Class-XII

Session - 2022-23

Subject - Physics (Theory)

Sample Question Paper - 31

With Solution

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Ch. No.	Chapter Name	Per Unit Marks	Section-A MCQs 1 Mark	Section-B SA 2 Marks	Section-C LA-I 3 Marks	Section-D LA-II 5 Marks	Section-E Case Study 4 Marks	Total Marks
1	Electric Charges and Fields				1 (Q. 27)			3
2	Electrostatic Potential and Capacitance	16	3 (Q. 1, 2, 17)					3
3	Current Electricity		1(Q. 16)			1 (Q. 31)	1 (Q. 34)	10
4	Moving Charges and Magnetism		1(Q. 3)			1 (Q.32)		6
5	Magnetism and Matter		1(Q. 5)		1 (Q.26)			4
6	Electromagnetic Induction	17	1 (Q. 6)	1 (Q. 24)				3
7	Alternating Current		2 (Q. 4, 7)	1 (Q. 19)				4
8	Electromagnetic Waves		1 (Q. 8)					1
9	Ray optics and Optical Instruments	18	1 (Q. 9)	2 (Q. 20, 22)		1 (Q. 33)		10
10	Wave Optics		1 (Q. 18)	1 (Q. 25)			1 (Q. 35)	7
11	Dual Nature of Radiation and Matter		1 (Q. 10)		1 (Q. 30)			4
12	Atoms	12	1 (Q. 12)		1 (Q. 29)			4
13	Nuclei		1 (Q. 11)		1 (Q. 28)			4
14	Semiconductor Electronics: Materials, Devices and Simple Circuits	7	3 (Q. 13, 14, 15)	2 (Q. 21, 23)				7
	Total Marks (Total Questions)		**18 (18)**	**14 (7)**	**15 (5)**	**15 (3)**	**8 (2)**	**70 (35)**

NOTE : The number given inside the bracket denotes question number, ask in the sample paper, while the number given outside the bracket are the number of questions from that particular chapter.

Time Allowed : 3 Hours **Max. Marks : 70**

General Instructions

1. There are 35 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. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

SECTION-A

1. To obtain 3 μF capacity from three capacitors of 2 μF each, they will be arranged.
(a) all the three in series
(b) all the three in parallel
(c) two capacitors in series and the third in parallel with the combination of first two
(d) two capacitors in parallel and the third in series with the combination of first two

2. The work done in carrying a charge q once around a circle of radius r with a charge Q placed at the centre will be
(a) $Qq(4\pi\varepsilon_0 r^2)$ (b) $Qq/(4\pi\varepsilon_0 r)$ (c) zero (d) $Qq^2/(4\pi\varepsilon_0 r)$

3. Two long parallel wires are at a distance of 1 metre. Both of them carry 5 ampere of current. The force of attraction per unit length between the two wires is
(a) 50×10^{-7} N/m (b) 2×10^{-8} N/m (c) 5×10^{-8} N/m (d) 10^{-7} N/m

4. A transformer is used to light a 100 W and 110 V lamp from a 220 V mains. If the main current is 0.5 amp, the efficiency of the transformer is approximately
(a) 50% (b) 90% (c) 10% (d) 30%

5. The magnetic susceptibility for diamagnetic materials is
(a) small and negative (b) small and positive (c) large and positive (d) large and negative

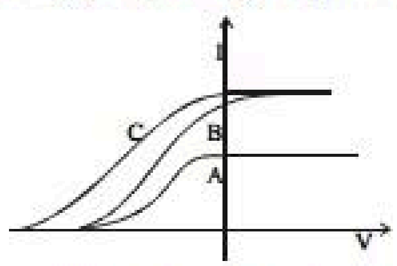
6. Lenz's law is a consequence of the law of conservation of
(a) charge (b) mass (c) energy (d) momentum

7. Alternating current cannot be measured by D.C. ammeter, because
(a) A.C. is virtual (b) A.C. changes its direction
(c) A.C. cannot pass through D.C. ammeter (d) average value of A.C for complete cycle is zero

8. The oscillating magnetic field in a plane electromagnetic wave is given by $B_y = 5 \times 10^{-6} \sin 1000\pi(5x - 4 \times 10^8 t)$T. The amplitude of electric field will be :
(a) $15 \times 10^2\ Vm^{-1}$ (b) $5 \times 10^{-6}\ Vm^{-1}$ (c) $16 \times 10^{12}\ Vm^{-1}$ (d) $4 \times 10^2\ Vm^{-1}$

9. A concave mirror is used for face viewing has focal length of 0.6m. At whay distance you should hold the mirror from your face to get an upright image with a magnification of 4?
(a) 0.20 m (b) 0.25 m (c) 0.40 m (d) 0.45 m

10. In a photoelectric experiment, anode potential (V) is plotted against plate current (I)



(a) A and B will have different intensities while B and C will have different frequencies
(b) B and C will have different intensities while A and C will have different frequencies
(c) A and B will have different intensities while A and C will have equal frequencies
(d) A and B will have equal intensities while B and C will have different frequencies

11. The mass number of He is 4 and that for sulphur is 32. The radius of sulphur nuclei is larger than that of helium by

(a) $\sqrt{8}$ (b) 4 (c) 2 (d) 8

12. Rutherford's atomic model was unstable because

(a) nuclei will break down
(b) electrons do not remain in orbit
(c) orbiting electrons radiate energy
(d) electrons are repelled by the nucleus

13. The impurity atoms with which pure silicon may be doped to make it a p-type semiconductor are those of

(a) phosphorus (b) boron (c) antimony (d) nitrogen

14. When an impurity is doped into an intrinsic semiconductor, the conductivity of the semiconductor

(a) increases (b) decreases (c) remains the same (d) becomes zero

15. In a reverse biased diode when the applied voltage changes by 1 V, the current is found to change by 0.5 μA. The reverse bias resistance of the diode is

(a) $2 \times 10^5\,\Omega$ (b) $2 \times 10^6\,\Omega$ (c) $200\,\Omega$ (d) $2\,\Omega$

For question numbers 16, 17 and 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 A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

16. **Assertion (A) :** Bending a wire does not effect electrical resistance.
Reason (R) : Resistance of wire is proportional to resistivity of material.

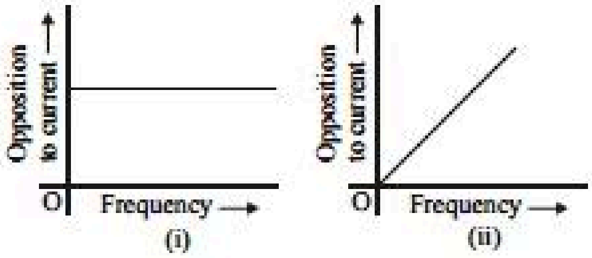
17. **Assertion (A) :** The electric potential at any point on the equatorial plane of a dipole is zero.
Reason (R) : Workdone in rotating a dipole from a direction perpendicular to the field to the given direction is called potential energy of dipole.

18. **Assertion (A) :** In YDSE, if $I_1 = 9I_0$ and $I_2 = 4I_0$ then $\frac{I_{max}}{I_{min}} = 25$.

Reason (R) : In YDSE $I_{max} = \frac{1}{2}(\sqrt{I_1} + \sqrt{I_2})^2$ and $I_{min} = \frac{1}{2}(\sqrt{I_1} - \sqrt{I_2})^2$.

SECTION-B

19. The graphs (i) and (ii) represent the variation of the opposition offered by the circuit element to the flow of alternating current with frequency of the applied emf. Identify the circuit element corresponding to each graph.



20. A convex lens of focal length 0.5 and concave lens of focal length 1 m are combined. What is the power of the combination of two lenses.

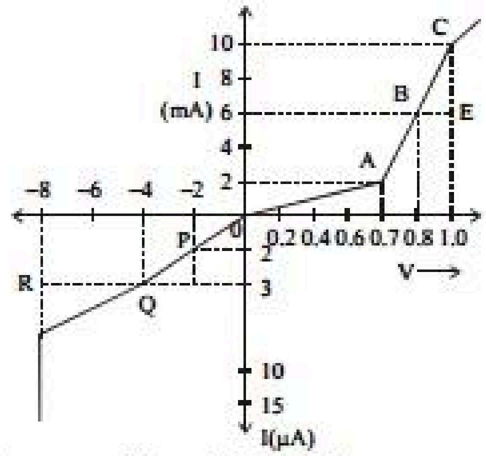
OR

The radius of curvature of curved surface of a thin plane - convex lens is 10 cm and the refractive index is 1.5. If the plane surface is silvered what will be the focal length of the lens?

21. What is depletion region? Explain how barrier is created in this region?

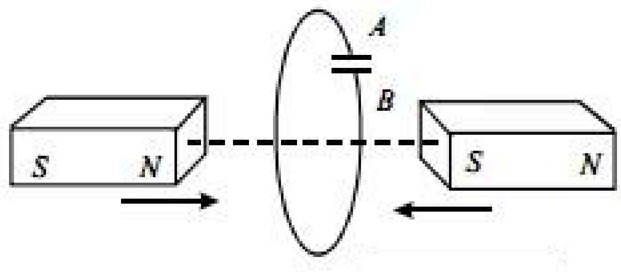
22. Draw a labelled ray diagram of refracting type telescope in normal adjustment. Write two main considerations required of an astronomical telescope.

23. The V–I characteristic of silicon diode is shown. Calculate the diode resistance in



(a) forward bias at V = 0.9 V and (b) reverse bias at V = – 3.0 V.

24. Predict the polarity of the capacitor in the situation described by adjoining figure. Explain the reason too.



OR

(i) Define mutual induction.

(ii) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s. what is the change of flux linkage with the other coil?

25. A parallel beam of light of 600 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1.2 m away. It is observed that the first minimum is at a distance of 3 mm from the centre of the screen. Calculate the width of the slit.

SECTION-C

26. Three identical specimens of a magnetic materials, nickel, antimony, aluminium are kept in a non-uniform magnetic field. Draw the modification in the field lined in each case.

27. An electric dipole of length 4 cm, when placed with its axis making an angle of 60° with a uniform electric field, experiences a torque of $4\sqrt{3}$ Nm. Calculate the potential energy of the dipole, if it has charge ± 8 nC.

28. Draw a plot of potential energy of a pair of nucleons, as a function of their separation. Write two important conclusions which you can draw regarding the nature of nuclear forces.

OR

In heavy nuclei, number of neutrons is more than number of protons, why?

29. (a) What is the significance of negative sign in the expression for the energy?

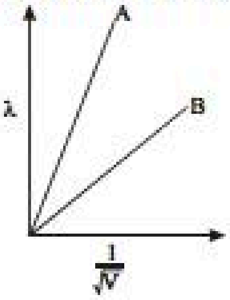
(b) Draw the energy level diagram showing how the line spectra corresponding to Paschen series occur due to transition between energy levels.

OR

(i) In hydrogen atom, an electron undergoes transition from 2nd excited state to the first excited state and then to the ground state. Identify the spectral series to which these transitions belong.

(ii) Find out the wavelengths of the emitted radiations in the two cases.

30. The two lines marked A and B in the given figure, show a plot of de-Broglie wavelength λ versus, $\frac{1}{\sqrt{V}}$, where V is the accelerating potential for two nuclei ${}_1^2\text{H}$ and ${}_1^3\text{H}$.



(i) What does the slope of the lines represent?

(ii) Identify, which of the lines corresponded to these nuclei.

SECTION-D

31. (a) State Kirchhoff's rules and explain on what basis they are justified.

(b) Two cells of emfs E_1 and E_2 and internal resistances r_1 and r_2 are connected in parallel. Derive the expression for the (i) emf and (ii) internal resistance of a single equivalent cell which can replace this combination.

OR

What is drift velocity of electrons and relaxation time of free electrons in a metallic conductor carrying a current? Establish a relation between them?

32. State Biot Savart law, expressing it in the vector form. Use it to obtain the expression for the magnetic field at an axial point, distance 'd' from the centre of a circular coil of radius 'a' carrying current 'I'. Also, find the ratio of the magnitudes of the magnetic field of this coil at the centre and at an axial point for which $d = a\sqrt{3}$.

OR

(a) Draw the magnetic field lines due to a current carrying loop.

(b) State using a suitable diagram, the working principle of a moving coil galvanometer. What is the function of radial magnetic field and the soft iron core used in it?

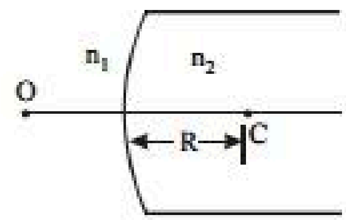
(c) For converting a galvanometer into an ammeter, a shunt resistance of small value is used in parallel, whereas in the case of a voltmeter a resistance of large vlaue is used in series. Explain why?

33. (a) Derive the prism formula, $n_{12} = \dfrac{\sin\dfrac{(A+\delta_m)}{2}}{\text{Sin}\dfrac{A}{2}}$

(b) Draw the graph showing the variation of the angle of deviation with angle of incidence, through a prism.

OR

Figure shows a convex spherical surface with centre of curvature C, separating the two media of refractive indices n_1 and n_2. Draw a ray diagram showing the formation of the image of a point object O lying on the principal axis. Derive the relationship between the object and image distance in terms of refractive indices of the media and the radius of curvature R of the surface.



SECTION-E

34. Case Study: Heating Effect of Current

Read the following paragraph and answer the questions.

The electric energy consumed in a circuit is defined as *the total work done in maintaining the current in an electric circuit for a given time.*

Electric energy = $VIt = Pt = I^2 Rt = V^2 t / R$

The **S.I. unit** of electric energy is joule (denoted by J)

where 1 joule = 1 watt × 1 second = 1 volt × 1 ampere × 1 sec.

In **household circuits** the electrical appliances are connected in parallel and the electrical energy consumed is measured in kWh

(i) Two 120 V light bulbs, one of 25 W and other of 200 W were connected in series across a 240 V line. One bulb burnt out almost instantaneously. Which one has burnt and why?

(ii) What happens to the power dissipation if the value of electric current passing through a conductor of constant resistance is doubled?

(iii) What is the largest voltage that you can safely put across a resistor marked 196 Ω-1 W?

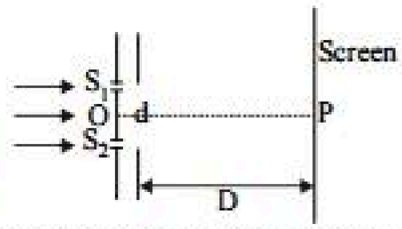
OR

(iii) A wire of radius r and another wire of radius 2r, both of same material and length are connected in series to each other. The combination is connected across a battery. Find the ratio of the heats produced in the two wires.

35. Case Study: Young's Double Slit Experiment

Read the following paragraph and answer the questions.

A student is performing Young's double slit experiment. There are two slits S_1 and S_2. Separation between them is d. There is large screen at a distance D(D >>d) from the slits. The set-up is shown in the following figure. A parallel beam of light is incident upon it. A monochromatic light of wavelength λ is used. The initial phase difference between the two slits which behaves as two coherent sources of light is zero.



The intensity of light waves on the screen coming out of S_1 and S_2 are same and is I_0. In this situation, the principal maximum is formed at the point P. At the point on screen where principal maximum is formed, phase difference between two interfering waves will be zero.

(i) What will be the effect on interference fringes if red light is replaced by blue light?

(ii) What is the effect on the interference fringes in a Young's double slit experiment when width of the two slits is increased?

(iii) What is the effect on the interference fringes in a Young's double slit experiment when monochromatic source is replaced by a source of white light.

OR

(iii) A double slit arrangement produces fringes for $\lambda = 5890$ Å that are 0.4° apart. What is the angular width if the entire arrangement is immersed in water ? ($\mu_w = 4/3$)

Solutions

SAMPLE PAPER-2

1. (c) $C = \frac{2 \times 2}{2+2} + 2 = 3\ \mu F$ (1 mark)

2. (c) The potential at any point of circular path will be same. (1 mark)

3. (a) $F = \frac{\mu_0}{4\pi} \times \frac{2 i_1 i_2}{r}$

$= 50 \times 10^{-7}$ N/m. Here F is force per unit length. (1 mark)

4. (b) Efficiency of the transformer

$\eta = \frac{P_{output}}{P_{input}} \times 100 = \frac{100}{220 \times 0.5} \times 100 = 90.9\%$ (1 mark)

5. (a) Small and negative (1 mark)

6. (c) Lenz's law is a consequence of the law of conservation of energy. (1 mark)

7. (d) Alternating current cannot be measured by D.C. ammeter because average value of A.C. for complete cycle is zero. (1 mark)

8. (d) Compare with $B_y = B_0 \sin(kx - \omega t)$

$\omega = 4 \times 10^8, K = 5$

Here, $B_0 = 5 \times 10^{-6}$

$\omega = 4 \times 10^8, K = 5$

$v =$ Speed of wave $= \frac{4 \times 10^8}{5} = 8 \times 10^7$ $\left[\therefore v = \frac{\omega}{k}\right]$

$E_0 = vB_0 = 40 \times 10^1 = 4 \times 10^2$ V/m (1 mark)

9. (d) $M = 4 = -\frac{V}{4} \Rightarrow V = -4u$

Using mirror formula $\frac{1}{V} + \frac{1}{4} = \frac{1}{F} \Rightarrow \frac{1}{-4u} + \frac{1}{4} = \frac{-1}{0.6}$

$\Rightarrow \frac{1-40}{-44} = \frac{-1}{0.6} \Rightarrow 4 = -0.45$ m (1 mark)

10. (a) From the graph it is clear that A and B have the same stopping potential and therefore the same frequency. Also B and C have the same intensity. (1 mark)

11. (c) $\frac{R_s}{R_{He}} = \left(\frac{A_s}{A_{He}}\right)^{1/3} = \left(\frac{32}{4}\right)^{1/3} = 2$ (1 mark)

12. (b) Rutherford's atomic model was unstable because electrons do not remain in orbit. (1 mark)

13. (b) To make a p-type semiconductor, pure silicon is doped with trivalent impurity like boron. (1 mark)

14. (a) On adding impurity. Conductivity of the semiconductor increases. (1 mark)

15. (b) Reverse resistance

$= \frac{\Delta V}{\Delta I} = \frac{1}{0.5 \times 10^{-6}} = 2 \times 10^6\ \Omega$ (1 mark)

16. (a) Resistance, $R = \rho \frac{l}{A}$

Here, ρ = resistivity

l = length

A = area of cross-section

Bending a wire does not change length (l) or area of cross-section (A). Hence, resistance remains same. (1 mark)

17. (b) At any point on equitorial plane of dipole, V = 0 (1 mark)

18. (c) $I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$

$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$ (1 mark)

19. (i) From graph (i), it is clear that resistance (opposition to current) is not changing with frequency, i.e., resistance does not depend on frequency of applied source, so the circuit element here is pure resistance (R).

From graph (ii), it is clear that resistance increases linearly with frequency, so the circuit element here is an inductor.

Inductive resistance $X_L = 2\pi f L \Rightarrow X_L \propto f$

(1 + 1 mark)

20. Given : $f_1 = 0.5\ m_1$, $f_2 = -1$m

Power of combination

$P = P_1 + P_2 = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{0.5} + \frac{1}{(-1)} = 2 - 1 = 1$ D

(2 marks)

OR

For plano-convex lens, $R_1 = \infty$; $R_2 = -10$ cm. $\mu = 1.5$

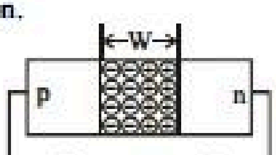
$\therefore \frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (1.5 - 1)\left(\frac{1}{\infty} - \frac{1}{-10}\right)$

$= 0.5 \times \frac{1}{10} = \frac{5}{100} = \frac{1}{20}$ $\therefore$ f = 20cm

Since the plane surface is silvered therfore the focal length

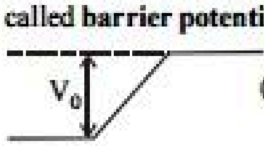
$= \frac{f}{2} = \frac{20}{2} = 10$cm (2 marks)

21. Electrons diffuse from $n \rightarrow p$ and holes diffuse from $p \rightarrow n$ side leaving a positively charged donor atom on n–side and negatively charged acceptor atom on p–side. This space charge region on either side is called depletion region. Near the junction this region depletes the movement of free charges. Hence, electric field due to positive space charge on n–side and negative space charge on p–side is created. Due to this electrons and holes now drift in opposite direction in this field and further extend this region.



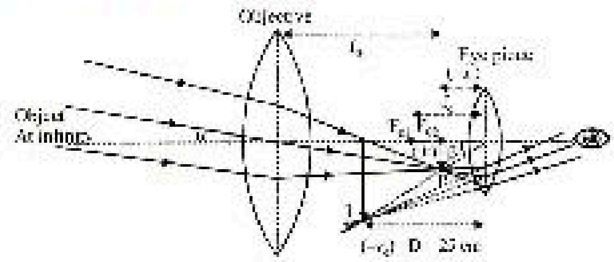
Diode under equilibrium V = 0

Thus a different polarity potential is developed which prevents movement of electron from n–region to p–region, called **barrier potential** and there is no net current.



(b) Barrier potential under no bias (2 marks)

22. The labelled ray diagram of refracting type teloscope in normal adjustment is as shown :



(1 mark)

The two considerations are (i) Objective should be of large focal length and apearture (ii) Eyepiece should be of small focal length and aperture. (½ + ½ mark)

23. (a) In forward bias, $V = +0.9V$

$\Delta V = BE = 1.0 - 0.8 = 0.2\ V$

$\Delta I = CE = 10 - 6 = 4\ mA$

∴ Forward resistance,

$$R_f = \frac{\Delta V}{\Delta I} = \frac{0.2}{4 \times 10^{-3}} = 50\Omega.$$ (1 mark)

(b) Reverse characteristics, $V = -3\ V$

$\Delta V = -2 - (-4) = 2\ V$

$\Delta I = 3 - 2 = 1\ \mu A$

∴ Reverse resistance,

$$R_r = \frac{\Delta V}{\Delta I} = \frac{2V}{1 \times 10^{-6}} = 2 \times 10^6\ \Omega.$$ (1 mark)

24. Induced current is in anticlockwise when seen from left hand side and its direction is in clockwise when seen from right hand side.

Therefore B is as negative plate while *A* is as (+) ve plate. (1 + 1 mark)

OR

(i) Mutual induction: It is the phenomenon in which a change of current in one coil induces an emf in another coil placed near it. The coil in which the current changes is called the primary coil and the coil in which the emf is induced is called the secondary coil. (1 mark)

(ii) As we know, $e = -M\frac{dI}{dt}$

$$e = -1.5 \times \frac{20 - 0}{0.5} = -60V$$

So, the flux linked with the other coil is given by

$$\Delta\phi = e \times \Delta t = -60 \times 0.5 = -30\ Wb$$ (1 mark)

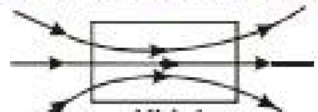
25. Given : $\lambda = 600\ nm = 600 \times 10^{-9}\ m$, $D = 1.2\ m$, $\beta = 3 \times 10^{-3}\ m$, $d = ?$

Distance of the first minimum

$$\beta = \frac{\lambda D}{d} \Rightarrow d = \frac{\lambda D}{\beta} = \frac{600 \times 10^{-9} \times 1.2}{3 \times 10^{-3}} = 2.4 \times 10^{-4}\ m$$

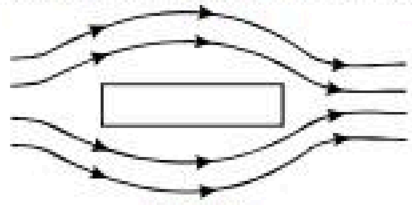
(2 marks)

26. Nickel is a ferromagnetic substance so field lines



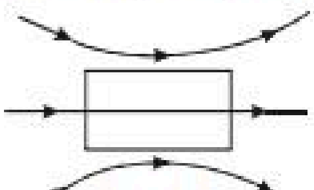
Nickel

Antimony is a diamagnetic substance so field lines



Antimony

Aluminium is a paramagnetic substance so field lines



Aluminium

(3 marks)

27. Torque on a dipole which is placed in an uniform electric field (E) is given by,

$$\tau = PE\sin\theta = (ql)\,E\sin\theta \quad ...(1)$$

Here, *l* is the length of the dipole, Q is the charge and E is the electric field. (1½ marks)

Potential energy,

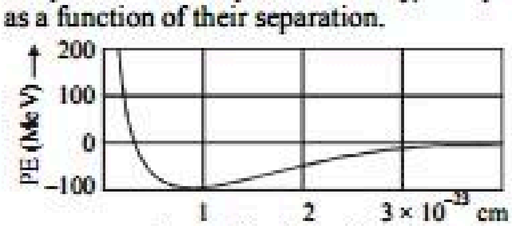
$$U = -PE\cos\theta = -(ql)\,E\cos\theta \quad ...(2)$$

Dividing (2) by (1), $\frac{\tau}{U} = \frac{qlE\sin\theta}{-qlE\cos\theta} = -\tan\theta$

$$\Rightarrow U = \frac{-\tau}{\tan\theta} \Rightarrow U = \frac{-\tau}{\tan 60^\circ} \Rightarrow U = \frac{-4\sqrt{3}}{\sqrt{3}}$$

$\Rightarrow U = -4J$ (1½ marks)

28. Graph between the potential energy of a pair of nucleons as a function of their separation.



Separation (in cm) (2 marks)

The conclusions drawn from the graph are

(i) Nuclear force is a short range force.

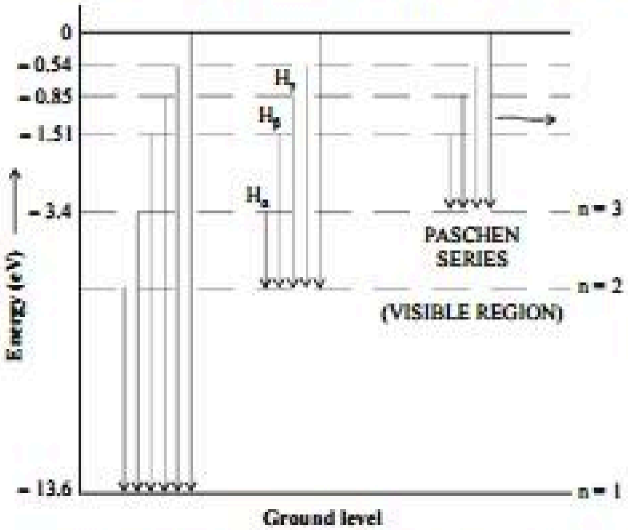
(ii) Nuclear force is of attractive nature for separation between the nuclei greater than 1 fm and of repulsive nature when separation in less than 1 fm. (1 mark)

OR

If number of protons is large, coulomb's repulsion would be large hence nucleus would split. To hold the nucleons inside the nucleus no. of neutrons is large to increase nuclear force which is a short range force and acts between neighbours only. (3 marks)

29. (a) The negative sign in the expression for the energy signify that the electron is bound to the nucleus and is not free. (1 mark)

(b) Energy level diagram for the Paschen series



(2 marks)

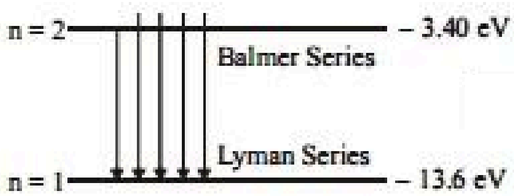
The Paschen series of the hydrogen atom is produced when transitions take place from higher orbits to the third orbit.

i.e., $n_1 = 3$ and $n_2 = 4, 5, 6,$ .... so on.

OR

(i) An electron undergoes transition from 2nd excited state to the first excited state is Balmer series and then to the ground state is Lyman series. (1 mark)

(ii) The wavelength of the emitted radiations in the two cases.



For $n_2 \xrightarrow{\lambda} n_1$

$$\Delta E = (-3.40 + 13.6) = 10.20\,\text{eV}$$

$$\lambda = \frac{12.43 \times 10^{-7}}{10.2} = 1.218 \times 10^{-7}\,\text{m}$$

$\lambda = 1218$ Å (2 marks)

30. $\because$ de-Broglie wavelength of accelerating charge particle is given by

$$\lambda = \frac{h}{\sqrt{2mqV}} \Rightarrow k\sqrt{V} = \frac{h}{\sqrt{2mq}} = \text{constant} \quad \text{(1 mark)}$$

(i) The slope of the line represent $\frac{h}{\sqrt{2mq}}$ (1 mark)

(ii) ${}_1H^2$ and ${}_1H^3$ carry same charge (as they have same atomic number)

$$\therefore \quad \lambda\sqrt{V} = \frac{1}{\sqrt{m}} \quad \text{(1 mark)}$$

The lighter mass i.e., ${}_1H^2$ is represented by line of greater slope i.e., A and similarly ${}_1H^3$ by line B.

31. (a) Kirchhoff's first rule (Junction rule): The algebraic sum of the currents meeting at a point in an electrical circuit is always zero.

$$\sum I = 0$$

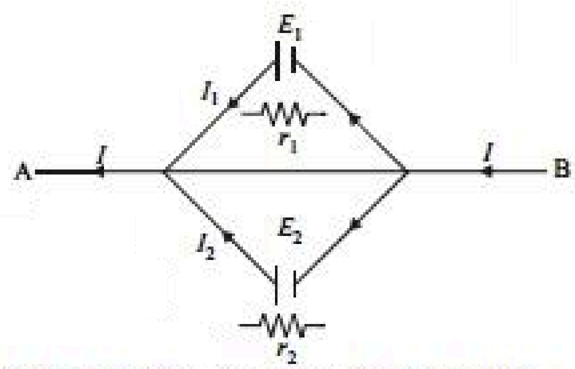
This law is justified on the basis of law of conservation of charge.

Kirchhoff's second law (Loop rule): In a closed loop, the algebraic sum of the emfs is equal to the algebraic sum of the products of the resistances and the current flowing through them.

$$\sum \varepsilon + \sum IR = 0 \quad \text{(2 marks)}$$

This law is justified on the basis of law of conservation of energy.

(b)



Terminal potential difference across the first cell is

$V = E_1 - I_1 r_1 \Rightarrow I_1 = \frac{E_1 - V}{r_1}$

For the second cell, terminal potential difference will be equal to that across the first cell. So, $V = E_2 - I_2 r_2$

$$\Rightarrow \quad I_2 = \frac{E_2 - V}{r_2}$$

Let E be effective emf and r is effective internal resistance. Let I be the current flowing through the cell.

$I = I_1 + I_2$

$$\Rightarrow \quad I = \frac{E_1 - V}{r_1} + \frac{E_2 - V}{r_2}$$

$$\Rightarrow \quad I = \frac{r_2(E_1 - V) + r_1(E_2 - V)}{r_1 r_2}$$

$$\Rightarrow \quad I r_1 r_2 = E_1 r_2 + E_2 r_1 - (r_1 + r_2)V$$

$$\Rightarrow \quad V = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2} - \frac{I r_1 r_2}{r_1 + r_2}$$

Comparing the equation with $V = E - Ir$, we get

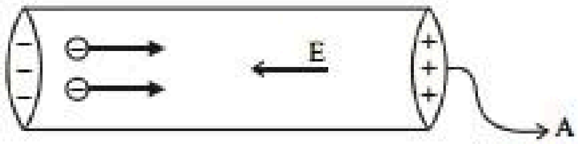
$$\text{Emf, } E = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$$

$$\text{Internal resistance, } r = \frac{r_1 r_2}{r_1 + r_2} \quad \text{(3 marks)}$$

OR

Drift velocity is defined as the average velocity with which the free electrons get drifted towards the positive end of the conductor under the influence of an external electric field.

Relaxation time is the average time that has elapsed since each electron suffered its last collision with the atoms or ions of conductor.



(1 mark)

Consider a metalic conductor of length l, and V be the potential difference applied across the ends. Then the magnitude of electric field,

$E = \frac{V}{\ell}$.

Since the charge on electron is −e, each electron experiences a force,

$\overline{F} = -e\overline{E}$ ......(i)

If m is the mass of an electric, the acceleration of each electron is,

$\bar{a} = \frac{-e\overline{E}}{m}$ ....(ii)

Due to this acceleration, apart from its thermal velocity, acquires additional velocity compenent in a direction opposite to the direction of electric field. At any instant of time, the velocity acquired by electron having thermal velocity u_1 will be $\vec{v}_1 = \vec{u}_1 + \bar{a}\tau_1$ and so on.

Where τ_1 is the time elapsed after it's last collision.

∴ The average velocity of all the electrons in the conductor (i.e., the drift velocity)

$\vec{v}_d = \frac{\vec{v}_1 + \vec{v}_2 + ... + \vec{v}_n}{n} = \frac{\bar{a}(\tau_1 + \tau_2 + ... + \tau_n)}{n}$ (Since the average thermal velocity of electrons is zero).

$= \bar{a}\tau$ where $\tau = \frac{\tau_1 + \tau_2 + ... + \tau_n}{n}$ is the relaxation time. (3 marks)

Putting the value of $\bar{a}$ from (2) drift velocity speed

$\vec{v}_d = \frac{e\bar{E}\tau}{m}$.

∴ Average drift speed $v_d = \frac{eE\tau}{m}$ (1 mark)

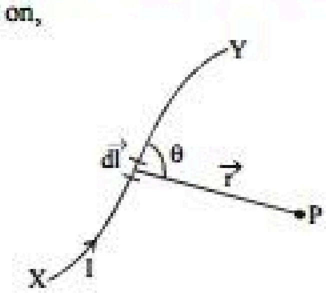
32. **Biot-Savart's law:–** The strength of magnetic field or magnetic flux density at a point P (dB) due to current element dl depends on,

(i) $dB \propto I$

(ii) $dB \propto dl$

(iii) $dB \propto \sin\theta$

(iv) $dB \propto \frac{1}{r^2}$,



Combining, $dB \propto \frac{Idl\sin\theta}{r^2} \Rightarrow dB = k\frac{Idl\sin\theta}{r^2}$

[k = Proportionality constant]

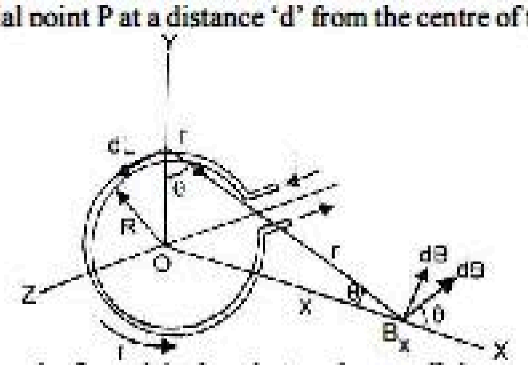
In S.I. units, $k = \frac{\mu_0}{4\pi}$ where μ_0 is called permeability of free space.

$\mu_0 = 4\pi \times 10^{-7}\ TA^{-1}m$

∴ $dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$ and, $d\overline{B} = \frac{\mu_0}{4\pi}I\frac{(\overline{dl} \times \overline{r})}{r^3}$ (2 marks)

$d\overline{B}$ is perpendicular to the plane containing $d\overline{\ell}$ and $\overline{r}$ and is directed inwards.

Let there be a circular loop of wire whose centre O and radius a located in the YZ plane and carrying a steady current I. We have to calculate the magnetic field at an axial point P at a distance 'd' from the centre of the loop.



From the figure it is clear that any lement dL is perpendicular to $\hat{r}$, furthermore all the elements around the loop are at the same distance r from P, where $r^2 = d^2 + a^2$.

Now from Biot Savart's law the magnetic field at point P due to the current element dL

$$dB = \frac{\mu_0}{4\pi}\frac{I\left|\overline{dL} \times \hat{r}\right|}{r^2} = \frac{\mu_0}{4\pi}\frac{IdL}{(d^2 + a^2)} \quad ...(i)$$

The direction of the magnetic field dB due to the element dL is perpendicular to the plane formed by $\hat{r}$ and dL as shown in figure above. The vector dB can be resolved into components dB_x aong the X axis and dBy which is perpendicular to the X-axis when the components perpendicular to the X-axis are assumed over the whole loop, the result is zero. That is, by symmetry any element on one side of the loop will set up a perpendicular component that cancels the component set up by an element diametrically opposite it. Therefore, it is obvious that the resultant magnetic field at P will be along the X-axis. This result can be obtained by integrating the component $dB_x = dB\cos\theta$. Therefore,

$$B = \oint dB\cos\theta = \frac{\mu_0 I}{4\pi}\oint\frac{dL\cos\theta}{d^2 + a^2} \quad ...(ii)$$

where the integral is to be taken over the entire loop since θ, x are constants for all elements of the loop and since

$\cos\theta = \frac{a}{\sqrt{d^2 + a^2}}$, therefore,

$$B = \frac{\mu_0 Ia}{4\pi(d^2 + a^2)^{3/2}}\oint dL = \frac{\mu_0 Ia^2}{2(d^2 + a^2)^{3/2}}$$

$$B_C = \frac{\mu_0 I}{2a}$$

And magnetic field on the axial line, when $d = a\sqrt{3}$

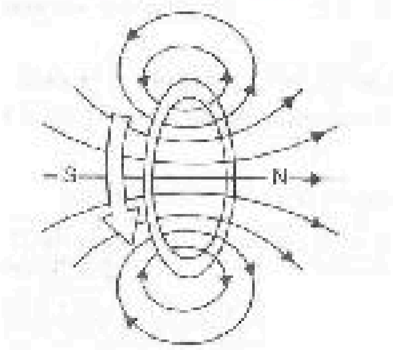
$$B_d = \frac{\mu_0 Ia^2}{2(3a^2 + a^2)^{3/2}} = \frac{\mu_0 Ia^2}{16a^3} = \frac{\mu_0 I}{16a} \quad ...(iv)$$

From (iii) and (iv)

$$\frac{B_c}{B_d} = \frac{\frac{\mu_0 I}{2a}}{\frac{\mu_0 I}{16a}} = 8$$ (3 marks)

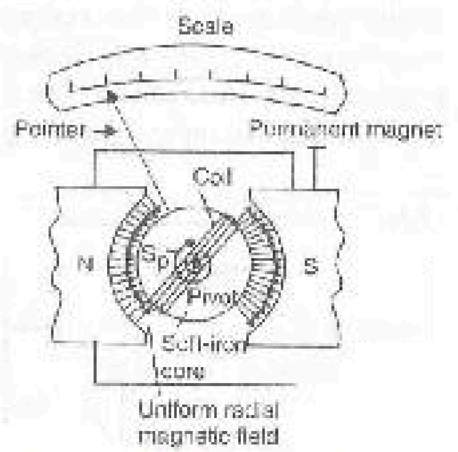
OR

(a) The magnetic field due to a current carrying loop :



(1 mark)

(b) The labelled diagram of a moving coil galvanometer :



Working principle : When a current carrying coil is placed in a magnetic field, it experience a torque, which tends to rotate it.

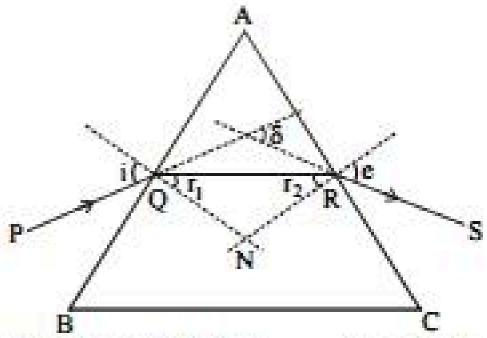
Function of radial magnetic field : It ensures that the plane of the coil remains parallel to the magnetic field.

Function of sof iron core : It ensures that the magnetic field is strong and remains on the coil. (2 marks)

(c) An ammeter is an instrument for measuring current therefore, its resistance has to be kept low as it is connected in series. Hence shunt of low resistance is joined in parallel to convert a galvanometer into an ammeter.

A voltmeter is a high resistance device. It is connected in parallel. Therefore its resistance is kept high such that the current in the main circuit is not affected. Hence a high resistance is joined in parallel to convert a galvanometer into a voltmeter. (2 marks)

33. Consider a triangular prism ABC. The angles of incidence and refraction at the first face AB are i and r_1, while the angle of incidence at the second face AC is r_2 and the angle of emergence e. The angle between the emergent ray and the direction of the incident ray is called the angle of deviation, δ.



From the Quadrilateral AQNR, $\angle A + \angle QNR = 180°$

From the triangle QNR, $r_1 + r_2 + \angle QNR = 180°$

Comparing these two equations,

$r_1 + r_2 = A$ ...(i)

The total deviation,

$\delta = (i - r_1) + (e - r_2)$

ie., $\delta = i + e - A$ ...(ii)

(since $r_1 + r_2 = A$)

Thus the angle of deviation depends on the angle of incidence.

$\therefore \quad \delta = \delta_m, i = e \Rightarrow r_1 = r_2$.

equation (i) gives,

$2r = A \text{ or } r = \frac{A}{2}$ ...(iii)

Also equation (ii) gives,

$\delta_m = 2i - A \quad \text{or} \quad i = \frac{(A + \delta_m)}{2}$ ...(iv)

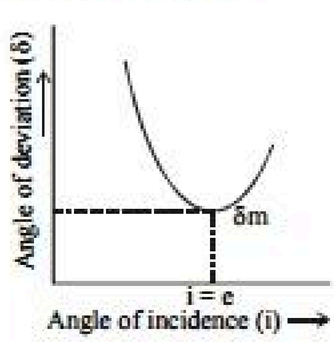
The refractive index of the prism is

$$n_{21} = \frac{n_2}{n_1} = \frac{\sin\left[\left(\frac{A + \delta_m}{2}\right)\right]}{\sin\left[\frac{A}{2}\right]}$$ ...(v)

For a small angled prism D_m is also very small.

So, $$n_{21} = \frac{\sin\left[\left(\frac{A + \delta_m}{2}\right)\right]}{\sin\left[\frac{A}{2}\right]}$$ (3 marks)

(b) A graph between angle of deviation and angle of incidence is shown below.



(2 marks)

From the graph we can see that at the minimum deviation δ_m, the refracted ray inside the prism becomes parallel to its base.

OR

From figure,

$PC = +R$

$PI = +v$

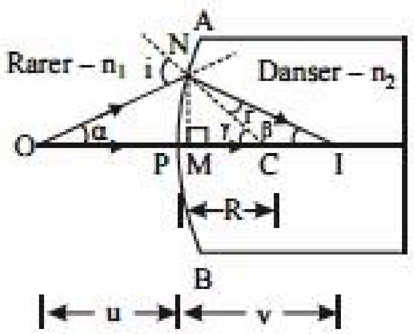
$PO = -u$

Let, $NM = h$

The convex spherical refracting surface forms the image of object O and I. The radius of curvature is R

In ΔNCO, $i = \gamma + \alpha$ ...(i)

In ΔNCI, $\gamma = r + \beta$



(2 marks)

$\Rightarrow \quad r = \gamma - \beta$ ...(ii)

For small angles α, β and γ, we have

$$\left.\begin{aligned} \alpha \simeq \tan\alpha &= \frac{MN}{MO} = \frac{MN}{PO} = \frac{+h}{-u} \\ \beta \simeq \tan\beta &= \frac{MN}{MI} = \frac{MN}{PI} = \frac{h}{-v} \\ \gamma \simeq \tan\gamma &= \frac{MN}{MC} = \frac{MN}{PC} = \frac{h}{+R} \end{aligned}\right\} \quad \text{...(iii)}$$

Assuming M is very close to P.

By Snell's law, $\frac{n_2}{n_1} = \mu = \frac{\sin i}{\sin r}$

For small i and r,

$$\frac{n_2}{n_1} = \frac{i}{r} \text{ or } rn_2 = in_1 \quad n_2(\gamma - \beta) = (\alpha - \gamma)n_1$$

[From Eqs. (i) and (ii)]

$$(n_2 - n_1)\gamma = n_1\alpha + n_2\beta$$

$$(n_2 - n_1)\left(\frac{h}{R}\right) = n_1\left(\frac{h}{-u}\right) + n_2\left(\frac{h}{v}\right) \quad \text{[From Eq. (iii)]}$$

$$\Rightarrow \quad \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$ (3 marks)

34. (i) As $P = \frac{V^2}{R}$.

$\therefore$ 25 W bulb has more resistance. Same current flows through both of them. So the 25 W bulb will develop more heat and burns out instantaneously. (1 mark)

(ii) $\because P = I^2R$, If I is doubled, it becomes 4 times. (1 mark)

(iii) $V^2 = PR \Rightarrow V = \sqrt{196 \times 1} = 14$ volt. (2 marks)

OR

(iii) $H = I^2 Rt$. Here $R_1 = \rho\frac{\ell}{\pi r^2}$ and $R_2 = \rho\frac{\ell}{\pi(2r)^2}$.

That is, $R_1 = 4R_2$. Hence, $\frac{H_1}{H_2} = 4$. (2 marks)

35. (i) As $\beta = \frac{D\lambda}{d}$ i.e. $\beta \propto \lambda \quad \because \lambda_b < \lambda_r$

Therefore fringe width is reduced and fringes come closer. (1 mark)

(ii) Fringe width, $\beta = \frac{D\lambda}{d}$

Here, D = distance between screen to slits

d = distance between slits

When slit width (d) increases, fringe width will decrease. (1 mark)

(iii) Coloured fringes are formed at screen. (2 marks)

OR

(iii) Let θ be the angular width in water. We know angular width = $\frac{\lambda}{d}$

$\Rightarrow$ Angular width $\propto \lambda$ (1 mark)

$$\frac{\theta}{0.4^\circ} = \frac{\lambda_w}{\lambda_a} \quad \text{...... (i)}$$

Now, ${}_a\mu_w = \frac{\lambda_a}{\lambda_w} \Rightarrow \frac{\lambda_a}{\lambda_w} = \frac{4}{3}$

Hence from eq. (1), we have

$$\frac{\theta}{0.4^\circ} = \frac{3}{4} \Rightarrow \theta = 0.3^\circ$$ (1 mark)