CHENNAI SAHODAYA SCHOOL COMPLEX

GENERAL INSTRUCTIONS

- Please check that this question paper contains **six** printed pages.
- Please check that this question paper contains **33** questions.
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- Reading time of 15 minutes is given to read the question paper alone. No writing during this time.

This question paper has five sections: Section A, Section B, Section C, Section D and Section E.

- All the sections are compulsory.
- **Section A** contains 16 questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study-based question of four marks and **Section E** contains three long answer question of five marks each.
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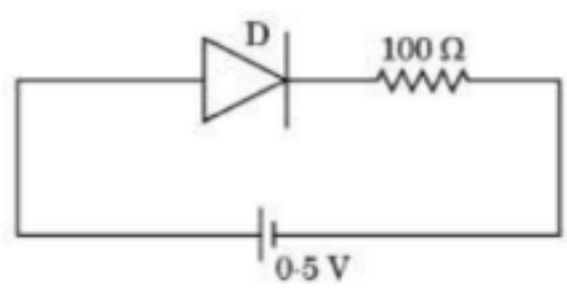
You may use the following values of physical constants where ever necessary

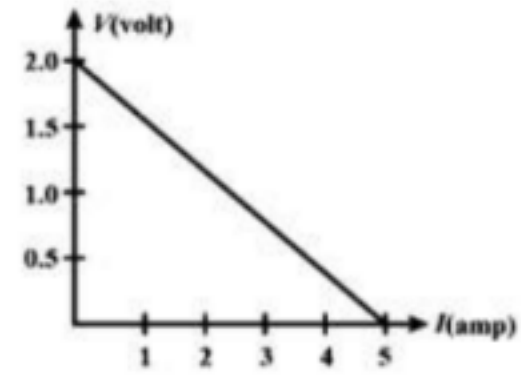
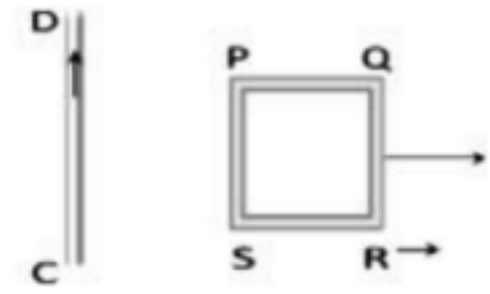
i. $c = 3 \times 10^8$ m/s
ii. $m_e = 9.1 \times 10^{-31}$ kg
iii. $e = 1.6 \times 10^{-19}$ C
iv. $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}
v. $h = 6.63 \times 10^{-34}$ Js
vi. $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2N^{-1}m^{-2}$

COMMON EXAMINATION 2023-24
Class 12
042 – PHYSICS
CODE 2

Roll No.: **Maximum Marks: 70**
Date: DD/MM/YYYY **Time allowed: 3 hours**

SECTION A

1.	Displacement current exists only when (a) electric field is changing (b) magnetic field is changing (c) electric field is not changing (d) magnetic field is not changing	(1)
2.	The threshold voltage for a p-n junction diode used in the circuit is 0·7 V. The type of biasing and current in the circuit are :  (a) Forward biasing, 0 A (b) Reverse biasing, 0 A (c) Forward biasing, 5 mA (d) Reverse biasing, 2 mA	(1)
3.	For a glass prism, the angle of minimum deviation will be smallest for the light of (a) red colour (b) blue colour (c) yellow colour (d) green colour	(1)
4.	A positively charged particle is released from rest in a uniform electric field. The electric potential energy of the charge (a) Remains constant because the electric field is uniform (b) Increases as the charge moves along the electric field (c) Decreases as the charge moves along the electric field (d) Decreases as the charge moves opposite to the direction of electric field	(1)
5.	In a series LR-circuit, the inductive reactance is equal to the resistance R of the circuit. An emf $E = E_0 \cos\omega t$ is applied to the circuit. The power consumed in the circuit is (a) $\frac{E_0^2}{R}$ (b) $\frac{E_0^2}{2R}$ (c) $\frac{E_0^2}{4R}$ (d) $\frac{E_0^2}{8R}$	(1)

6.	The ratio of the nuclear densities of two nuclei having mass numbers 27 and 125 is (a) 27:125 (b) 3:5 (c) 1:1 (d) 5:3	(1)
7.	An electron experiences a force of 1.6×10^{-16} N î in an electric field $\vec{E}$. The electric field $\vec{E}$ is (a) 1.0×10^{3} N/C î (b) -1.0×10^{3} N/C î (c) 1.0×10^{-3} N/C î (d) -1.0×10^{-3} N/C î	(1)
8.	An electron enters a uniform magnetic field with speed v. It describes a semicircular path and comes out of the field. The final speed of the electron is : (a) Zero (b) v (c) $\frac{v}{2}$ (d) 2v	(1)
9.	Potential difference across terminals of a cell was measured against different currents flowing through the cell. Maximum current obtained from the cell and internal resistance of the cell are (a) 5 A & 2.5 Ω (b) 5 A & 0.25 Ω (c) 5 A & 0.4 Ω (d) 5 A & 4 Ω 	(1)
10.	A square loop PQRS is carried away from a current carrying long straight conducting wire CD (figure). The direction of induced current in the loop will be (a) Anticlockwise (b) Clockwise (c) Sometimes clockwise sometimes anticlockwise (d) Current will not be induced 	(1)
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12.	The magnitude of electric field at a distance of 4m from a point charge is 9N/C. For the same point charge, the magnitude of electric field will be 16N/C at a distance of (a) 1m (b) 2m (c) 3m (d) 6m	(1)
13.	**Assertion (A):** Photoelectric effect demonstrates the particle nature of light. **Reason (R):** Photoelectric current is proportional to intensity of incident radiation for frequencies more than the threshold frequency. (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	(1)
14.	**Assertion (A):** Susceptibility of diamagnetic materials is independent of temperature. **Reason (R):** Diamagnetic materials do not have permanent magnetic dipole moment. (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	(1)
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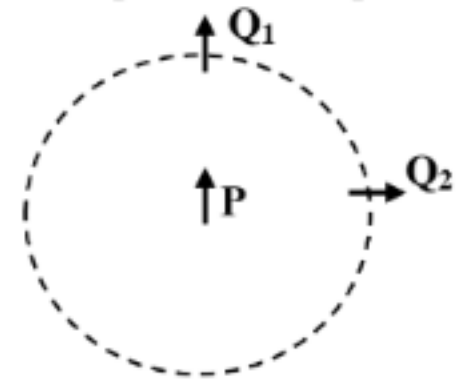
SECTION B

17. Identify the electromagnetic waves whose wavelengths vary as (2)
(a) $10^{-12}\ m < \lambda < 10^{-8}\ m$
(b) $10^{-3}\ m < \lambda < 10^{-1}\ m$
Write one use for each.

18. a) An iron rod of $0.2cm^2$ cross-sectional area is subjected to a magnetising field of 1200A/m. The susceptibility of iron is 599. Find permeability and magnetic flux produced. (2)

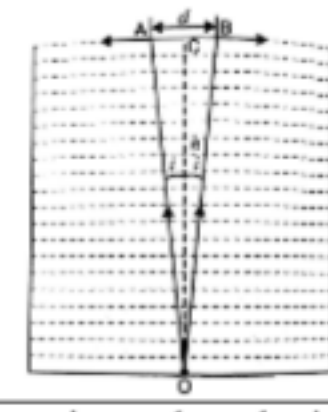
OR

b) A small magnetised needle P is placed at the origin of x-y plane with its magnetic moment pointing along the y-axis. Another identical magnetised needle Q is placed in two positions Q_1 and Q_2 as shown. (2)



(i) In which case is the potential energy of Q minimum?
(ii) In which case is Q not in equilibrium?
Justify your answers.

19. A jar of height h is filled with a transparent liquid of refractive index μ. At the centre on the bottom is a dot O. Find the minimum diameter of a disc such that when it is placed on the top surface symmetrically about the centre, the dot becomes invisible. (2)



20. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment. If the distance between the plane of the slits and screen is 1.4m and the distance between the slits is 0.28mm, find the least distance from the central maximum where the bright fringes due to both the wavelengths coincide? (2)

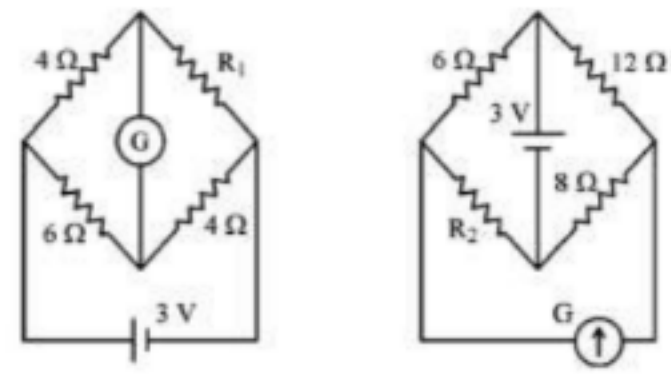
21. Draw the energy band diagram for a p-type and n-type semiconductor for $T > 0K$. (2)

SECTION C

22. (a) The density of the nuclear matter is tremendously larger than the physical density of the material. Explain. (3)
(b) Draw a plot of the potential energy between a pair of nucleons as a function of distance between them inside a nucleus. Write two important conclusions that can be drawn from the graph.

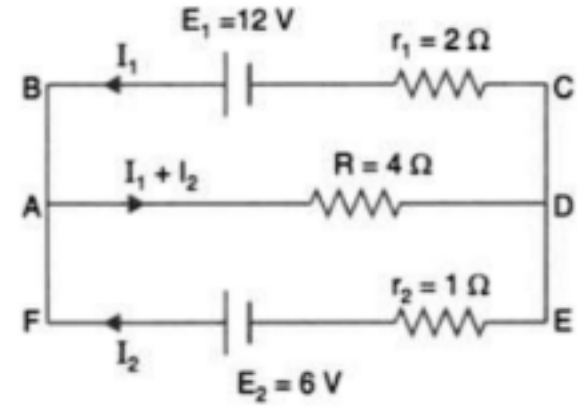
23. (i) Draw a graph to show the variation of the number of scattered particles detected (N) in Geiger-Marsden experiment as a function of scattering angle (θ). (3)
(ii) Discuss briefly two conclusions that can be drawn from this graph and how they lead to the discovery of nucleus in an atom.

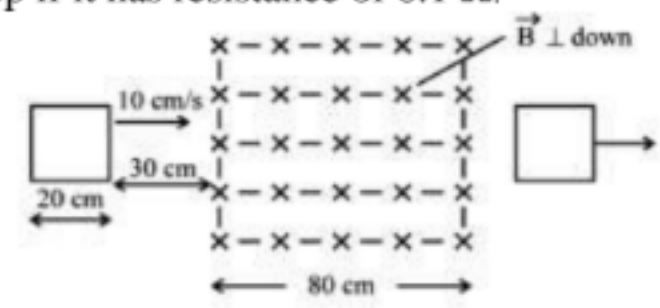
24. a) Define the term mobility of free electrons. (3)
In the circuits shown in the figures, the galvanometer shows no deflection in each case. Find the ratio of R1 and R2.



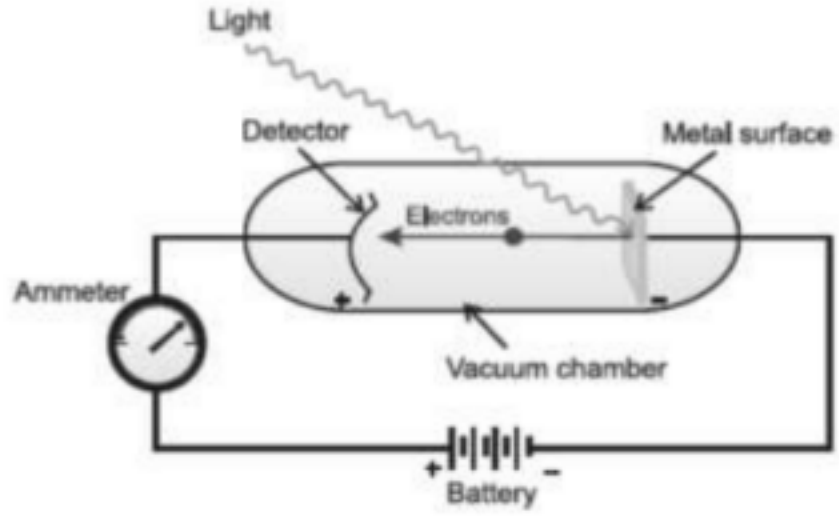
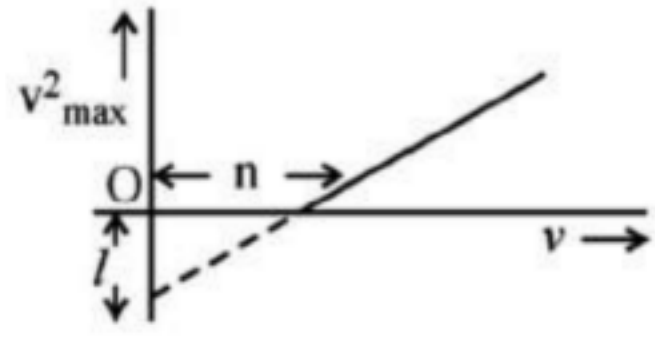
OR

b) Find the current across each branch using Kirchhoff's laws and hence find potential difference across cell E_2. (3)



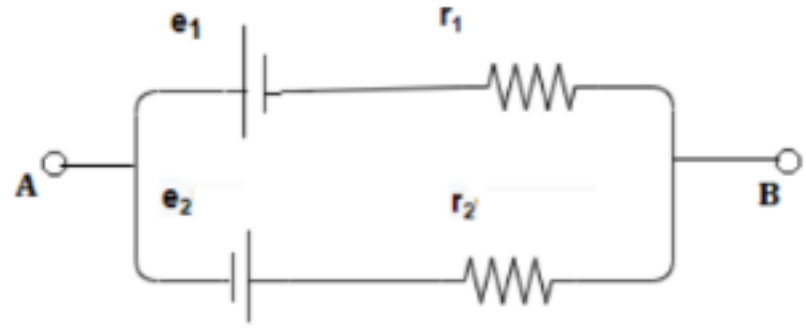
25.	You are given three circuit elements X, Y and Z. When X is connected to an ac source; the voltage and current are in phase. When Y is connected in series with X, the voltage leads the current by $\pi/4$. When Z is connected in series with X, the current leads the voltage by $\pi/4$. Identify X, Y and Z and find the impedance when all the three are connected in series.	(3)
26.	Explain the property of a p-n junction which makes it suitable for rectifying alternating voltages. With the help of a circuit diagram, discuss the working of a half-wave rectifier.	(3)
27.	Draw the ray diagram of an astronomical refracting telescope in normal adjustment. Define and derive the expression for magnifying power.	(3)
28.	A square loop of side 20 cm is initially kept 30 cm away from a region of uniform magnetic field of 0.1 T as shown in the figure. It is then moved towards the right with a velocity of 10 cm s–1 till it goes out of the field. Plot a graph showing the variation of (i) magnetic flux (f) through the loop with time (t). (ii) induced emf (e) in the loop with time t. (iii) induced current in the loop if it has resistance of 0.1 Ω. 	(3)

SECTION D

29.	**CASE STUDY** **Photoelectric Effect** When ultraviolet light falls on certain metals like zinc, cadmium and magnesium etc. electron emission takes place from the surface. Alkali metals emit electrons even with visible light. After the discovery of electrons in 1897, these electrons were termed as photoelectrons and the phenomenon is called photoelectric effect. 	
	(a) Alkali metals show photoelectric effect with visible light but Zn, Mg and Cd respond to uv light. Why? (i) Alkali metals have less threshold wavelength. (ii) Zn, Cd and Mg have greater threshold wavelength. (iii) Alkali metals have greater threshold frequency. (iv) Zn, Cd and Mg have greater threshold frequency.	(1)
	(b) Maximum kinetic energy of the photoelectrons emitted from a metal surface is 5eV. What will be its stopping potential?	(1)
	(c) From the graph of v^2_{max} Vs ν, obtain expressions for Plank's constant and work function. 	(2)
	(OR)	
	(c) The work function for a certain metal is 4.2 eV. Will this metal give photoelectric emission for incident radiation of wavelength 330 nm?	(2)

30. **CASE STUDY – Cells in parallel**

A battery is a combination of two or more cells. The cells can be connected in series or parallel. In the following figure, a single battery is represented in which two cells of emf e_1 and e_2 and internal resistance r_1 and r_2 are connected.



Given $e_1 = 1V$, $e_2 = 2V$, $r_1 = 2\Omega$, $r_2 = 1\Omega$

(a) The internal resistance of the combination will be (1)

(i) 3Ω (ii) $\frac{2}{3}\Omega$ (iii) $\frac{3}{2}\Omega$ (iv) 1Ω

(b) Will terminal B be negative or positive w.r.t. terminal A? (1)

(c) What is the equivalent emf of the combination? (2)

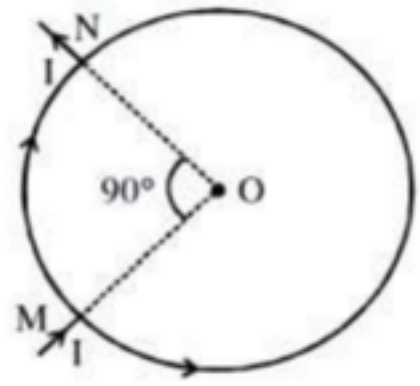
(OR)

(c) What is the current in the internal circuit when there is no external resistor connected? (2)

SECTION E

31. (a) Use Biot-Savart law to derive the expression for the magnetic field due to a circular coil of radius R having N turns at a point on the axis at a distance '*x*' from its centre. Draw the magnetic field lines due to this coil. (3)

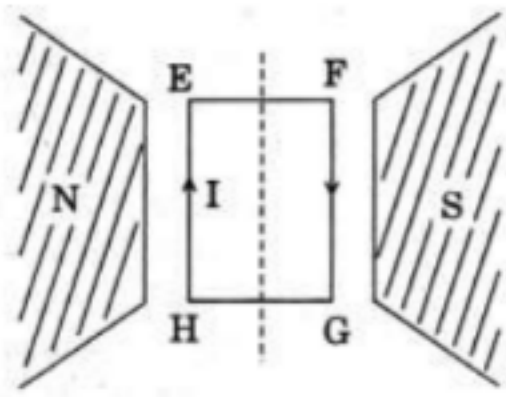
(b) A current 'I' enters a uniform circular loop of radius 'R' at point M and flows out at N as shown in the figure. Obtain the net magnetic field at the centre of the loop. (2)



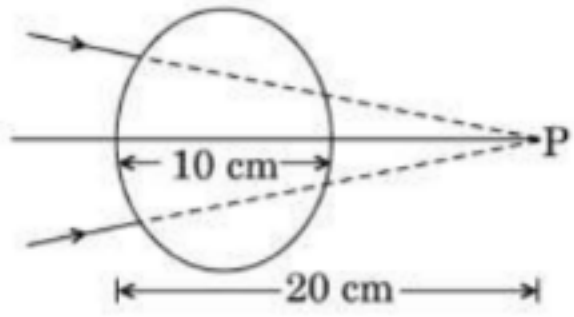
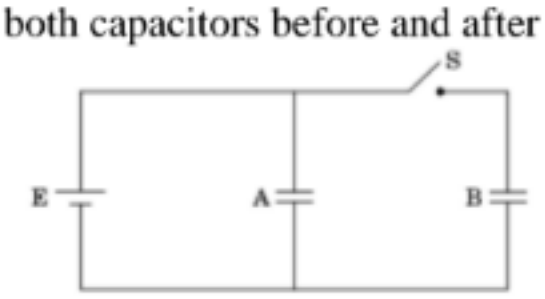
OR

(a) Two straight long parallel conductors carry currents I_1 and I_2 in the same direction. Deduce the expression for the force per unit length between them. Hence define 1 ampere. (3)

(b) A rectangular current carrying loop EFGH is kept in a uniform magnetic field as shown in the figure. (2)



(i) What is the direction of the magnetic moment of the current loop?
(ii) When is the torque acting on the loop maximum?
(iii) When is the torque acting on the loop minimum?

32.	(a) Two thin lenses are placed coaxially in contact. Obtain the expression for the focal length of this combination in terms of the focal lengths of the two lenses.	(3)
	(b) A converging beam of light travelling in air converges at a point P as shown in the figure. When a glass sphere of refractive index 1·5 is introduced in between the path of the beam, calculate the new position of the image. Also draw the ray diagram for the image formed. 	(2)
	OR	
	(a) Can the interference pattern be produced by two independent monochromatic sources of light? Explain.	(1)
	(b) A parallel beam of light of wavelength 500nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1m away. It is observed that the first minimum is at a distance of 2.5mm from the centre of the screen. Find the width of the slit.	(2)
	(c) Two coherent sources whose intensity ratio is 81:1 produce interference fringes. Calculate the ratio of intensity of maxima and minima in the fringe system.	(2)
33.	(a) Derive the expression for capacitance of a parallel plate capacitor with a dielectric of thickness t < d inserted between the plates.	(3)
	(b) Two identical parallel plate capacitors A and B are connected to a battery of V volts with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant K. Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric. 	(2)
	OR	
	(a) State Gauss law. Using it derive the expression for electric field at a point due to an infinite line of charge of linear charge density λ.	(3)
	(b) If an electron is revolving in a circle around an infinite line of charge with constant speed v such that the line of charge passes through the centre of the circle perpendicular to the plane of the circle, deduce the expression for kinetic energy of the electron. Also plot a graph of kinetic energy Vs linear charge density.	(2)

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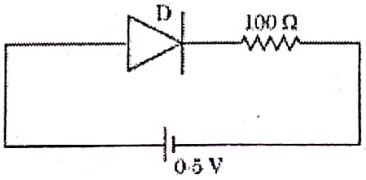
2.	The threshold voltage for a p-n junction diode used in the circuit is 0·7 V. The type of biasing and current in the circuit are :  (a) Forward biasing, 0 A (b) Reverse biasing, 0 A (c) Forward biasing, 5 mA (d) Reverse biasing, 2 mA	(1)
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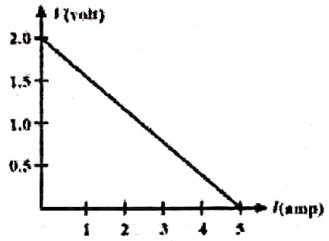
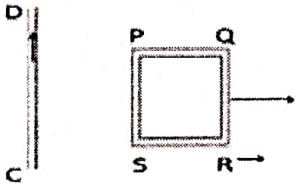
9.	Potential difference across terminals of a cell was measured against different currents flowing through the cell. Maximum current obtained from the cell and internal resistance of the cell are (a) 5 A & 2.5 Ω (b) 5 A & 0.25 Ω (c) 5 A & 0.4 Ω (d) 5 A & 4 Ω 	(1)
10.	A square loop PQRS is carried away from a current carrying long straight conducting wire CD (figure). The direction of induced current in the loop will be (a) Anticlockwise (b) Clockwise (c) Sometimes clockwise sometimes anticlockwise (d) Current will not be induced 	(1)
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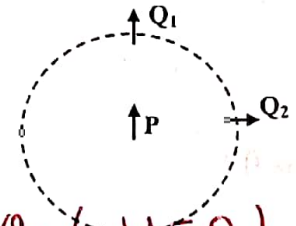
SECTION B

17. Identify the electromagnetic waves whose wavelengths vary as (2)
(a) 10^{-12} m < λ < 10^{-8} m — X-ray (Scientific research & crystallography)
(b) 10^{-3} m < λ < 10^{-1} m — Microwaves (Cook food in Microwave ovens & radar)
Write one use for each.

18. a) An iron rod of 0.2cm² cross-sectional area is subjected to a magnetising field of 1200A/m. The susceptibility of iron is 599. Find permeability and magnetic flux produced. (2)
* $600\mu_0$
* 1.8×10^{-5} Wb

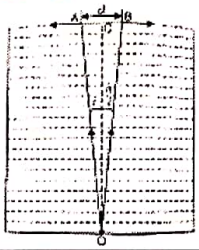
OR

b) A small magnetised needle P is placed at the origin of x-y plane with its magnetic moment pointing along the y-axis. Another identical magnetised needle Q is placed in two positions Q_1 and Q_2 as shown. (2)



(i) In which case is the potential energy of Q minimum?
(ii) In which case is Q not in equilibrium?
Justify your answers.
* P.E. is min at Q_1 ($U_{min} = -MB$)
* Q is not at equilibrium at Q_2 ($\tau = 0$)

19. A jar of height h is filled with a transparent liquid of refractive index μ. At the centre on the bottom is a dot O. Find the minimum diameter of a disc such that when it is placed on the top surface symmetrically about the centre, the dot becomes invisible. (2)



$d = 2r = \frac{2h}{\sqrt{\mu^2 - 1}}$

20. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment. If the distance between the plane of the slits and screen is 1.4m and the distance between the slits is 0.28mm, find the least distance from the central maximum where the bright fringes due to both the wavelengths coincide? (2)
Hint: $n_1\lambda_1 = n_2\lambda_2$
* 13mm

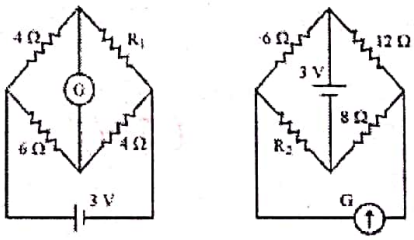
21. Draw the energy band diagram for a p-type and n-type semiconductor for T > 0K. (2)
(Theory): Semiconductor

SECTION C

22. (a) The density of the nuclear matter is tremendously larger than the physical density of the material. Explain. (3)
(Theory): Nuclei
(b) Draw a plot of the potential energy between a pair of nucleons as a function of distance between them inside a nucleus. Write two important conclusions that can be drawn from the graph.
(Theory): Nuclei

23. (i) Draw a graph to show the variation of the number of scattered particles detected (N) in Geiger-Marsden experiment as a function of scattering angle (θ). (3)
(Theory): DNRM
(ii) Discuss briefly two conclusions that can be drawn from this graph and how they lead to the discovery of nucleus in an atom.

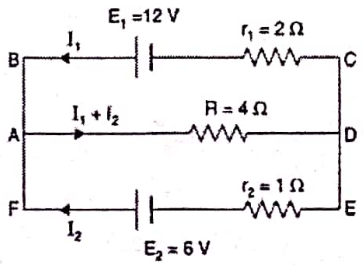
24. a) Define the term mobility of free electrons. (3)
In the circuits shown in the figures, the galvanometer shows no deflection in each case. Find the ratio of R1 and R2.



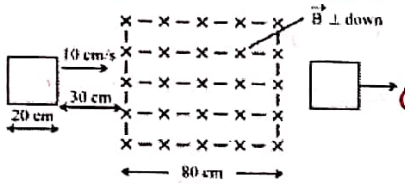
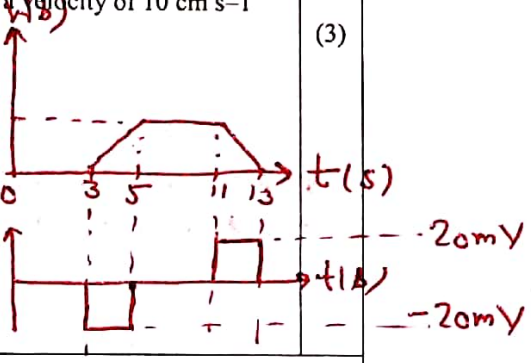
$R_1 = \frac{8}{3}\Omega$, $R_2 = 4\Omega$
and $\frac{R_1}{R_2} = \frac{2}{3}$

OR

b) Find the current across each branch using Kirchhoff's laws and hence find potential difference across cell E_2. (3)



* $I_1 = \frac{18}{7}$ A, $I_2 = -\frac{6}{7}$ A
* $V = \frac{48}{7}$ V

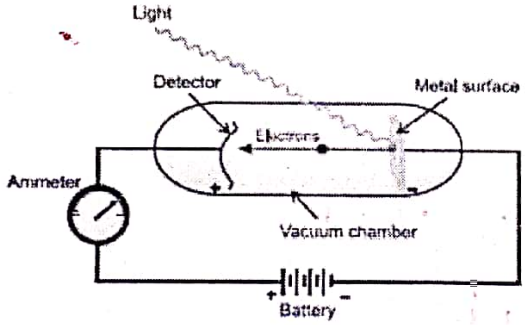
25.	You are given three circuit elements X, Y and Z. When X is connected to an ac source; the voltage and current are in phase. When Y is connected in series with X, the voltage leads the current by $\pi/4$. When Z is connected in series with X, the current leads the voltage by $\pi/4$. Identify X, Y and Z and find the impedance when all the three are connected in series. (Z = R)	(3)
26.	Explain the property of a p-n junction which makes it suitable for rectifying alternating voltages. With the help of a circuit diagram, discuss the working of a half-wave rectifier. (Theory): Semiconductor.	(3)
27.	Draw the ray diagram of an astronomical refracting telescope in normal adjustment. Define and derive the expression for magnifying power. (Theory): Ray Optics	(3)
28.	A square loop of side 20 cm is initially kept 30 cm away from a region of uniform magnetic field of 0.1 T as shown in the figure. It is then moved towards the right with a velocity of 10 cm s–1 till it goes out of the field. Plot a graph showing the variation of (i) magnetic flux (f) through the loop with time (t). (ii) induced emf (e) in the loop with time t. (iii) induced current in the loop if it has resistance of 0.1 Ω. (20mA)   	(3)

SECTION D

29. **CASE STUDY**

Photoelectric Effect

When ultraviolet light falls on certain metals like zinc, cadmium and magnesium etc. electron emission takes place from the surface. Alkali metals emit electrons even with visible light. After the discovery of electrons in 1897, these electrons were termed as photoelectrons and the phenomenon is called photoelectric effect.



(a) Alkali metals show photoelectric effect with visible light but Zn, Mg and Cd respond to uv light. Why? (1)

(i) Alkali metals have less threshold wavelength.

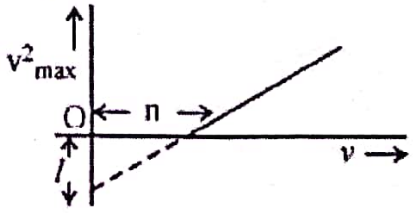
(ii) Zn, Cd and Mg have greater threshold wavelength.

(iii) Alkali metals have greater threshold frequency.

(iv) Zn, Cd and Mg have greater threshold frequency.

(b) Maximum kinetic energy of the photoelectrons emitted from a metal surface is 5eV. What will be its stopping potential? (5V) (1)

(c) From the graph of v^2_{max} Vs v, obtain expressions for Plank's constant and work function. (2)



$* h = \frac{ml}{2n}$

$* \phi_0 = \frac{ml}{2} = nh$.

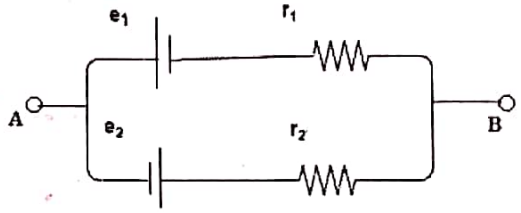
(OR)

(c) The work function for a certain metal is 4.2 eV. Will this metal give photoelectric emission for incident radiation of wavelength 330 nm? $\left(E = \frac{1240}{330} = 3.75eV\right)$ (2)

As, $E < \phi_0$, So No emission.

30. **CASE STUDY – Cells in parallel**

A battery is a combination of two or more cells. The cells can be connected in series or parallel. In the following figure, a single battery is represented in which two cells of emf e_1 and e_2 and internal resistance r_1 and r_2 are connected.



Given $e_1 = 1V$, $e_2 = 2V$, $r_1 = 2\Omega$, $r_2 = 1\Omega$

(a) The internal resistance of the combination will be (1)

(i) 3Ω (ii) $\frac{2}{3}\Omega$ (iii) $\frac{3}{2}\Omega$ (iv) 1Ω (1)

(b) Will terminal B be negative or positive w.r.t. terminal A? (positive) (2)

(c) What is the equivalent emf of the combination? (1V)

(OR)

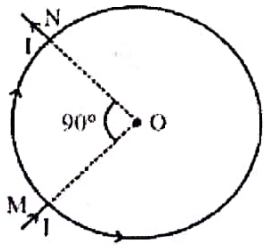
(c) What is the current in the internal circuit when there is no external resistor connected? $\left(\frac{1}{3}A\right)$ (2)

SECTION E

31. (a) Use Biot-Savart law to derive the expression for the magnetic field due to a circular coil of radius R having N turns at a point on the axis at a distance 'x' from its centre. Draw the magnetic field lines due to this coil. (3)

(Theory) $\therefore B = \frac{\mu_0 N I R^2}{2(x^2+R^2)^{3/2}}$

(b) A current 'I' enters a uniform circular loop of radius 'R' at point M and flows out at N as shown in the figure. Obtain the net magnetic field at the centre of the loop. (2)



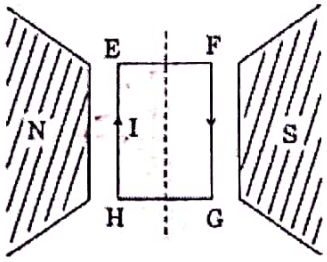
$B_0 = 0$

OR

(a) Two straight long parallel conductors carry currents I_1 and I_2 in the same direction. Deduce the expression for the force per unit length between them. Hence define 1 ampere. (3)

$f = \frac{\mu_0 I_1 I_2}{2\pi d}$

(b) A rectangular current carrying loop EFGH is kept in a uniform magnetic field as shown in the figure. (2)

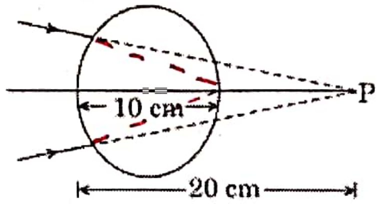


(i) What is the direction of the magnetic moment of the current loop? (⊗)

(ii) When is the torque acting on the loop maximum? ($\theta = 90°$)

(iii) When is the torque acting on the loop minimum? ($\theta = 0°/180°$)

32.	(a) Two thin lenses are placed coaxially in contact. Obtain the expression for the focal length of this combination in terms of the focal lengths of the two lenses. $\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2}$	(3)
	(b) A converging beam of light travelling in air converges at a point P as shown in the figure. When a glass sphere of refractive index 1·5 is introduced in between the path of the beam, calculate the new position of the image. Also draw the ray diagram for the image formed.	(2)

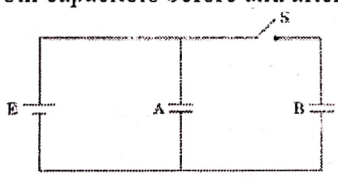


For 1st surface, $v' = 10cm$

For 2nd surface, $v = 0$

OR

	(a) Can the interference pattern be produced by two independent monochromatic sources of light? Explain. No; Only by coherent Sources.	(1)
	(b) A parallel beam of light of wavelength 500nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1m away. It is observed that the first minimum is at a distance of 2.5mm from the centre of the screen. Find the width of the slit. $a = \frac{D\lambda}{x} = 0.2mm$	(2)
	(c) Two coherent sources whose intensity ratio is 81:1 produce interference fringes. Calculate the ratio of intensity of maxima and minima in the fringe system. $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2 = 25:16$	(2)
33.	(a) Derive the expression for capacitance of a parallel plate capacitor with a dielectric of thickness t < d inserted between the plates. $C = \frac{\epsilon_0 A}{\left(d - t + \frac{t}{K}\right)}$	(3)
	(b) Two identical parallel plate capacitors A and B are connected to a battery of V volts with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant K. Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric.	(2)



$* \frac{U_A}{U_A'} = \frac{\frac{1}{2}CV^2}{\frac{1}{2}C\left(\frac{V}{1+K}\right)^2} = (1+K)^2$

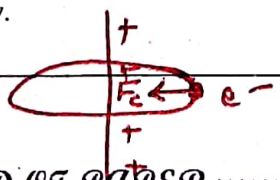
$* \frac{U_B}{U_{B'}} = \frac{0}{\frac{1}{2}KC\left(\frac{V}{1+K}\right)^2} = 0$

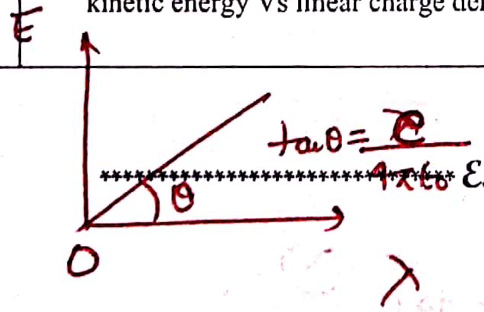
OR

	(a) State Gauss law. Using it derive the expression for electric field at a point due to an infinite line of charge of linear charge density λ. $* \oint \vec{E}\cdot d\vec{s} = \frac{q_{in}}{\epsilon_0}$ $* E = \frac{\lambda}{2\pi\epsilon_0 r}$	(3)
	(b) If an electron is revolving in a circle around an infinite line of charge with constant speed v such that the line of charge passes through the centre of the circle perpendicular to the plane of the circle, deduce the expression for kinetic energy of the electron. Also plot a graph of kinetic energy Vs linear charge density.	(2)

$* \frac{mv^2}{r} = \frac{e\lambda}{2\pi\epsilon_0 r}$

$\Rightarrow E = \frac{\lambda e}{4\pi\epsilon_0}$





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