy stored in A and B finally and that stored in A initially.

SECTION - D

31. (a) (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.

OR

(b) (i) Draw a labelled ray diagram showing the image formation by a refracting telescope. Define its magnifying power. Write two limitations of a refracting telescope over a reflecting telescope.

(ii) The focal lengths of the objective and the eye-piece of a compound microscope are 1.0 cm and 2.5 cm respectively. Find the tube length of the microscope for obtaining a magnification of 300.

32. (a) (i) Use Gauss' law to obtain an expression for the electric field due to an infinitely long thin straight wire with uniform linear charge density λ.

(ii) An infinitely long positively charge straight wire has a linear charge density λ. An electron is revolving in a circle with a constant speed *v* such that the wire passes through the centre, and is perpendicular to the plane, of the circle. Find the kinetic energy of the electron in terms of magnitudes of its charge and linear charge density λ on the wire.

(iii) Draw a graph of kinetic energy as a function of linear charge density λ.

OR

(b) (i) Consider two identical point charges located at points (0, 0) and (a, 0).

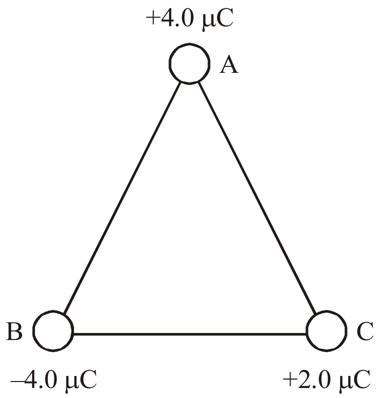
(1) Is there a point on the line joining them at which the electric field is zero ?

(2) Is there a point on the line joining them at which the electric potential is zero ?

Justify your answers for each case.

(ii) State the significance of negative value of electrostatic potential energy of a system of charges.

Three charges are placed at the corners of an equilateral triangle ABC of side 2.0 m as shown in figure. Calculate the electric potential energy of the system of three charges.



33. (a) (i) Define coefficient of self-induction. Obtain an expression for self-inductance of a long solenoid of length *l*, area of cross-section A having N turns.

(ii) Calculate the self-inductance of a coil using the following data obtained when an AC source of frequency $\left(\frac{200}{\pi}\right)$ Hz and a DC source is applied across the coil.

AC Source		
S.No.	V (Volts)	I (A)
1	3.0	0.5
2	6.0	1.0
3	9.0	1.5

DC Source		
S.No.	V (Volts)	I (A)
1	4.0	1.0
2	6.0	1.5
3	8.0	2.0

OR

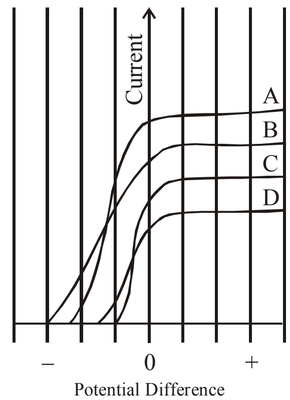
(b) (i) With the help of a labelled diagram, describe the principle and working of an ac generator. Hence, obtain an expression for the instantaneous value of the emf generated.

(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.

SECTION-E

Note : Questions number **34** and **35** are case study based questions. Read the following paragraph and answer the questions.

34. (a) Figure shows the variation of photoelectric current measured in a photo cell circuit as a function of the potential difference between the plates of the photo cell when light beams A, B, C and D of different wavelengths are incident on the photo cell. Examine the given figure and answer the following questions :



(i) Which light beam has the highest frequency and why ?

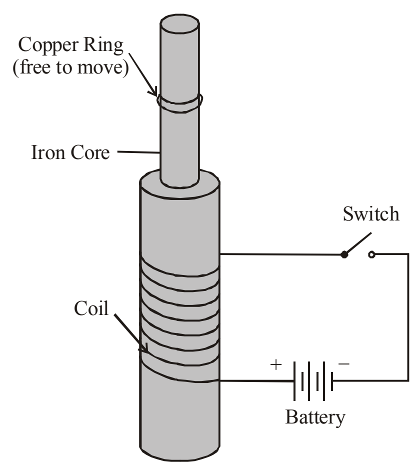
(ii) Which light beam has the longest wavelength and why ?

(iii) Which light beam ejects photoelectrons with maximum momentum and why ?

OR

(b) What is the effect on threshold frequency and stopping potential on increasing the frequency of incident beam of light ? Justify your answer.

35. (a) Consider the experimental set up shown in the figure. This jumping ring experiment is an outstanding demonstration of some simple laws of Physics. A conducting non-magnetic ring is placed over the vertical core of a solenoid. When current is passed through the solenoid, the ring is thrown off.



Answer the following questions:

(i) Explain the reason of jumping of the ring when the switch is closed in the circuit.

(ii) What will happen if the terminals of the battery are reversed and the switch is closed ? Explain.

(iii) Explain the two laws that help us understand this phenomenon.

OR

(b) Briefly explain various ways to increase the strength of magnetic field produced by a given solenoid.

Solutions

1. **(c)** In free space, $E = cB$ **(1 Mark)**

2. **(b)** For minimum energy, we have longest wavelength
So, n = 3 to n = 2 will be most suitable answer. **(1 Mark)**

3. **(c)** Frequency of light waves do not change with change in medium. **(1 Mark)**

4. **(b)** The formation of depletion region in p-n junction diode is due to diffusion of both electron and holes. **(1 Mark)**

5. **(d)** We have
$$E_{3m} = E \Rightarrow \frac{Kq}{3^2} = E \Rightarrow Kq = 9E$$
Let $\frac{E}{4}$ be the magnitude at of field at 'd' m away from it. So, $\frac{Kq}{d^2} = \frac{E}{4}$
$$\Rightarrow \frac{9E}{d^2} = \frac{E}{4} \Rightarrow d^2 = 36 \Rightarrow d = 6\text{ m}$$ **(1 Mark)**

6. **(d)** More binding energy per nucleon means more stability of nucleus. **(1 Mark)**

7. **(b)** We have
$q = It \Rightarrow q = 8 \times 10^{-3} \times 10 = 0.08\text{ C} = 8 \times 10^{-2}\text{ C}$
So, no. of electrons $= 6.25 \times 10^{18} \times 8 \times 10^{-2}$
$= 50.00 \times 10^{16} = 5 \times 10^{17}$ **(1 Mark)**

> ***Note***
> *1 Coulomb charge means charge on 6.25×10^{18} electrons.*

8. **(b)** On moving down the group 14, size of atom increases. So, ionisation energy decreases. Therefore, carbon has highest ionisation energy. **(1 Mark)**

9. **(c)** We have
$$P = \frac{V^2}{R} \Rightarrow P = \frac{6^2}{10} = 3.6\text{ Watt.}$$ **(1 Mark)**

10. **(c)** In semiconductors,
$n_e n_h = n_i^2$
$$n_e = \frac{n_i^2}{n_h} = \frac{(1.2 \times 10^{15})^2}{4 \times 10^{20}} = \frac{1.44 \times 10^{30}}{4 \times 10^{20}}$$
$= 0.36 \times 10^{10} = 3.6 \times 10^9\text{ m}^{-3}$ **(1 Mark)**

11. **(d)** We have $E = V + ir \Rightarrow ir = E - V \Rightarrow r = \frac{E - V}{i}$
$$\Rightarrow r = \left(\frac{E - V}{V}\right)R \Rightarrow r = \left(\frac{E}{V} - 1\right)R$$ **(1 Mark)**

12. **(b)** Energy of photon, $E = \frac{1240}{663}\text{ eV} = 1.87\text{ eV}$
Work function, $\phi = 1.50\text{ eV}$
So, $(K.E)_{max} = (1.87 - 1.50)\text{ eV}$
$= 0.37\text{ eV}$
$= 0.592 \times 10^{-19}\text{ J} = 5.92 \times 10^{-20}\text{ J}$
$\approx 6 \times 10^{-20}\text{ J}$ **(1 Mark)**

13. **(b)** The flow of positive charge is taken as the direction of current. So, here the currents are in opposite direction therefore they will repel each other. **(1 Mark)**

14. **(b)** We have
$$\frac{\lambda_2}{\lambda_1} = \frac{\mu_1}{\mu_2} \Rightarrow \frac{400}{600} = \frac{1}{\mu} \Rightarrow \mu = \frac{3}{2}$$ **(1 Mark)**

15. **(b)** We have
$$B = \frac{\mu_0 ir}{2\pi a^2} \text{ for } r < a$$
$$= \frac{\mu_0 i}{2\pi r} \text{ for } r \geq a$$
So, $B_1 = \frac{\mu_0 ia}{2 \times 2\pi a^2} = \frac{\mu_0 i}{4\pi a}$
$B_2 = \frac{\mu_0 i}{2\pi \times 2a} = \frac{\mu_0 i}{4\pi a}$
Thus, $\frac{B_1}{B_2} = 1$ **(1 Mark)**

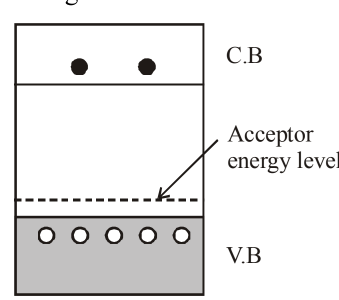
16. **(a)** In conservative field, work done is independent of path chosen and work done in moving a charge around closed path is zero. **(1 Mark)**

17. **(a)** Fringe width in YDSE is given as
$$\beta = \frac{\lambda D}{d}\cdot \text{ So, } \beta \propto \lambda$$
$$\propto D$$
$$\propto \frac{1}{d}$$ **(1 Mark)**

18. **(b)** Dimagnetic material exhibits magnetism in reverse direction. And due to absence of unpaired electron in dimagnetic material it does not exhibit permanent dipole moment. **(1 Mark)**

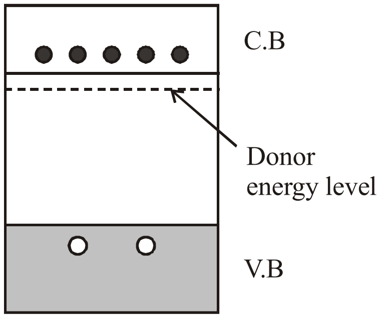
19. We have
$\frac{\beta}{2} = d$ [$\because$ Distance between maxima and minima is $\beta/2$]
$\Rightarrow \beta = 2d$ **(1 Mark)**
$\Rightarrow \frac{\lambda \times 1000\,d}{d} = 2d \Rightarrow \lambda = \frac{1}{500}d$ **(1 Mark)**

20. Energy band diagram of both semiconductor at $T > 0$ K



p-type semiconductor

(1 Mark)



n-type semiconductor **(1 Mark)**

21. (i) When a strong current passes through the semiconductor it heats up the crystal and covalent bond are broken. Hence because of excess number of free electrons it behaves like a conductor. **(1 Mark)**

(ii) The addition of impurities contributes free electrons or holes which increases the conductivity of the intrinsic semiconductor. **(1 Mark)**

22. (a) Infra-red waves are produced by hot bodies and molecules. **(½ Mark)**

They are also called heat waves because water molecules present in most of the materials readily absorb infra-red rays and their thermal motion increases, due to which material yet heated. **(½ Mark)**

Two uses of infra-red waves are

(i) In remote switches of house-hold electric system.

(ii) Physical therapy to treat muscular strain. **(½ × 2 = 1 Mark)**

OR

(b) X-rays are produced by Coolidge X-ray tube by bombarding a metal target by high energy electrons **(1 Mark)**

Two uses of X-rays are

(i) Medical application like detection of fractures, formation of stones etc.

(ii) To study crystal structure of solid. **(½ × 2 = 1 Mark)**

23. An ammeter is made by connecting low resistance (shunt) in parallel to the galvanometer. When a low resistance is connected parallel to galvanometer, then most of the current passes through this resistance and thereby increasing its range. **(2 Marks)**

24. (a) Ionization energy is the minimum energy required to remove the most loosely bound electron of an isolated gaseous atom, positive ion, or molecule. **(1 Mark)**

For hydrogen atom, ionisation energy is 13.6 eV. **(1 Mark)**

OR

(b) Mass defect is difference in the total mass of all the nucleons and mass of nucleus. **(1 Mark)**

i.e. Mass defect = mass of all nucleons – mass of nucleus

$$= [Zm_p + (A - Z)m_n] - m_{nucleus}$$

Higher is the mass defect, higher is the BEPN. So, higher is the stability. **(1 Mark)**

25. For spherical surface, we have

$$\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$ **(½ Mark)**

$$\Rightarrow \frac{1.5}{V} - \frac{1}{-60} = \frac{1.5 - 1}{-20}$$ [For convex surface, R is –ve] **(½ Mark)**

$$\Rightarrow \frac{1.5}{V} = -\frac{0.5}{20} - \frac{1}{60} \Rightarrow \frac{1.5}{V} = -\frac{1}{40} - \frac{1}{60}$$

$$\Rightarrow \frac{1.5}{V} = \frac{-3-2}{120} \Rightarrow \frac{1.5}{V} = \frac{-5}{120}$$ **(½ Mark)**

$\Rightarrow V = -36\,\text{cm}$ **(½ Mark)**

26. (a) We have

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + \omega^2 L^2}$$ **(½ Mark)**

$$= \sqrt{10^2 + 100^2\pi^2 \times \frac{100^2}{\pi^2} \times 10^{-6}}$$

$$= \sqrt{10^2 + (100)^4 \times 10^{-6}}$$

$$= \sqrt{10^2 + 10^2}$$

$$= 10\sqrt{2}\ \Omega$$ **(½ Mark)**

(b) The phase angle is given as

$$\cos\phi = \frac{R}{Z} = \frac{10}{10\sqrt{2}} = \frac{1}{\sqrt{2}} \Rightarrow \phi = 45^\circ$$ **(1 Mark)**

(c) $$I_0 = \frac{V_0}{Z} = \frac{141}{10\sqrt{2}} = \frac{141}{14.1} = 10\text{ A}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{10}{\sqrt{2}}$$ **(½ Mark)**

So, voltage across inductor = $I_{rms} X_L$

$$= \frac{10}{\sqrt{2}} \times 100\pi \times \frac{100}{\pi} \times 10^{-3}$$

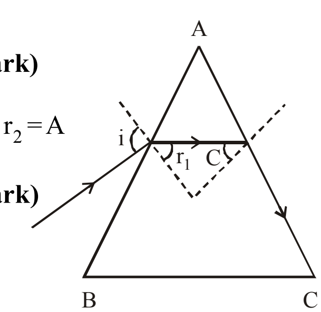
$$= 5\sqrt{2} \times 10^4 \times 10^{-3}$$

$$= 50\sqrt{2}\text{ volt.}$$ **(½ Mark)**

27. **At surface AC**

$\mu_g \sin C = 1 \sin 90^\circ$

$$\Rightarrow \sin C = \frac{1}{\mu_g} = \frac{1}{\mu}$$ **(1 Mark)**



We know that in prism $r_1 + r_2 = A$

So, $r_1 + C = A$

$r_1 = A - C$ **(1 Mark)**

At surface AB

$\sin i = \mu \sin r_1$

$\Rightarrow \sin i = \mu \sin (A - C)$

$$\Rightarrow \sin i = \frac{1}{\sin C}\sin(A - C) \Rightarrow \sin i = \frac{\sin(A - C)}{\sin C}$$ **(1 Mark)**

Note

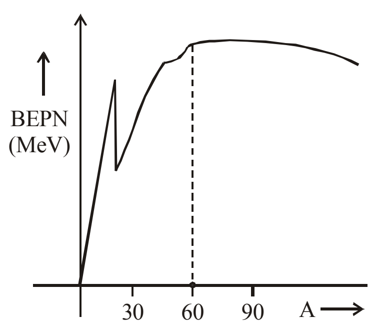
* *If a light ray is incident normally on first surface i.e., $\angle i = 0°$ so refraction of first surface $\angle r_1 = 0°$.*
* *When angle of prism A > C (critical angle) then no ray emerges from second surface of the prism.*

28. (a) (i)

	Nuclear fission	Nuclear fusion
→	When the nucleus of an atom split into lighter nuclei through a nuclear reaction, the process is termed nuclear fission.	Nuclear fusion is a reaction through which two or more lighter nuclei collide with each other to form a heavier nucleus.
→	${}^{235}_{92}U + {}^{1}_{0}n \rightarrow$ ${}^{144}_{56}Ba + {}^{89}_{36}Kr +$ $3{}^{1}_{0}n + 210$ MeV	$\rightarrow {}^{1}_{1}H + {}^{1}_{1}H \rightarrow {}^{2}_{1}H +$ $e^{+} + \nu +$ 0.42 MeV

(½ × 2 = 1 Mark)

(ii) We have BEPN curve as follows :



(1 Mark)

Fission Reactions

From the curve of binding energy, the heaviest nuclei are less stable than the nuclei near A = 60. This suggests that energy can be released if heavy nuclei split apart into smaller nuclei having masses nearer A = 60. This process is called fission. It is the process that powers atomic bombs and nuclear power reactors. **(½ Mark)**

Fusion Reactions

The curve of binding energy suggests a second way in which energy could be released in nuclear reactions. The lightest elements (like hydrogen and helium) have nuclei that are less stable than heavier elements up to A ~ 60. Thus, sticking two light nuclei together to form a heavier nucleus can release energy. This process is called fusion, and is the process that powers hydrogen (thermonuclear) bombs and (perhaps eventually) fusion energy reactors. **(½ Mark)**

OR

(b) (i) Size of a nucleus is experimentally estimated from Rutherford's α-particle scattering experiment. **(½ Mark)**

If 'R' is radius of a nucleus of mass number 'A'. Then, $R = R_0A^{1/3}$, where $R_0 = 1.2$ fm. **(1 Mark)**

(ii) The radius (size) R of nucleus is related to its mass number (A) as

$R = R_0A^{1/3}$ where $R_0 = 1.1 \times 10^{-15}$ m **(½ Mark)**

If m is the average mass of a nucleon, then mass of nucleus = mA, where A is mass number

Volume of nucleus = $\frac{4}{3}\pi R^3$

$= \frac{4}{3}\pi(R_0A^{1/3})^3 = \frac{4}{3}\pi R_0^3 A$ **(½ Mark)**

∴ Density of nucleus,

$$\rho_N = \frac{\text{mass}}{\text{volume}} = \frac{mA}{\frac{4}{3}\pi R_0^3}$$ **(½ Mark)**

Clearly nuclear density ρ_N is independent of mass number A.

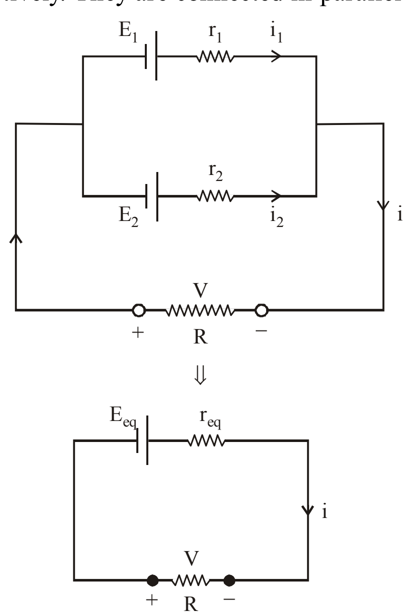
Note

Nuclear density, $\rho = \frac{3m}{4\pi R_0^3}$

Here, $R_0 = 1.2 \times 10^{-15}$m, m = Average of mass of a nucleon (mass of proton + mass of neutron) = 1.66×10^{-27} kg

This formula suggest that density of nuclear matter is same for all nuclei.

29. We have two cell E_1 and E_2 having resistance r_1 and r_2 respectively. They are connected in parallel as shown in figure.



We have

$$V = E_1 - i_1 r_1 \Rightarrow i_1 = \frac{E_1 - V}{r_1}$$

$$V = E_2 - i_2 r_2 \Rightarrow i_2 = \frac{E_2 - V}{r_2}$$

Also, $V = E_{eq} - ir_{eq} \Rightarrow i = \frac{E_{eq} - V}{r_{eq}}$ **(1 Mark)**

As $i = i_1 + i_2$

$$\frac{E_{eq} - V}{r_{eq}} = \frac{E_1 - V}{r_1} + \frac{E_2 - V}{r_2}$$

$$\Rightarrow \frac{E_{eq}}{r_{eq}} - \frac{V}{r_{eq}} = \left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$ **(1 Mark)**

Equating coefficient on both sides, we get

$$\frac{E_{eq}}{r_{eq}} = \left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) \text{ and } \frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$

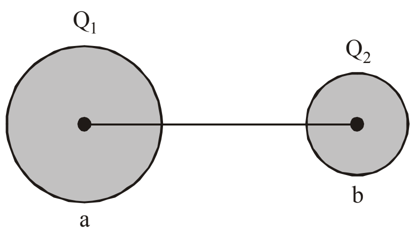
$$\Rightarrow E_{eq} = r_{eq}\left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) \text{ and } \frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$

$$\Rightarrow E_{eq} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} \text{ and } \frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$ **(1 Mark)**

Note

Parallel grouping of cells is used when r >> nR.
Here, n = number of identical cells

30. (a)



Let Q_1 and Q_2 be the charge on two sphere when they are connected by the wire.

As two sphere are connected by wire, they will have same potential.

So, $\frac{KQ_1}{a} = \frac{KQ_2}{b} \Rightarrow \frac{Q_1}{Q_2} = \frac{a}{b}$ **(1 Mark)**

Let E_1 and E_2 be the electric field at surface of 'a' and 'b'.

Then, $E_1 = \frac{KQ_1}{a^2}$ and $E_2 = \frac{KQ_2}{b^2}$ **(1 Mark)**

So, $\frac{E_1}{E_2} = \frac{Q_1}{Q_2} \cdot \frac{b^2}{a^2} = \frac{a}{b} \cdot \frac{b^2}{a^2} = \frac{b}{a}$ **(1 Mark)**

OR

(b) (i) We have

$Q_i = Q_f$

$\Rightarrow (Q_A)_i + (Q_B)_i = (Q_A)_f + (Q_B)_f$

$\Rightarrow CV + 0 = (C + 2C)V_f$

$\Rightarrow V_f = \frac{CV}{3C} \Rightarrow V_f = \frac{V}{3}$ **(½ Mark)**

So, $(Q_A)_f = C \times \frac{V}{3} = \frac{CV}{3}$ **(½ Mark)**

$(Q_B)_f = 2C \times \frac{V}{3} = \frac{2CV}{3}$ **(½ Mark)**

(ii) $(U_A)_i = \frac{1}{2}CV^2$

$(U_B)_i = 0$ **(½ Mark)**

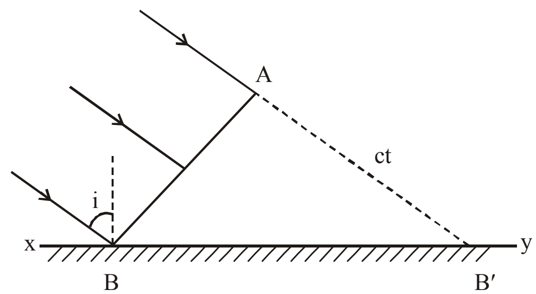
$(U_A)_f = \frac{1}{2}C\left(\frac{V}{3}\right)^2 = \frac{1}{18}CV^2$ **(½ Mark)**

$(U_B)_f = \frac{1}{2}2C\left(\frac{V}{3}\right)^2 = \frac{CV^2}{9}$ **(½ Mark)**

31. (a) (i) Huygen's principle states that every point on a given wavefront act as a source of secondary wavelets which travel in all direction with the velocity of light in the medium. The position of the new wavefront at any instant is a surface touching these secondary wavelets tangentially in the forward direction at that instant. **(1 Mark)**

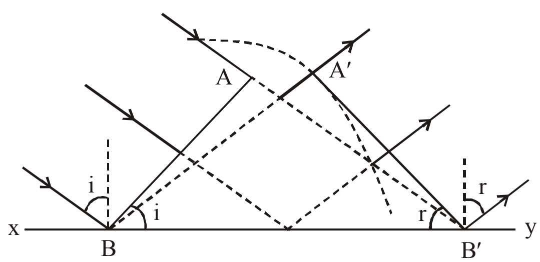
Laws of reflection by Huygens' principle

Let us consider a plane wavefront *AB* incident on the plane reflection surface *xy*. Incident rays are normal to the wavefront *AB*.



(1 Mark)

Let in time '*t*' the secondary wavelets reaches *B′* covering a distance *ct*. Similarly from each point on primary wavefront *AB*. Secondary wavelets start growing with the speed '*c*'. To find reflected wavefront after time '*t*', let us draw a sphere of radius '*ct*' taking '*B*' as center and now a tangent is drawn from *B′* on the sphere the tangent *B′A′* represents reflected wavefront after time t.



(1 Mark)

For every point on wavefront *AB* a corresponding point lie on the reflected wavefront *A′B′*.

So, comparing two triangle $\Delta BAB'$ and $\Delta B'A'B$

We get $AB' = A'B = ct$

BB' = common

$\angle A = \angle A' = 90°$ **(½ Mark)**

Hence, two triangles are congruent, hence ∠i = ∠r. This proves law of reflection. Also incident ray, normal to point of incidence and reflected ray lie in same plane. This prove second law of reflection. **(½ Mark)**

(ii) We have m = +3

So, $-\frac{v}{u} = +3$

$\Rightarrow \quad v = -3u$ **(½ Mark)**

By mirror formula $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

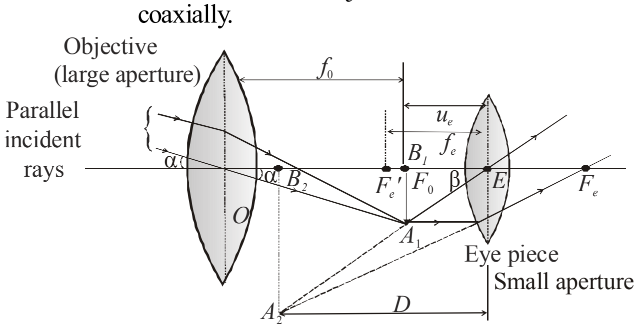
$\Rightarrow \frac{1}{-3u} + \frac{1}{-u} = \frac{1}{f} \Rightarrow -\frac{4}{3u} = \frac{1}{12} \Rightarrow u = -16\text{ cm}$

(½ Mark)

OR

(b) (i) **Refracting type telescope**

A refracting type astronomical telescope, used to see the distant objects at large distances, consists of objective, i.e., a converging lens, or lens combination of larger focal length f_0 and larger aperture, and an eyepiece, i.e., also a converging lens, or lens combination, but of smaller focal length f_e and smaller aperture, placed coaxially.



(½ Mark)

Magnifying power (M) : Magnifying power (*M*), also called angular magnification of a telescope is defined as *the ratio of the visual angle subtended by the final image at the eye and the visual angle subtended by the object when the object lies in the actual position*. (In contrast to the definition of magnifying power of a microscope, the object is not placed at the near point in case of telescope) **(½ Mark)**

$$M = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} \quad (\because \alpha, \beta \text{ are small})$$

$$M = \frac{A_1B_1 / EB_1}{A_1B_1 / OB_1} \quad (\text{in } \Delta AB_1O \text{ and } \Delta\ AB_1E)$$

$\Rightarrow M = \frac{OB_1}{EB_1}$ **(½ Mark)**

Using sign convention and taking u_e as object distance for eyepiece, we get

$$M = \frac{+f_0}{-u_e} = -\frac{f_0}{u_e} \quad \text{... (1)}$$ **(½ Mark)**

This is the general formula for magnifying power of a telescope.

Magnifying power M, if eye is focussed at near point

For the eyepiece, $v = -D$, $v = -u_e$, $f = +f_e$,
where , D = minimum distance of distinct vision

Using lens formula, we get $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

or, $\frac{1}{-D} - \frac{1}{-u_e} = \frac{1}{f_e}$

$$\therefore \quad \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D} = \frac{1}{f_e}\left(1 + \frac{f_e}{D}\right) \quad \text{... (2)}$$

(½ Mark)

Put eq. (2) in (1), we get $M = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$ ... (3)

In this case, the length of the telescope L $= f_0 + u_e$.

Note

Negative sign in magnifying power of astronomical telescope shows that image is inverted.

Magnifying power M when eye is focussed at ∞ (normal adjustment)

In this case, as already explained, we have $u_e = -f_e$ ... (4)

Put eq. (4) in (1) to get $M = \frac{f_0}{f_e}$ ... (5)

(½ Mark)

In this case, the length of the telescope L $= f_0 + f_e$.

This is the reason why the focal length of objective is taken large and of eyepiece small in case of a telescope. This also increases the resolving power of the telescope.

Further, linear or lateral magnification does not convey much meaning in case of a telescope because the size of final images too is negligible compared to actual size of the objects which are generally planets or stars.

Limitations of a refracting telescope over a reflecting telescope

(1) Image is fainter because of its large light gathering power.

(2) The resolving power (the ability to observe two object distinctly) is low, due to the large diameter of objective. **(½ × 2 = 1 Mark)**

(ii) We have

$$M = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$$

As focal length of objective is small. So, $u_0 \simeq f_0$

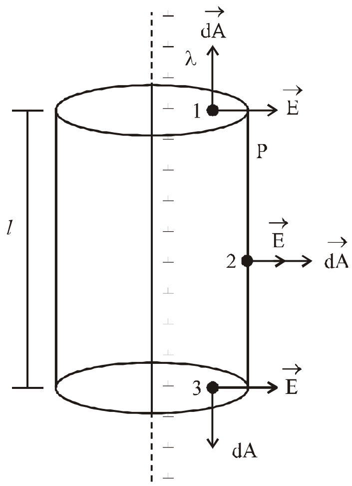
Also as focal length of eye is small. So, $v_0 \simeq L$

$$\therefore M = \frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$ **(½ Mark)**

$$\Rightarrow 300 = \frac{L}{1}\left(1 + \frac{25}{2.5}\right) \Rightarrow 300 = L \times 11$$

$$\therefore \quad L = \frac{300}{11}\text{ cm}$$ **(½ Mark)**

32. (a) (i) Let us take an infinitely long positively charged straight wire having linear charge density 'λ' as shown in figure below.



(1 Mark)

Suppose we have to determine electric field at 'P'. For this we will draw a gaussian surface as shown in fig.

Net flux through gaussian surface is

$$\phi = \oint \vec{E}.\vec{dA}$$

$$\Rightarrow \quad \phi = \int_1 \cancelto{0}{\vec{E}\cdot\vec{dA}} + \int_2 \vec{E}\cdot\vec{dA} + \int_3 \cancelto{0}{\vec{E}\cdot\vec{dA}}$$

(½ Mark)

$[\because$ For surface 1 and 3, $\vec{E} \perp \vec{A}\,]$

$$\Rightarrow \quad \phi = \int_2 \vec{E}.\vec{dA} \Rightarrow \phi = \int E.dA$$

$$\Rightarrow \quad \phi = E \times \int dA$$

$$\Rightarrow \quad \phi = E \times 2\pi r l$$ **(½ Mark)**

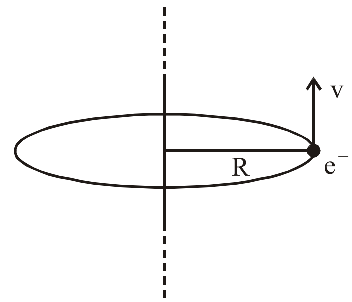
By Gauss law, $\phi = \frac{q_{in}}{\in_0}$ **(½ Mark)**

$$\Rightarrow \quad E \times 2\pi r l = \frac{\lambda l}{\in_0}$$

$$\Rightarrow E = \frac{\lambda}{2\pi \in_0 r}$$ and direction is away from wire

(½ Mark)

(ii) Here, the necessary centripetal force is provided by electrostatic attraction



So, $\frac{mv^2}{R} = qE$ **(½ Mark)**

$$\Rightarrow \quad \frac{mv^2}{R} = \frac{e\lambda}{2\pi \in_0 R}$$

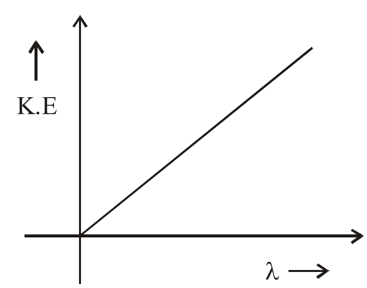
$$\Rightarrow \quad mv^2 = \frac{e\lambda}{2\pi \in_0} \Rightarrow \frac{1}{2}mv^2 = \frac{e\lambda}{4\pi \in_0}$$

$$\Rightarrow \quad K.E = \frac{e\lambda}{4\pi \in_0}$$ **(½ Mark)**

(iii) As $K.E = \frac{e\lambda}{4\pi \in_0}$

$$\Rightarrow \quad K.E \propto \lambda$$

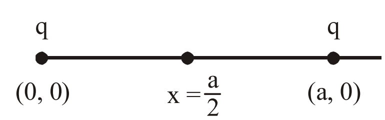
So, graph will be straight line passing through origin as shown below



(1 Mark)

OR

(b) (i)



(1) At x = a/2, electric field due to both charge will cancel each other.

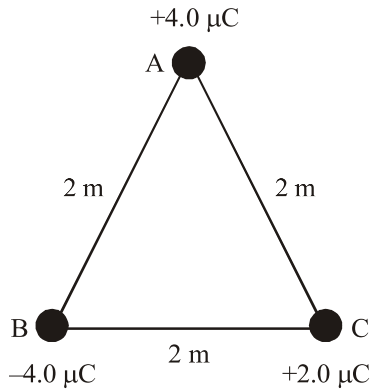
So at x = a/2, electric field will be zero.

(1 Mark)

(2) As potential is additive. So, net potential at any point can never be zero if both the charges are positive. **(1 Mark)**

(ii) Negative value of potential energy of a system of charges means positive amount of work is required against the electrostatic force to take the charges from the given location to infinity.

(1 Mark)



$$U = \frac{1}{4\pi \in_0 r}[(4 \times -4) + (-4 \times 2) + (2 \times 4)] \times 10^{-12}$$ **(½ Mark)**

$$\Rightarrow \quad U = \frac{9 \times 10^9}{2}[-16 - 8 + 8] \times 10^{-12}$$ **(½ Mark)**

$$\Rightarrow \quad U = \frac{9 \times 10^9}{2} \times -16 \times 10^{-12}$$ **(½ Mark)**

$$\Rightarrow \quad U = -72 \times 10^{-3}\ J = -72\ mJ$$ **(½ Mark)**

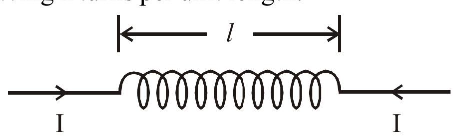
33. (a) (i) As induced emf, $|e| = \left|L\frac{di}{dt}\right|$

So, $|L| = \frac{|e|}{\left|\frac{di}{dt}\right|}$. If $\left|\frac{di}{dt}\right| = 1$ A/sec

Then, $|L| = |e|$

So, coefficient of self induction is equal to emf induced in inductor when current through it change at a rate of 1 |A| sec. **(1 Mark)**

Let the radius and length of air cored solenoid be 'r' and 'l' respectively such that r << l and having n turns per unit length.



$$n = \frac{N}{l} \quad \text{... (i)}$$

where, N = total number of turns.

If 'I' current flows through the coil, then magnetic field is given by

$$B = \mu_0 nI$$

where, n = number of turns per unit length

∴ Magnetic flux linked with each turn,

$$\phi = BA = \mu_0 nIA$$ **(½ Mark)**

∴ Total magnetic flux linked with solenoid,

$$N\phi = (\mu_0 nIA)N$$ **(½ Mark)**

But $N\phi = LI$ **(½ Mark)**

where, L is coefficient of self-induction,

$$(\mu_0 nIA) = LI$$

$$\Rightarrow \quad L = \mu_0 nAN = \mu_0\left(\frac{N}{l}\right)AN = \frac{\mu_0 AN^2}{l}$$

This is required expression. **(½ Mark)**

Note

The self-inductance of the solenoid depends on its number of turns, geometry and permeability of the medium.

(ii) From DC source, we can calculate resistance

$$R_1 = \frac{4}{1} = 4\,\Omega, \quad R_2 = \frac{6}{1.5} = 4\,\Omega$$

and $$R_3 = \frac{8}{2} = 4\,\Omega$$

So, $$R_{mean} = \frac{4+4+4}{3} = 4\,\Omega$$ **(½ Mark)**

From AC source, we can calculate impedance

$$Z_1 = \frac{3}{0.5} = 6\,\Omega, \quad Z_2 = \frac{6}{1} = 6\,\Omega$$

and $$Z_3 = \frac{9}{1.5} = 6\,\Omega$$

So, $$Z_{mean} = \frac{6+6+6}{3} = 6\,\Omega$$ **(½ Mark)**

Now, $Z^2 = R^2 + \omega^2 L^2$

$$L^2 = \frac{Z^2 - R^2}{\omega^2}$$

$$L^2 = \frac{Z^2 - R^2}{4\pi^2 f^2} = \frac{(6^2 - 4^2) \times \pi^2}{4 \times \pi^2 \times 200^2}$$ **(½ Mark)**

$$= \frac{20}{4 \times 10 \times 4 \times 10^4} = \frac{1}{8} \times 10^{-4}$$

So, $$L = \frac{1}{2\sqrt{2}} \times 10^{-2} = 0.36 \times 10^{-2}\ H$$ **(½ Mark)**

$$= 3.6\ mH$$

OR

(i) **AC generator or Dynamo**

It is used to convert mechanical energy into electrical energy. **(½ Mark)**

Principle and working : It works on the principle of electromagnetic induction. **(½ Mark)**

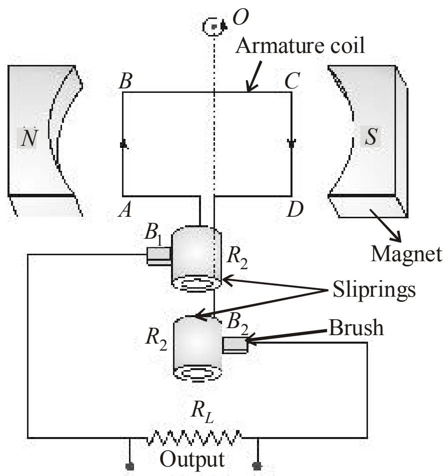
The main components of ac generator are :

(i) Armature coil : It consist of large number of turns of insulated copper wire wound over iron core.

(ii) Magnet : Strong permanent magnet (for small generator) or an electromagnet (for large generator) with cylindrical poles in shape.

(iii) Slip rings : The two ends of the armature coil are connected to two brass rings R_1 and R_2. These rings rotate along with the armature coil.

(iv) Brushes : Two carbon brushes (B_1 and B_2), are pressed against the slip rings. These brushes are connected to the load through which the output is obtained. **(1 Mark)**



(1 Mark)

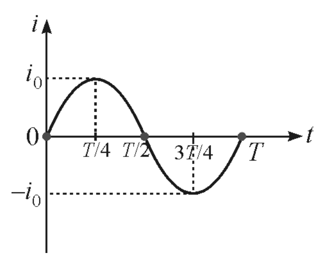
Working: When a coil is rotated in magnetic field, an emf is induced in the coil. The coil may be rotated by water energy, steam energy or oil energy. Let at any instant magnetic flux through armature coil,

$$N\phi_B = NBA\cos\theta = NBA\cos\omega t$$

The induced emf $\quad e = -\dfrac{d\phi_B}{dt} = NBA\omega\sin\omega t$

or $\quad e = e_0\sin\omega t$, where $e_0 = NBA\omega$.

(½ Mark)



And induced current $i = \dfrac{e}{R} = \dfrac{e_0}{R}\sin\omega t = i_0\sin\omega t$

The direction of current changes periodically and therefore the current is called alternating current. **(½ Mark)**

(ii) We have

$e_{max} = NBA\omega$

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

$= 2400\,V$ **(½ Mark)**

$$P_{av} = \frac{e_{rms}^2}{R} = \frac{e_{max}^2}{2R} = \frac{2400^2}{2\times 100} = 28.8\,kW$$

(½ Mark)

34. (a) (i) 'B' has highest frequency because of its highest stopping potential. **(1 Mark)**

(ii) 'C' has longest wavelength because of its lowest stopping potential. **(1 Mark)**

(iii) 'B' ejects photoelectrons with maximum momentum because high momentum means high kinetic energy and therefore high stopping potential. **(2 Marks)**

OR

(b) **Effect on threshold frequency**

When frequency is increased there is no effect on threshold frequency because threshold frequency is property of metal. It does not depends on frequency of photon radiation. **(1 Mark)**

Effect on stopping potential

When frequency is increased, stopping potential get increased.

As $\quad h\nu = h\nu_0 + eV_S \Rightarrow V_S = \dfrac{h}{e}\nu - \dfrac{h}{e}\nu_0$

We can see from equation that increasing frequency increases stopping potential. **(1 Mark)**

Note

Slope of graph between stopping potential and frequency of the incident light gives the ratio of Planck's constant to electronic charge.

35. (a) (i) As the switch is closed in circuit, flux will change through the ring. Due to which current will be induced in it. The induced current opposes this change, and sets up its own magnetic field. This opposition is in effect as a repulsion (two like pole facing one another) and this cause rings to jump 20 cm to 50 cm in air. **(1 Mark)**

(ii) There will no change in repulsive forces, the only change that will occur is in the direction of induced current in the ring. **(1 Mark)**

(iii) Two laws that helps us in understanding this phenomenon are:

(i) Lenz law

(ii) Faraday's law **(2 × 1 = 2 Marks)**

OR

(b) Magnetic field inside the solenoid is given as

$B = \mu_0\mu_r nI$ **(½ Mark)**

i.e. $B \propto \mu_r$

$\propto n$

$\propto I$

So, if permeability of core material is increased, magnetic field is increased. **(½ Mark)**

If number of turns per unit length is increased, again magnetic field is increased. **(½ Mark)**

If current is increased, then also magnetic field is increased. **(½ Mark)**