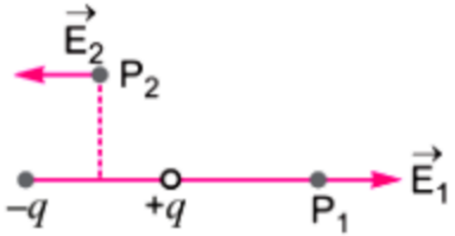
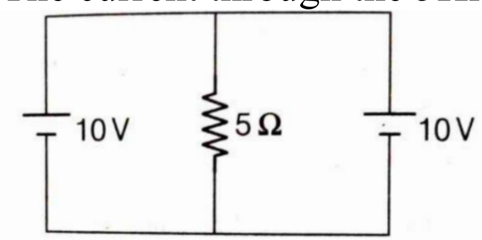
Pre-Board Examination : 2025-26
Sub : Physics

(The figures in the margin indicate full marks for the questions)

Time – 3 hours **Full marks-70**

1.	**Answer following questions : 1x8=8**
a	What is the angle between the directions of electric dipole moment and electric field at any, (i) axial point and (ii) equatorial point due to an electric dipole?
Ans	 The angle between the directions of electric dipole moment and electric field at any, on the axial point is **0^0** and on the equatorial point is **180^0** due to an electric dipole?
b	The current through the 5Ωresistor is  (a) 2A (b) 4A (c) Zero (d) 1A
Ans	If the batteries are arranged such that their positive terminals face each other, the net voltage is:

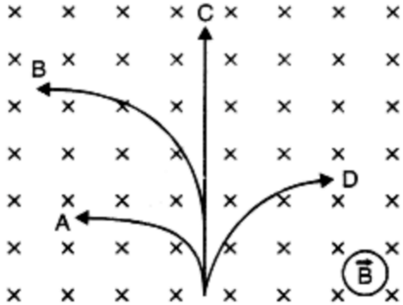
If the batteries are arranged such that their positive terminals face each other, the net voltage is: $V_{net} = 10V - 10V = 0V$

Substituting this into Ohm's Law:

Using Ohm's Law, the current I is

$$I = \frac{V_{net}}{R} = \frac{0V}{5\Omega} = 0A$$

c A neutron, a proton, an α particle and an electron enter a region of constant magnetic field with equal velocities . The magnetic field is along the inward normal to the plane of the paper.



The tracks of the particles are labelled in figure. The electron follows track…. and the alpha particle follows track….

(a) A , C (b) C , A (c) B , D (d) D , B

Ans (d) D , B

Track D (Electron): Negatively charged, deflected to the right.

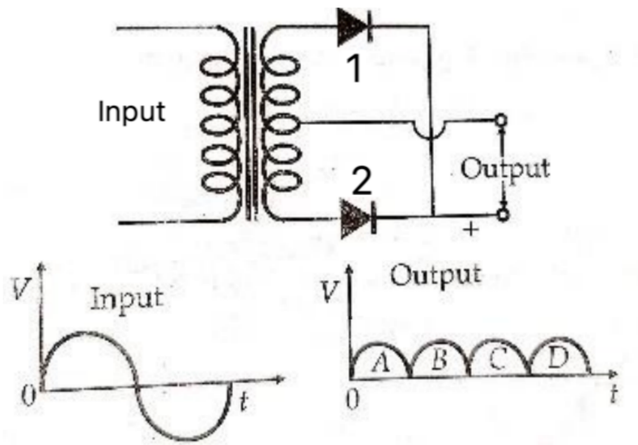
Track B (αParticle): Positively charged, deflected to the left with a larger radius.

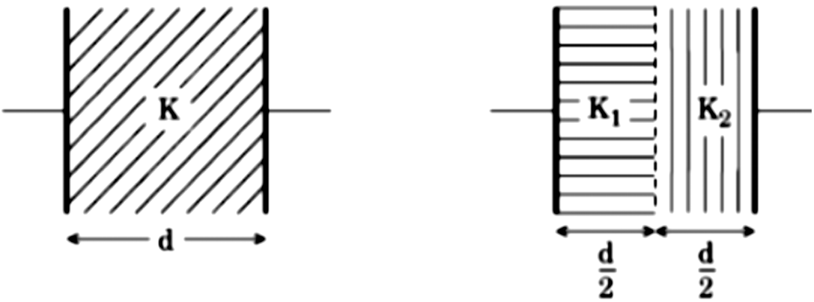
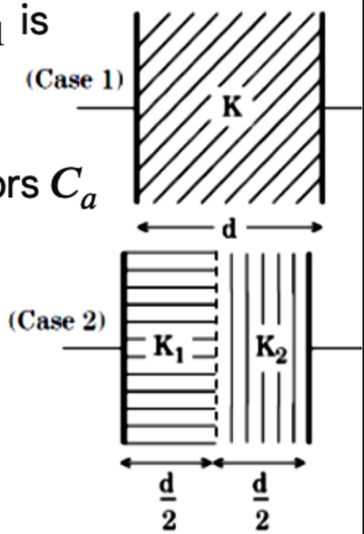
Track A (Proton): Positively charged, deflected to the left with a smaller radius.

Track C (Neutron): Uncharged, no deflection.

d A coil having 500 sq. loops of side 10 cm is placed

	normal to magnetic flux which increases at a rate of 1 T/s. The induced emf is (a) 0.1V (b) 0.5V (c)1V (d) 5 V
Ans	Number of turns (N): **500** Side of the square loop (s): **10 cm = 0.1 m** Rate of change of magnetic flux/field ($\frac{dB}{dt}$): **1 T/s** The area (A) of one square loop is $A = s^2 = (0.1\,\text{m})^2 = 0.01\,\text{m}^2$ According to Faraday's Law, the induced emf (ε) for a coil with N turns is: $\varepsilon = N \cdot A \cdot \frac{dB}{dt}$ $\Longrightarrow \varepsilon = 500 \times 0.01\,\text{m}^2 \times 1\,\text{T/s} = 5\,\text{V}$
e	In an AC circuit V and I are given by $V = 50 \sin 50t$ volt and $I = 100 \sin (50t + \pi/3)$ mA. The power dissipated in the circuit (a)2.5 kW (b) 1.25 kW (c) 5.0 kW (d) 500 W
Ans	Peak voltage: $V_0 = 50\text{ V}$ Peak current: $I_0 = 100\text{ mA} = 0.1\text{ A}$ Phase difference: $\phi = \frac{\pi}{3}$ The average power dissipated in an AC circuit is $P_{avg} = V_{rms} I_{rms} \cos\phi = \frac{V_0 I_0}{2}\cos\phi = \frac{50 \times 0.1}{2}\cos\left(\frac{\pi}{3}\right) = \frac{5}{2} \times 0.5 = 1.25\text{ W}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$ $I_{rms} = \frac{I_0}{\sqrt{2}}$
f	Which of the following metals is not sensitive to

	visible light? (a) Cesium (b)Sodium (c) Rubidium (d) Cadmium
Ans	(b)
g	The ionisation energy of hydrogen atom is 13.6 eV. Following Bohr's theory the energy corresponding to a transition between 3rd and 4th orbits is (a) 3.40 eV (b) 1.51 eV (c) 0.85 eV (d) 0.66 eV
Ans	According to Bohr's theory, the energy of an electron in the n^{th} orbit of a hydrogen atom is given by: $E_n = -\frac{13.6}{n^2}$ eV For $n = 3$: $E_3 = -\frac{13.6}{3^2} = -\frac{13.6}{9} \approx -1.51$ eV For $n = 4$: $E_4 = -\frac{13.6}{4^2} = -\frac{13.6}{16} = -0.85$ eV $\Delta E = \lvert E_4 - E_3 \rvert = \lvert -0.85 - (-1.51) \rvert = 1.51 - 0.85$ $\Rightarrow \Delta E = 0.66$ eV
h	A full wave rectifier circuit along with the output is shown. The contribution from the diode 2 are  (a) C (b) A , C (c) B,D (d) A,B,C,D

Ans	(c) B,D
2	The space between the plates of a parallel plate capacitor is completely filled in two ways. In the first case, it is filled with a slab of dielectric constant K. In the second case, it is filled with two slabs of equal thickness and dielectric constantsK_1 and K_2 respectively as shown in the figure. The capacitance of the capacitor is same in the two cases. Obtain the relationship between, K, K_1 and K_2  (Case 1) (Case 2) 2
Ans	In the first case, capacitance C_1 is $C_1 = \frac{K\epsilon_0 A}{d}$ In the second case, two capacitors C_a and C_b connected in series: $C_a = \frac{K_1\epsilon_0 A}{d/2} = \frac{2K_1\epsilon_0 A}{d}$ $C_b = \frac{K_2\epsilon_0 A}{d/2} = \frac{2K_2\epsilon_0 A}{d}$ 

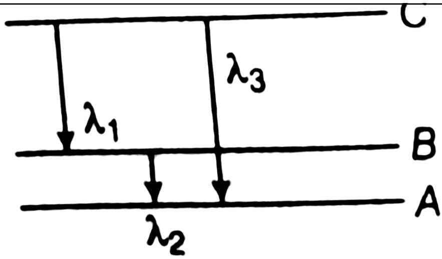
	The equivalent capacitance C_2 is $\frac{1}{C_2} = \frac{1}{C_a} + \frac{1}{C_b} = \frac{d}{2K_1\epsilon_0 A} + \frac{d}{2K_2\epsilon_0 A}$ $\Rightarrow \frac{1}{C_2} = \frac{d}{2\epsilon_0 A}(\frac{1}{K_1} + \frac{1}{K_2}) = \frac{d(K_1+K_2)}{2K_1K_2\epsilon_0 A}$ $\Rightarrow C_2 = \frac{2K_1K_2\epsilon_0 A}{d(K_1+K_2)}$ Since the capacitance is the same in both cases, we set $C_1 = C_2$: $\Rightarrow \frac{K\epsilon_0 A}{d} = \frac{2K_1K_2\epsilon_0 A}{d(K_1+K_2)}$ $\Rightarrow K = \frac{2K_1K_2}{K_1+K_2}$
3	Define temperature coefficient of resistance. The resistance of a tungsten filament at 150^0C is 133Ω . What will be its resistance at 5000C? Given the temperature coefficient of tungsten is 0.0045 $^{0}C^{-1}$.
Ans	The resistance R_t of a conductor at a temperature t is $R_t = R_0(1+\alpha t)$ where R_0 be the resistance at 0˚C where α is the temperature coefficient of resistance. At 150˚C: $133 = R_0(1 + 0.0045 \times 150)$ At 500˚C: $R_{500} = R_0(1 + 0.0045 \times 500)$ $\frac{R_{500}}{133} = \frac{1+(0.0045\times 500)}{1+(0.0045\times 150)} \Longrightarrow \frac{R_{500}}{133} = \frac{1+2.25}{1+0.675}$ $\Longrightarrow \frac{R_{500}}{133} = \frac{3.25}{1.675} = 1.9403$ $\Longrightarrow R_{500} = 133 \times 1.9403 = \mathbf{258.1\ \Omega}$.

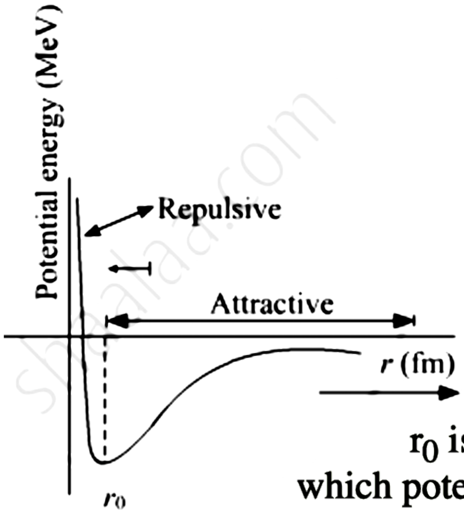
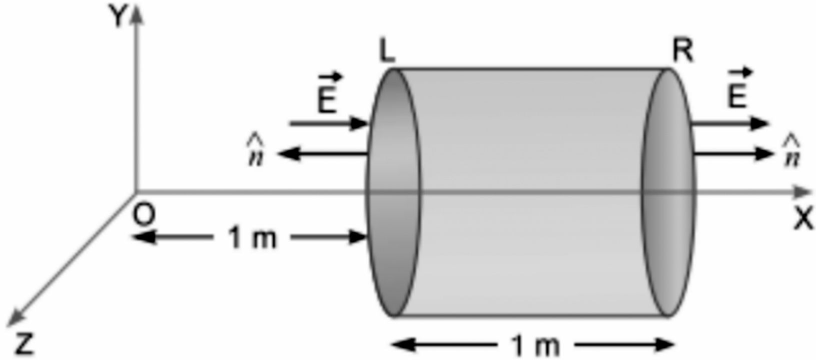
4	The oscillating magnetic field of an EM wave is given by $B_y = 8 \times 10^{-6} \sin [\, 2 \times 10^{11} t + 300\,\pi x]$ Tesla (a) Calculate the wave length of EM wave (b) Write down the expression for oscillating electric field. 2
Ans	The given magnetic field equation is $B_y = 8 \times 10^{-6} \sin[2 \times 10^{11} t + 300\pi x]$ Comparing this with $B_y = B_0 \sin(\omega t + kx)$ $k = 300\pi$ rad/m The wavelength λ is given by: $\lambda = \frac{2\pi}{k}$ $\lambda = \frac{2\pi}{300\pi} = \frac{1}{150} \approx \mathbf{0.00667}$ m Given $B_0 = 8 \times 10^{-6}$ T The amplitude of the electric field E_0 is $E_0 = cB_0$ $E_0 = (3 \times 10^8) \times (8 \times 10^{-6}) = \mathbf{2400}$ V/m The wave travels in the negative x-direction The electric field oscillates in phase with the magnetic field along the z-axis: $E_z = E_0 \sin(\omega t + kx)$ $\mathbf{E_z} = \mathbf{2400} \sin[\mathbf{2 \times 10^{11} t + 300\pi x}]$ V/m
5	Electromagnetic radiations with wavelength: (i) λ_1 are used to kill germs in water purifier.

	(ii) λ_2 are used in TV communications. (iii) λ_3 play an important role in maintaining earth's warmth. Name the part of EM spectrum to which these radiations belongs. Arrange these wavelengths in decreasing order of their magnitude. 2
Ans	The electromagnetic radiations mentioned belong to the following parts of the EM spectrum: ◦ λ_1 (Used to kill germs in water purifiers): Ultraviolet (UV) rays. ◦ λ_2 (Used in TV communications): Radio waves. ◦ λ_3 (Maintaining Earth's warmth): Infrared (IR) radiation, which is responsible for the greenhouse effect. **Decreasing Order of Wavelength Magnitude •** The wavelengths arranged in decreasing order (from longest to shortest) are: 1 λ_2 (Radio waves) - Longest wavelength. 2 λ_3 (Infrared radiation) - Intermediate wavelength. 3 λ_1 (Ultraviolet rays) - Shortest wavelength. ® Order: $\lambda_2 > \lambda_3 > \lambda_1$
6	Yellow light (λ = 6000Å) illuminates a single slit of width 1 x 10^{-4} m. Calculate (i)the distance between the two dark lines on either side of the central maximum, when the diffraction pattern is viewed on a screen kept 1.5 m away from the slit (ii)the angular spread of the first diffraction minimum

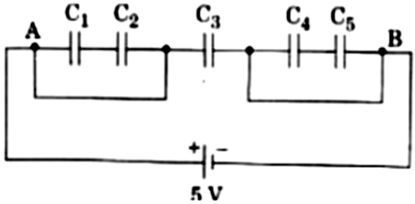
	2
Ans	(i) Here, $\lambda = 6000Å = 6 \times 10^{-7}m$ $a = 1 \times 10^{-4}m, D = 1.5m$ Angular separation of two dark bands on each side of central bright band, $2\theta = \frac{2\lambda}{a}$ and actual distance between them, $2x = \frac{2\lambda}{a} \times D = \frac{2 \times 6 \times 10^{-7} \times 1.5}{1 \times 10^{-4}}$ $= 1.8 \times 10^{-2}m$ (ii) For first minimum, $(\sin\theta \approx \theta)$ $\theta = \frac{\lambda}{a} = \frac{6 \times 10^{-7}}{1 \times 10^{-4}} = 6 \times 10^{-3}$ rad
7	An alpha particle, a proton and an electron are moving with equal kinetic energy. Which one of these particles has the longest de-Broglie wavelength? Give reason. 2
Ans	De-Broglie's wavelength is given as, $\lambda = \frac{h}{\sqrt{2mK}}$ Where, h is Planck's constant, *m* is the mass of the particle, *K* is the kinetic energy of the particle The mass of the electron is least among an electron, an alpha particle, and a photon. $\because \lambda \propto \frac{1}{\sqrt{m}}$, therefore, the electron has the largest de-Broglie wavelength.
8	Explain briefly the Hallwach's experimental observation on photoelectric effect. 2

9	The work function of caesium metal is 2.14 eV. when light of frequency 6×10^{14} Hz is incident on the metal surface, photoemission of electrons occurs. Find a) Energy of incident photon b)Maximum kinetic energy of photoelectrons. 2
	(a) The maximum kinetic energy is by photoelectric effect : $K = hv - \phi_0$ Where, $h = 6.626 \times 10^{-34}$ Js $\therefore K = \frac{6.626 \times 10^{-34} \times 6 \times 10^{14}}{1.6 \times 10^{-19}} - 2.14$ $= 2.485 - 2.140 = 0.345$ eV **(b) For stopping potential V_0, for kinetic energy** $K = eV_0$ $\therefore V_0 = \frac{K}{e} = \frac{0.345 \times 1.6 \times 10^{-19}}{1.6 \times 10^{-19}} = 0.345$ V **(c) Maximum speed of the emitted photoelectrons = v** $K = \frac{1}{2}mv^2$ Where, m = Mass of an electron $= 9.1 \times 10^{-31}$ kg $v^2 = \frac{2K}{m} = \frac{2 \times 0.345 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}} = 0.1104 \times 10^{12}$ $\therefore v = 3.323 \times 10^5$ m/s = 332.3 km/s **Hence, the maximum speed of the emitted photoelectrons is 332.3 km/s.**
10	Find the relation between the three wavelengths λ_1, λ_2 and λ_3 from the energy level diagram shown below.

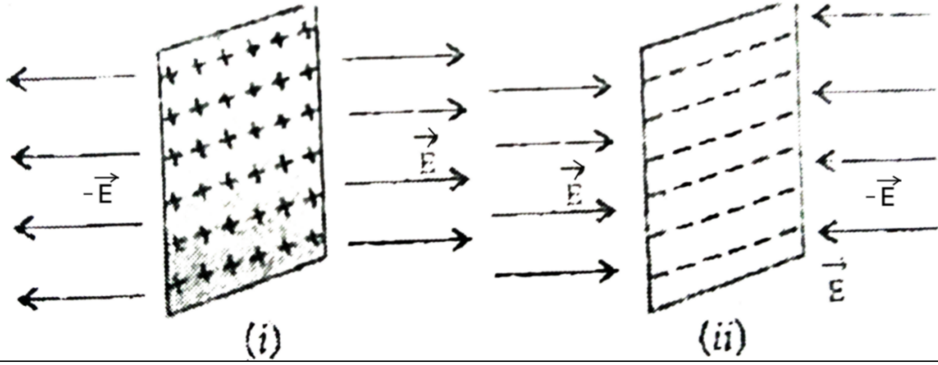
	 2
Ans	$E_c - E_B = \frac{hc}{\lambda_1}$ ...(1) $E_B - E_A = \frac{hc}{\lambda_2}$ ...(2) $E_C - E_A = \frac{hc}{\lambda_3}$ ...(3) Adding (1) and (2), we have $E_C - E_A = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$ ...(4) From (3) and (4), we have $\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \Rightarrow \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$ $\Rightarrow \lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$
11	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. 2 Or Explain how energy is produced in sun ? 2

Ans	The potential energy of a pair of nuclear as a function of their separation:  r_0 is the distance at which potential energy is minimum For a separation greater than r_0, the force is attractive and for separations less than r_0 the force is strongly repulsive.
12	A hollow cylindrical box of length 1m and area of cross-section 25 cm^2 is placed in a threedimensional coordinate system as shown in the figure. The electric field in the region is given by $\vec{E} = 50xi$, t where E is in N/C and x is in metres.  Find (i) net flux through the cylinder. (ii) charge enclosed by the cylinder . 3

Ans	
	Given, $\vec{E} = 50x\hat{i}$ and $\Delta s = 25cm^2 = 25 \times 10^{-4}m^2$ As the electric field is only along the x-axis, so, flux will pass only through the cross-section of cylinder. magnitude of electric field at cross - section A, $E_A = 50 \times 1 = 50NC^{-1}$ magnitude of electric field at cross - section B, $E_B = 50 \times 2 = 100NC^{-1}$ The corresponding electric fluxes are : $\emptyset_A = \vec{E}.\Delta\vec{s} = 50 \times 25 \times 10^{-4} \times \cos 180°$ $= -0.125Nm^2C^{-1}$ $\emptyset_A = \vec{E}.\Delta\vec{s} = 100 \times 25 \times 10^{-4} \times \cos 0°$ $= 0.25Nm^2C^{-1}$ So, the net flux through the cylinder, $\emptyset = \emptyset_A + \emptyset_B = -0.125 + 0.25 = 0.125Nm^2C^{-1}$ (ii) Using Gauss's law: $\oint \vec{E}.d\vec{s} = \frac{q}{\epsilon_0}$ $\Rightarrow 0.125 = \frac{q}{8.85 \times 10^{-12}}$ $\Rightarrow q = 8.85 \times 0.125 \times 10^{-12} = 1.1 \times 10^{-12}C$
	Or

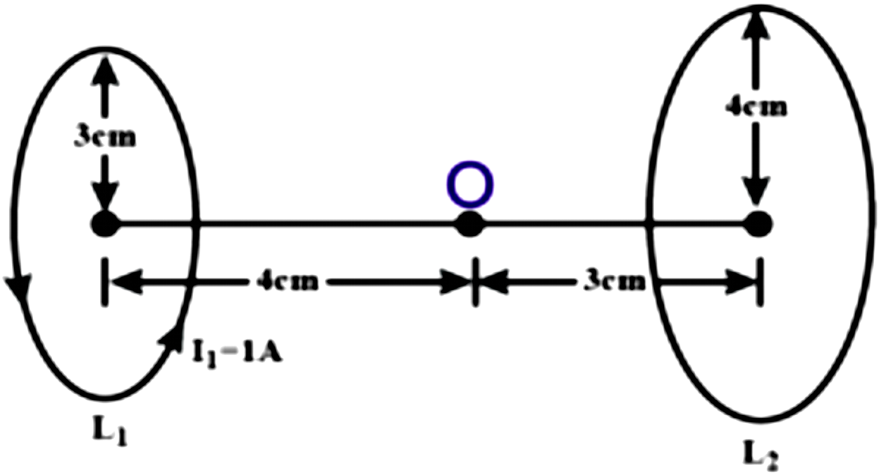
	In the figure given below, find the equivalent capacitance of the network between A and B **3**  $C_1 = C_5 = 8\mu F$, $C_2 = C_3 = C_4 = 4\ \mu F$ (i) Calculate effective capacitance between A and B (ii) Maximum charge supplied by the source (iii) The energy stored in the network
<u>Ans</u>	(i) Since C_1 and C_2 are short circuit and C_4 and C_5 are short circuit , so equivalent capacitance of the network is $C_3 = 4\mu F$ (ii) Maximum charge , $Q = CV = 4 \times 10^{-6} \times 5 = 20\ \mu C$ (iii) Energy stored , $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 4\times10^{-6} \times 5^2$ $U = 50 \times10^{-6} = 50\ \mu J$
13	Electric charge is uniformly distributed on the surface of a spherical balloon. Show how electric intensity and electric potential vary (a) on the surface (b) inside and (c) outside. 3

Ans	As a uniformly charged spherical balloon is blown up, the total charge Q remains constant while the radius R increases. The electric field E varies as follows: **(i) Inside ($r < R$):** E remains zero, as no charge is enclosed. **(ii) On the surface ($r = R$):** E decreases ($E = \frac{kQ}{R^2}$) because the radius increases. **(iii) Outside ($r > R$):** E decreases ($E = \frac{kQ}{r^2}$) at any fixed distance r from the center as the charge density drops.
	Or (a) State Gauss theorem in electrostatics. Using it, prove that the electric field at a point due to a uniformly charged infinite plane sheet is independent of the distance. (b) How is the field directed if (i) the sheet is positively charged, (ii) negatively charged? 2+1= 3
Ans	(i) The electric field is directed perpendicularly away from the sheet. (ii) The electric field is directed perpendicularly towards the sheet.



14	(i) What is the nature of trajectory of a charged particle in a uniform magnetic field with initial velocity at an angle , in between 0° and 90°, with the direction of the magnetic field ? Explain . (ii) A circular coil, having 100 turns of wire, of radius 20cm each, lies in the XY plane with its centre at the origin of co-ordinates. Find the magnetic field, at the point (0, 0, 20√3cm), when the coil carries a current of (2 /π) A. 3
Ans	The plane of coil is XY plane and field point is on the Z-axis. Magnetic field on the axial Point $B = \frac{\mu_0 I R^2 N}{2(R^2+z^2)^{\frac{3}{2}}} = \frac{4\pi\times10^{-7}\times\frac{2}{\pi}\times(0.2)^2\times100}{2[(0.2)^2+(0.2\sqrt{3})^2]^{\frac{3}{2}}} T$ $B = \frac{8\times0.04\times10^{-7}\times100}{2\times0.04\times8\times0.2} T = 25\ \mu T$
	Or

Two coaxial circular loops L_1 and L_2 of radii 3cm and 4cm are placed as shown. What should be the magnitude and direction of the current in the loop L_2 so that the net magnetic field at the point O be zero?



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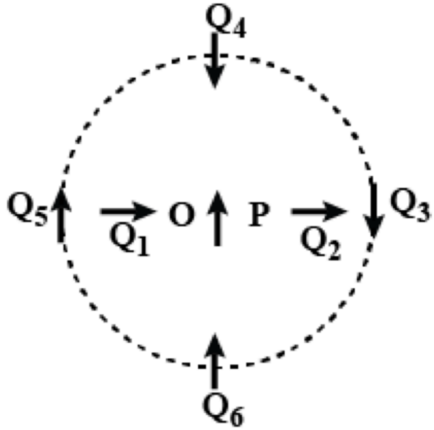
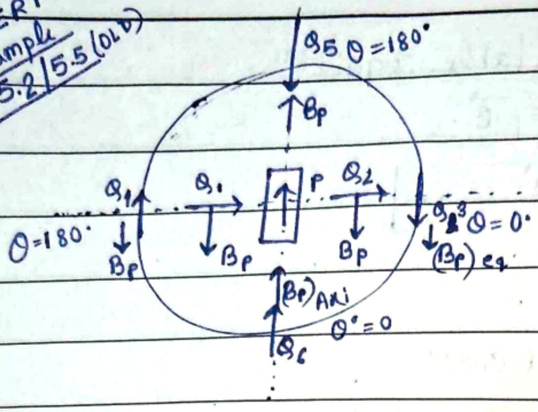
Ans	The magnetic field B at a point on the axis of a circular loop of radius R at a distance x from its center is : $$B = \frac{\mu_0 I R^2}{2(R^2 + x^2)^{3/2}}$$ For the net magnetic field at point **O** to be zero, the magnetic fields produced by L_1 and L_2 must be equal in magnitude but opposite in direction. Given $R_1 = 3$ cm, $x_1 = 4$ cm (distance from L_1 center to O) and $R_2 = 4$ cm, $x_2 = 3$ cm (distance from L_2 center to O) $$B_1 = B_2 \Longrightarrow \frac{\mu_0 I_1 R_1^2}{2(R_1^2 + x_1^2)^{3/2}} = \frac{\mu_0 I_2 R_2^2}{2(R_2^2 + x_2^2)^{3/2}}$$ $\Longrightarrow I_1 R_1^2 = I_2 R_2^2$ because $(3^2 + 4^2) = (4^2 + 3^2) = 25.$ $$\Longrightarrow 1 \cdot (3)^2 = I_2 \cdot (4)^2 \Longrightarrow I_2 = \frac{9}{16} \text{ A} \approx 0.5625 \text{ A}$$
15	The following figure shows a small magnetized needle P placed at a point O. The arrow shows the direction of its magnetic moment. The other arrows show different positions (and orientations of the magnetic moment) of another identical magnetized needle Q. 

(a)Which configurations will be in stable equilibrium ?
(b)Which configurations will be in unstable equilibrium?
(c) Which configuration is having the lowest potential energy ? Explain each case . 3

Ans

NCERT Example 5.2/5.5(old)



(i) In configuration PQ_1 & PQ_2, ∠ bet $\vec{B_P}$ & $\vec{M_Q}$ is 90°
So, in config^n PQ_1 & PQ_2 no eq^m is established.

(ii) In configuration PQ_3 & PQ_6, ∠ bet $\vec{B_P}$ & $\vec{M_Q}$ is 0°
So, PQ_6 & PQ_3 represent more stable eq^m
In config. PQ_4 & PQ_5, ∠ b/w $\vec{B_P}$ & $\vec{M_Q}$ is 180°. So PQ_4 & PQ_5 represent most unstable equilibrium.

(iii) We know,

$$(B_P)_{PQ_6} > (B_P)_{PQ_3}$$

$$\Rightarrow M_Q (B_P)_{PQ_6} > M_Q (B_P)_{PQ_3}$$

$$\Rightarrow -M_Q (B_P)_{PQ_6} < -M_Q (B_P)_{PQ_3}$$

$$\Rightarrow U_{PQ_6} < U_{PQ_3}$$

So, PQ_6 represent lowest potential energy.

Or

(i)Explain using a labelled diagram the principle and working of a moving coil galvanometer.

(ii)Obtain the relation between the current sensitivity and voltage sensitivity. 2+1= 3

16 State the Faraday's laws of electromagnetic induction . Plot a graph showing the variation of

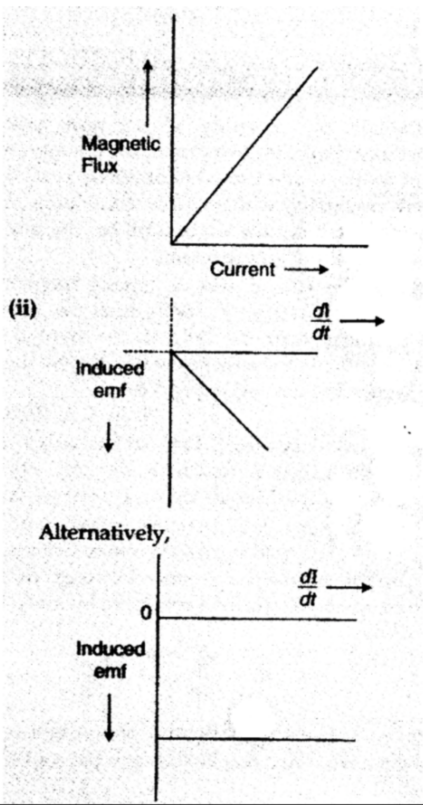
(i) Magnetic flux versus the current

(ii) Induced emf versus $\frac{di}{dt}$

(iii) Magnetic potential energy stored versus the current. 1½+½+½+½=3

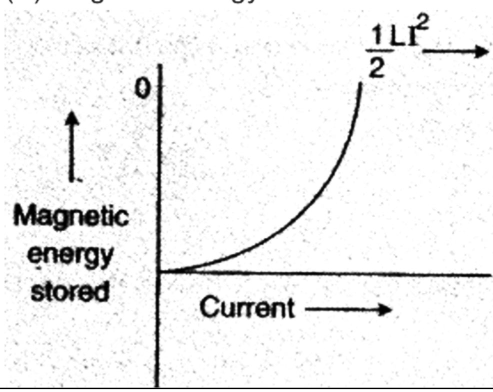
Ans

(i) Magnetic flux versus current



When 1 is increasing at constant rate,

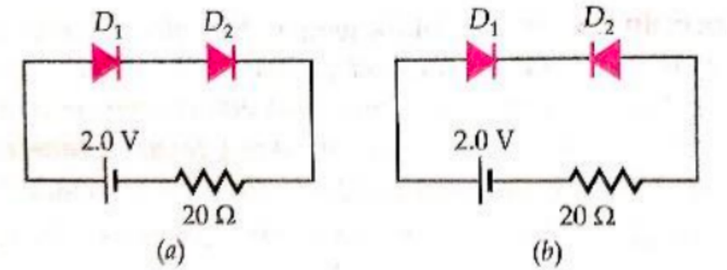
(iii) Magnetic energy stored

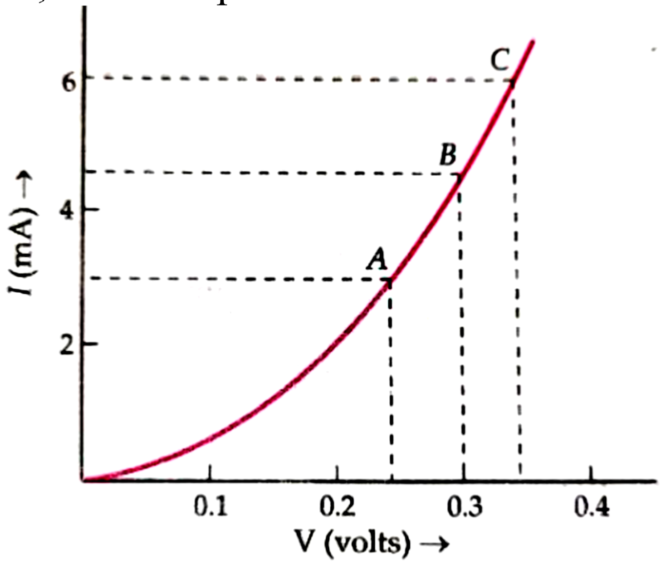


	Or Obtain the expression for the mutual inductance of two long co-axial solenoids S_1 and S_2 wound one over the other, each of length L and radii r_1 and r_2 and n_1 and n_2 be number of turns per unit length, when a current I is set up in the outer solenoid S_2. 3
17	(i)An ac voltage of emf $\boldsymbol{e = E_0 \sin\omega t}$ is applied across a capacitor of capacitance C, find an expression for the AC flowing in the circuit. Draw the phasor diagram to show the phase relationship between current and voltage. (ii) What is capacitive reactance ? (iii) Draw its variation with ω . 1½+1+½=3 Or (i) A power transmission line feeds input power at 2200 V to a step-down transformer with its primary windings having 3000 turns. Find the number of turns in the secondary to get the power output at 220 V. (ii) A step-up transformer converts a low voltage into high voltage. Does it not violate the principle of conservation of energy? Explain. 2+1=3
Ans	The relationship between voltage and the number of turns in a transformer is given by $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ $\Longrightarrow \frac{220}{2200} = \frac{N_s}{3000} \Longrightarrow \frac{1}{10} = \frac{N_s}{3000}$ $\Longrightarrow N_s = \frac{3000}{10} = 300$ (

	ii) A step-up transformer increases voltage, but it does **not** create energy. According to the law of conservation of energy, the output power cannot exceed the input power. In an ideal transformer: $P_{input} = P_{output} \implies V_p I_p = V_s I_s$ When the voltage (*V*) is stepped up, the current *I I*) must decrease proportionally to maintain the same power level. In real-world applications, the output power is actually slightly less than the input power due to minor energy losses (like heat or sound), further confirming that energy is conserved.
18	An equilateral glass prism has a refractive index 1.6 in air. Calculate the angle of minimum deviation of the prism, when kept in a medium of refractive index $\frac{4\sqrt{2}}{5}$ 3
Ans	Refractive index of the prism w.r.to the medium $\frac{\mu_{prism}}{\mu_{medium}} = \frac{\sin\left[\left(\frac{A+D_m}{2}\right)\right]}{\sin\left(\frac{A}{2}\right)}$ $\implies \frac{1.6}{\frac{4\sqrt{2}}{5}} = \frac{\sin\left[\left(\frac{60^\circ+D_m}{2}\right)\right]}{\sin\left(\frac{60^\circ}{2}\right)}$ $\implies \sqrt{2} = \frac{\sin\left[\left(\frac{60^\circ+D_m}{2}\right)\right]}{\frac{1}{2}}$ $\implies \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = \left(\frac{60^\circ + D_m}{2}\right)$ $\implies 90^\circ = 60^\circ + D_m \implies D_m = 30^\circ$

	Or Two monochromatic waves emanating from two coherent sources have the displacements represented by **$y_1 = a \cos\omega t$** and **$y_2 = a \cos(\omega t + \phi)$**, where ϕ is the phase difference between the two displacements (i) Show that the resultant intensity at a point due to their superposition is given by **$I = 4I_o \cos^2 \frac{\phi}{2}$**, where **$I_o = a^2$.** (ii) Hence obtain the conditions for constructive and destructive interference. 3
Ans	$y_1 = a\cos\omega t$ ....(i) and $y_2 = a\cos(\omega t + \phi)$ ....(ii) According to the principle of superposition, $Y = y_1 + y_2$ $\Rightarrow Y = a\cos\omega t + a\cos(\omega t + \phi)$ ....(iii) Using $\cos A + \cos B = 2\cos(\frac{A+B}{2})\cos(\frac{A-B}{2})$, we get: $\Rightarrow Y = 2a\cos(\frac{\phi}{2})\cos(\omega t + \frac{\phi}{2})$ ....(iv) The resultant wave has the form $Y = A\cos(\omega t + \alpha)$, where the resultant amplitude A is: $A = 2a\cos(\frac{\phi}{2})$ ....(v) Intensity I is proportional to the square of the amplitude ($I = kA^2$) The intensity of each individual wave is: $I_0 = ka^2$ ....(vi) The resultant intensity I is: $I = k[2a\cos(\frac{\phi}{2})]^2 = 4ka^2\cos^2(\frac{\phi}{2})$ $\Rightarrow I = 4I_0\cos^2(\frac{\phi}{2})$ ....(vii) Intensity is maximum when the term $\cos^2(\frac{\phi}{2})$ is maximum. The maximum value of $\cos^2(\frac{\phi}{2}) = 1$ (vii) $\Rightarrow I_{max} = 4I_0(1) = 4I_0$ ....(viii)

19	(i) For a extrinsic semiconductor, indicate on the energy band diagram the donor and acceptor levels? 1½ (ii) Determine the currents through the resistances of the circuits shown in Fig  1½
Ans	In circuit (a) Both D_1 and D_2 are forward baiased hence both will conduct current Therefore I = 2/20 = 0.1 A (b) Diode D_1 is forward bias and D_2 is reverse bias, therefore resistance D_1 is "O" and resistance D_2 is infinite. Hence D1 will conduct and D2 do not conduct No current flows in the circuit.
	Or (i) Give the ratio of number of holes and the no. of conduction electrons in an intrinsic semiconductor. 1 (ii) A semiconductor has equal electron and hole concentration of 6×10^8 m^{-3} . On doping with a certain impurity electron concentration increases to 3×10^{12} m^{-3}. Identify the type of semiconductor after doping ? 2
Ans	(i) The ratio of number of holes and the no. of conduction electrons in an intrinsic semiconductor is $n_e = n_h$

	(ii) Here, $n_i = 6 \times 10^8 m^{-3}, n_e = 3 \times 10^{12} m^{-3}$ $n_h = \frac{n_i^2}{n_e} = \frac{(6 \times 10^8)^2}{3 \times 10^{12}} = 12 \times 10^4 m^{-3}$ As, after doping, $n_e > n_h$, so the new semiconductor is n-type. Energy gap decreases with doping.
20	(i) What is dynamic resistance of PN junction diode ? (ii) Figure shows the characteristic curve of a junction diode. Determine the d.c. and a.c. resistance of the diode, when it operates at 0.3 V.  1+2=3
Ans	(i) Dynamic resistance is the small-signal resistance of a non-linear component, defined as the ratio of a small change in voltage (ΔV) to the resulting small change in current (ΔI) at a specific operating point (r_d=ΔV/ΔI).

(ii) **Identify coordinates for D.C. Resistance**

The d.c. resistance (R_{dc}) at a specific operating point is calculated using Ohm's law ($R = V/I$).

From the standard characteristic curve for this problem, when the voltage � � =0.3V, the corresponding current is ��=4.5mA

(or 4.5×10^{-3}A).

$$R_{dc} = \frac{V}{I} = \frac{0.3}{4.5\times10^{-3}}$$

$$R_{dc} \approx 66.7\ \Omega$$

Identify values for A.C. Resistance

The a.c. resistance (r_{ac}) is the dynamic resistance, defined as the ratio of a small change in voltage (ΔV) to the resulting small change in current (ΔI).

For this curve, around the 0.3Voperating point,

$$r_{ac} = \frac{\Delta V}{\Delta I} = \frac{0.4-0.3}{(7.5-4.5)\times10^{-3}} \Rightarrow r_{ac} = \frac{0.1}{3\times10^{-3}}$$

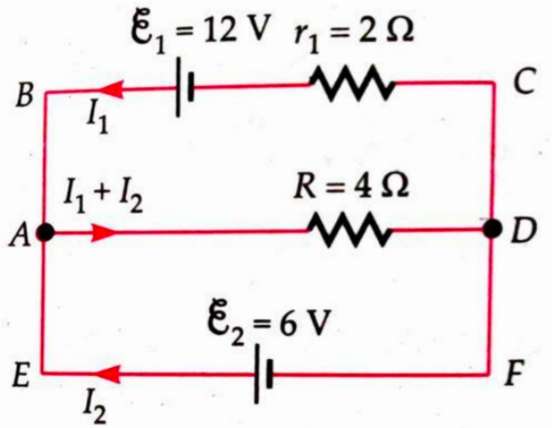
$$r_{ac} \approx 33.3\ \Omega$$

Or

Explain with the help of suitable diagram, the two processes which occur during the formations of p-n junction diode. Hence define the terms depletion region and potential barrier? 3

21 (i) State and explain Kirchhoff's laws.

(ii) In the electric network shown in the figure, use Kirchhoff's rules to calculate the power consumed by the resistance R=4Ω

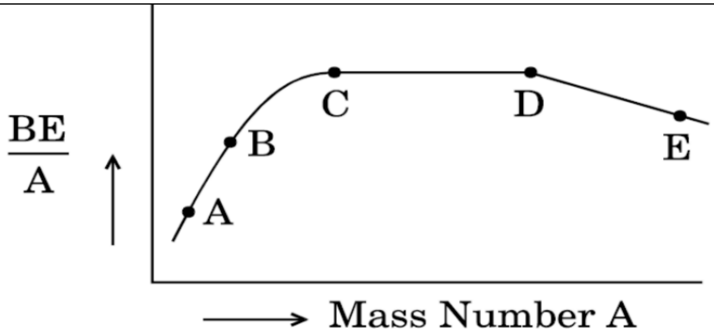
	
Ans	Using kirchhoff's cecond rate in the closed loop $ABCDA$ we have $+\varepsilon_1 - l_1 r_1 - (l_1 + l_2)R = 0$ or $+12 - l_1 \times 2 - (l_1 + l_2)4 = 0$ or $6l_1 + 4l_2 = +12$ or $3l_1 + 2l_2 = +6$.......(i) In the closed loop $ADEFA$ we have $(l_1 + l_2)R - \varepsilon_2 = 0$ or $(l_1 + l_2)4 = 6$ or $2l_1 + 2l_2 = 3$......(ii) On solving (i) and (ii) we get $l_1 = 3A, l_2 = -\frac{3}{2}A$ $\therefore l_1 + l_2 3 - \frac{3}{2} = \frac{3}{2}A$ power connected by resistance $R(= 4\Omega)$ is $= (l_1 + l_2)^2 R = \left(\frac{3}{2}\right)^2 \times 4 = 9W$

	Or (i) Two wires A and B of the same material having length in the ratio 1:2 and radii in the ratio 2:1. What is the ratio of the resistance? 1½ **(ii)** A potential difference V is applied across a conductor of length L. How is the drift velocity affected when V is doubled and L is halved? 1½ (iii) A potential difference of 6V is applied across a conductor of length 0.12m . Calculate the drift velocity of the electrons , it the electron mobility is $5.6 \times 10^{-6}\ m^2 v^{-1} s^{-1}$. **2**
Ans	(i) The resistance R of a wire is $R = \rho \frac{L}{A} = \rho \frac{L}{\pi r^2}$ Since both wires are of the same material, the resistivity ρ is constant. Given: $L_A : L_B = 1 : 2$ and $r_A : r_B = 2 : 1$. The ratio of resistances is: $\frac{R_A}{R_B} = \frac{L_A}{L_B} \times \left(\frac{r_B}{r_A}\right)^2$ $\Rightarrow \frac{R_A}{R_B} = \frac{1}{2} \times \left(\frac{1}{2}\right)^2 = \frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$
22	**(i)** Define magnifying power of astronomical telescope at the normal setting .1 **(ii)** An astronomical telescope has an angular magnification of magnitude 5 for distant objects. The separation between the objective and an eye piece is

	36 cm and the final image is formed at infinity. Calculate the focal length of the objective and the focal length of the eye piece? 2 **(iii)** Give two reasons to explain why a reflecting telescope is preferred over a refracting telescope. 2
Ans	(ii) For an astronomical telescope with the final image at infinity (normal adjustment), the magnitude of angular magnification (M) is given by the ratio of the focal length of the objective(f_o) to the focal length of the eyepiece (f_e) $$M = \frac{f_o}{f_e} = 5 \Rightarrow f_o = 5f_e$$ In normal adjustment, the separation L between the objective and the eyepiece is the sum of their focal lengths: $L = f_o + f_e$ $$\Rightarrow 5f_e + f_e = 36 \Rightarrow 6f_e = 36$$ $$\Rightarrow f_e = 6 \text{ cm} \Rightarrow f_o = 5 \times 6 = 30 \text{ cm}$$
	Or **(i)** The radii of curvature of both the surfaces of a lens are equal. If one of the surfaces is made plane by grinding, then will the focal length of lens change? Will the power change? 2 (ii) The refractive index of a material of a concave lens is n_1. It is immersed in a medium of refractive index n_2 . A parallel beam of light is incident on the

	lens. Trace the path of emergent rays when (i) $n_2 = n_1$ (ii) $n_2 > n_1$ (iii) $n_2 < n_1$. 3
Ans	(i) For a thin lens with radii of curvature R_1 and R_2, the Lens Maker's Formula is: $\frac{1}{f} = (n-1)(\frac{1}{R_1} - \frac{1}{R_2})$ For a biconvex lens where $R_1 = R$ and $R_2 = -R$: $$\frac{1}{f} = (n-1)(\frac{1}{R} - \frac{1}{-R}) = \frac{2(n-1)}{R}$$ If one surface is ground plane ($R_2 = \infty$), the new focal length f' is: $\frac{1}{f'} = (n-1)(\frac{1}{R} - \frac{1}{\infty}) = \frac{(n-1)}{R}$ Comparing the two, $\frac{1}{f'} = \frac{1}{2f}$, so $\boldsymbol{f' = 2f}$. Since power $P = \frac{1}{f}$, the new power is $\boldsymbol{P' = \frac{P}{2}}$. (ii) The behavior of a lens depends on the relative refractive index $n_{rel} = \frac{n_1}{n_2}$. **Case (i)** $n_2 = n_1$ **:** The lens material and medium are identical. There is no refraction at the boundaries.Light rays pass through the lens **undeviated** in a straight line. **Case (ii)** $n_2 > n_1$ **:** The medium is denser than the lens. A concave lens (normally diverging) will change its nature and behave as a **converging lens**.

	Parallel rays will converge toward the principal axis. **Case (iii)** $n_2 < n_1$ **:** The lens is denser than the medium. The concave lens maintains its natural behavior and acts as a **diverging lens**. Parallel rays will diverge away from the principal axis.
23	(i) Show that the expression of the wave number is $\overline{\nu} = Z^2 R_H \left[\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right]$ 2 (ii) Find the value of R_H. **1** (iii) Draw the hydrogen spectrum . 2
	Or **(i)** Imagine the fission of a $^{56}_{26}Fe$ into two equal fragments of $^{28}_{13}Al$ nucleus. Is the fission energetically possible? Justify your answer by working out Q value of the process. Given: m {$^{56}_{26}Fe$}= 55.93494u, m {$^{28}_{13}Al$} = 27.98191u. **(ii)** The figure shows the plot of binding energy (BE) per nucleon as a function of mass number A. The letters A, B, C, D and E represent the positions of typical nuclei on the curve.



Point out, out of A, B, C, D and E , which one will undergo nuclear fission and which one will undergo nuclear fusion and which one is the most stable nucleus ? 2+3 =5

Ans

(i) The fission of $^{56}_{26}Fe$ can be given as: $^{56}_{13}Fe \longrightarrow 2\,^{28}_{13}Al$

It is given that:

Atomic mass of $m\left(^{56}_{26}Fe\right) = 55.93494$ u

Atomic mass of $m\left(^{28}_{13}Al\right) = 27.98191$ u

The Q-value of this nuclear reaction is given as:

$$Q = \left[m\left(^{56}_{26}Fe\right) - 2m\left(^{28}_{13}Al\right)\right] \times 931 \text{ MeV}$$

$$= [55.93494 - 2 \times 27.98191] \times 931 \text{ MeV}$$

$$= (-0.02888) \times 931 \text{ MeV} = -26.902 \text{ MeV}$$

The Q-value of the fission is negative. Therefore, fission is not possible energetically. For an energetically-possible fission

(ii) The nuclei at A and B undergo nuclear fusion as their binding energy per nucleon is small and they are less stable so they fuse with other nuclei to become stable.

The nucleus at E undergo nuclear fission as its binding

	energy per nucleon is less it splits into two or more lighter nuclei and becomes stable. The nucleus at C is having highest BE/A , so it is the most stable nucleus .