Solved Paper 2017
Physics
Class-XII

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

General Instructions :

(i) *All questions are compulsory. There are* ***26*** *questions in all.*

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

(iii) *Section* ***A*** *contains* ***five*** *questions of* ***one*** *mark each, Section* ***B*** *contains* ***five*** *questions of* ***two*** *marks each, Section* ***C*** *contains* ***twelve*** *questions of* ***three*** *marks each, Section* ***D*** *contains* ***one*** *value based question of* ***four*** *marks and Section* ***E*** *contains* ***three*** *questions of* ***five*** *marks each.*

(iv) *There is no overall choice. However, an internal choice has been provided in* ***one*** *question of* ***two*** *marks,* ***one*** *question of* ***three*** *marks and all the* ***three*** *questions of* ***five*** *marks weightage. You have to attempt only* ***one*** *of the choices in such questions.*

(v) *You may use the following values of physical constants wherever necessary :*

$c = 3 \times 10^8\ m/s$

$h = 6.63 \times 10^{-34}$ Js

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

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

$\varepsilon_0 = 8.854 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$

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

Mass of electron (m_e) = 9.1×10^{-31} kg

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = 1.38×10^{-23} JK^{-1}

Delhi Set I Code No. 55/1/1

SECTION -A

1. Does the charge given to a metallic sphere depend on whether it is hollow or solid? Give reason for your answer. 1

Ans. No, ½

because the charge resides only on the surface of the conductor. ½

[CBSE Marking Scheme, 2017]

2. A long straight current carrying wire passes normally through the centre of circular loop. If the current through the wire increases, will there be an induced emf in the loop? Justify. 1

Ans. No, ½

as the magnetic field due to current carrying wire will be in the plane of the circular loop, so magnetic flux will remain zero. ½

[Alternatively, Magnetic flux does not change with the change of current.] 1

[CBSE Marking Scheme, 2017]

3. At a place, the horizontal component of earth's magnetic field is B and angle of dip is 60°. What is the value of horizontal component of the earth's magnetic field at equator? 1

Ans. $B_H = B_E \cos \delta$ ½

$B_H = B_E \cos 60° \Rightarrow B_E = 2B_H$

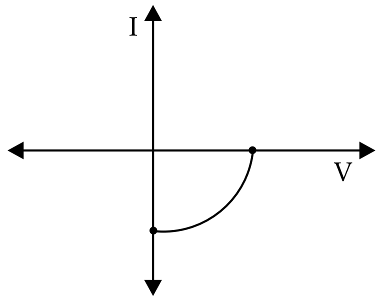
At equator $\delta = 0°$ ½

$\therefore \quad B_H = 2B \cos 0° = 2B$

[Alternatively, award full one mark, if student doesn't take the value (=$2B$) of B_E while finding the value of horizontal component at equator, and just writes the formula only.]

[CBSE Marking Scheme, 2017] 1

4. Name the junction diode whose I-V characteristic is drawn below : 1



Ans. Solar cell. **[CBSE Marking Scheme, 2017] 1**

5. How is the speed of em-waves in vacuum determined by the electric and magnetic fields? 1

Ans. Speed of em-waves is determined by the ratio of the peak values of electric and magnetic field vectors.

[Alternatively, Give full credit, if student writes directly $C = \frac{E_0}{B_0}$]

[CBSE Marking Scheme, 2017] 1

SECTION -B

6. How does Ampere-Maxwell law explain the flow of current through a capacitor when it is being charged by a battery? Write the expression for the displacement current in terms of the rate of change of electric flux. 2

Ans. When a battery is attached to a capacitor, conduction current flow in wire outside capacitor. In the capacitor the Electric flux $\phi_E = EA$

Where, $E = \frac{Q}{\varepsilon_0 A}, Q = \varepsilon_0 EA$

$\therefore \quad I = \frac{dQ}{dt} = \varepsilon_0 \frac{d\phi_E}{dt}$

This maintains the current in the capacitor.

Amperes-Maxwell law states that displacement current comes into existence due to rate of change of electric flux *w.r.t.* time.

$\therefore$ Displacement current $I_d = \varepsilon_0 \frac{d\phi_E}{dt}$ 2

7. Define the distance of closest approach. An α-particle of kinetic energy '*K*' is bombarded on a thin gold foil. The distance of the closest approach is '*r*'. What will be the distance of closest approach for an α-particle of double the kinetic energy? 2

OR

Write two important limitations of Rutherford nuclear model of the atom. 2

Ans. Definition of distance of closest approach 1

Finding of distance of closest approach when kinetic energy is doubled 1

It is the distance of charged particle from the centre of the nucleus, at which the whole of the initial kinetic energy of the (far off) charged particle gets converted into the electric potential energy of the system. 1

Distance of closest approach (r_c) is given by

$$r_c = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2Ze^2}{K}$$ ½

'*K*' is doubled, $\therefore r_c$ becomes $\frac{r}{2}$ ½

[**Alternatively:** If a candidate writes directly $\frac{r}{2}$ without mentioning formula, award the 1 mark for this part.]

OR

Two important limitations of Rutherford nuclear model 1+1

1. According to Rutherford model, electron orbiting around the nucleus, continuously radiates energy due to the acceleration; hence the atom will not remain stable.
2. As electron spirals inwards; its angular velocity and frequency change continuously; therefore it will emit a continuous spectrum.

[CBSE Marking Scheme, 2017]

8. Find out the wavelength of the electron orbiting in the ground state of hydrogen atom. 2

Ans. Calculation of wavelength of electron in ground state: 2

Radius of ground state of hydrogen atom = $0.53\text{Å} = 0.53 \times 10^{-10}$m ½

According to de Broglie relation $2\pi r = n\lambda$ ½

For ground state $n = 1$

$2 \times 3.14 \times 0.53 \times 10^{-10} = 1 \times \lambda$ ½

$\therefore \quad \lambda = 3.32 \times 10^{-10}$ m

$= 3.32$ Å ½

Alternatively

Velocity of electron, in the ground state, of hydrogen atom

$= 2.18 \times 10^{-6}$ m/s ½

Hence momentum of revolving electron

$p = mv$

$= 9.1 \times 10^{-31} \times 2.18 \times 10^{-6}$ kg m/s ½

$$\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.18 \times 10^{6}} \text{ m}$$ ½

$= 3.32$ Å ½

[**Note :** Also accept the following answer:

Let λ_n be the wavelength of the electron in the n^{th} orbit, we then have 1

$2\pi r_n = n\lambda$

For ground state $n = 1$

$2\pi r_n = \lambda$ 1

($r = r_0$ is the radius of the ground state)

[Alternatively

$$\lambda_n = \frac{h}{mv_n} \quad 1$$

and $v_n = v_0$ (velocity of electron in ground state)

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

[CBSE Marking Scheme, 2017]

9. Define the magnifying power of a compound microscope when the final image is formed at infinity. Why must both the objective and the eyepiece of a compound microscope have short focal lengths? Explain. 2

Ans. Definition of magnifying power 1

Reason for short focal lengths of objective and eyepiece 1

Magnifying power is defined as the angle subtended at the eye by the image to the angle subtended (at the unaided eye) by the object.

(**Alternatively:** Also accept this definition in the form of formula.)

$$m = m_0 \times m_e = \frac{L}{f_0} \times \frac{D}{f_e} \quad 1$$

To increase the magnifying power both the objective and eyepiece must have short focal lengths $\left(\text{as } m = \frac{L}{f_0} \times \frac{D}{f_e}\right)$ 1

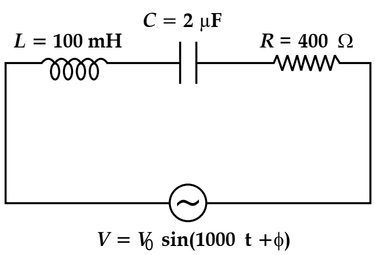
[CBSE Marking Scheme, 2017]

***10. Which basic mode of communication is used in satellite communication? What type of wave propagation is used in this mode? Write, giving reason, the frequency range used in this mode of propagation.**

SECTION -C

11. (i) Find the value of the phase difference between the current and the voltage in the series LCR circuit shown below. Which one leads in phase: current or voltage?

(ii) Without making any other change, find the value of the additional capacitor C_1, to be connected in parallel with the capacitor C, in order to make the power factor of the circuit unity. 3



** Out of Syllabus*

Ans.(i) Calculation of phase difference between current and voltage 1

Name of quantity which leads ½

(ii) Calculation of value of 'C_1', is to be connected in parallel 1½

(i) $X_L = \omega L = (1000 \times 10^{-3})\ \Omega = 100\Omega$

$$X_c = \frac{1}{\omega_c} = \left(\frac{1}{1000 \times 2 \times 10^{-6}}\right)\Omega = 500\Omega \quad ½$$

Phase angle $\tan\phi = \frac{X_L - X_C}{R}$

$$\tan\phi = \frac{100 - 500}{400} = -1$$

$$\phi = -\frac{\pi}{4} \quad ½$$

As $X_C > X_L$, (ϕ phase angle is negative), hence current leads voltage ½

(ii) To make power factor unity

$X_C' = X_L$

$\frac{1}{\omega C'} = 100$ ½

$C' = 10\mu F$ ½

$C' = C + C_1$

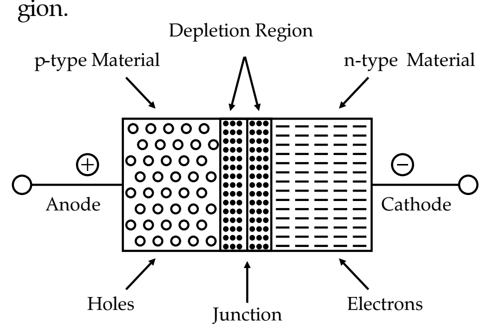
$10 = 2 + C_1$

$C_1 = 8\mu F$ ½

[CBSE Marking Scheme, 2017]

12. Write the two processes that take place in the formation of a p-n junction. Explain with the help of a diagram, the formation of depletion region and barrier potential in a p-n junction. 3

Ans. Two important processes which occur during formation of *p-n* junction are diffusion and drift. Due to concentration gradient in *p* and *n* sides holes diffuse from *p* to *n* and electrons diffuse from *n* to *p* side. Due to this there is a layer of ionised donor atoms on *n* side having positive charge and similarly a layer of ionised acceptor ions on *p* side having negative charge. This region is known as space charges region. 1



This in turn, produces potential barrier V_B across the junction which opposes the further diffusion through the junction. Thus, small region forms in the vicinity of the junction which is depleted of free charge carrier and has only immobile ions is called the depletion region.

The potential distribution near the *pn* junction is known as potential barrier. **2**

13. (i) Obtain the expression for the cyclotron frequency.

(ii) A deuteron and a proton are accelerated by the cyclotron. Can both be accelerated with the same oscillator frequency? Give reason to justify your answer. 3

Ans. (i) Derivation of the expression for cyclotron frequency 1

(ii) Reason / justification for the correct answer 2

(i) Suppose the positive charge ion with charge q moves in a circle with a velocity v, then:

$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB} \qquad ½$$

Frequency of revolution

$$f = \frac{1}{\text{Time Period}} = \frac{v}{2\pi r} \qquad ½$$

$$f = \frac{qB}{2\neq m}$$

(ii) No

The masses of the two particles, *i.e.* deuteron and proton, are different. Since (cyclotron) frequency depends inversely on the mass, they cannot be accelerated by the same oscillator frequency. **2**

[CBSE Marking Scheme, 2017]

14. (i) How does one explain the emission of electrons from a photosensitive surface with the help of Einstein's photoelectric equation?

(ii) The work function of the following metals is given : Na = 2.75 eV, K = 2.3 eV, Mo = 4.17 eV and Ni = 5.15 eV. Which of these metals will not cause photoelectric emission for radiation of wavelength 3300 Å from a laser source placed 1 m away from these metals? What happens if the laser source is brought nearer and placed 50 cm away? 3

Ans. (i) Explanation of emission of electrons from the photosensitive surface 1½

(ii) Identification of metal/s which does/do not cause photoelectric effect 1

photoelectric emission Effect produced ½

(i) Einstein's Photoelectric equation is $h\nu = \phi_0 + K_{max}$ ½

When a photon of energy '$h\nu$' is incident on the metal, some part of this energy is utilized as work function to eject the electron and remaining energy appears as the kinetic energy of the emitted electron. **1**

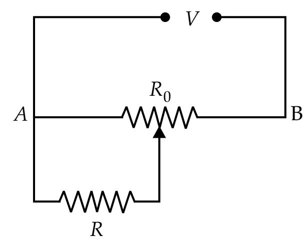
(ii) $$E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^{8}}{3.3\times10^{-7}\times1.6\times10^{-19}} eV \qquad ½$$

$$= 3.77 \text{ eV} \qquad ½$$

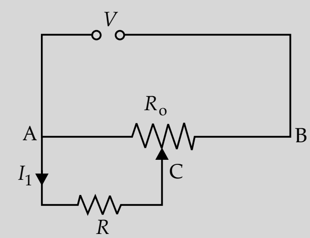
The work function of Mo and Ni is more than the energy of the incident photons; so photoelectric emission will not take place from tzhese metals. Kinetic energy of photo electrons will not change, only photoelectric current will change. ½

[CBSE Marking Scheme, 2017]

15. A resistance of R draws current from a potentiometer. The potentiometer wire, AB, has a total resistance of R_0. A voltage V is supplied to the potentiometer. Derive an expression for the voltage across R when the sliding contact is in the middle of potentiometer wire. 3



Ans. Derivation of expression of voltage across resistance R 3



Resistance between points A & C

$$\frac{1}{R_1} = \frac{1}{R} + \frac{1}{\left(\frac{R_0}{2}\right)} \qquad ½$$

Effective resistance between points A & B

$$R_2 = \left(\frac{R\frac{R_0}{2}}{R+\frac{R_0}{2}}\right) + \frac{R_0}{2} \qquad ½$$

Current drawn from the voltage source,

$$I = \frac{V}{R_2} \qquad ½$$

$$I = \frac{V}{\left(\frac{R\frac{R_0}{2}}{R+\frac{R_0}{2}}\right) + \frac{R_0}{2}} \qquad ½$$

Let current through R be I_1

$$I_1 = \frac{I\left(\frac{R_0}{2}\right)}{R+\frac{R_0}{2}}$$

Voltage across R, $V_1 = I_1 R$

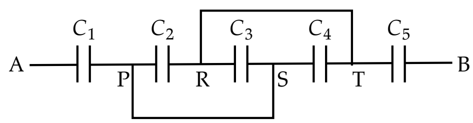
$$= \frac{IR_0}{2\left(R + \frac{R_0}{2}\right)} . R$$

$$= \frac{RR_0}{2\left(R + \frac{R_0}{2}\right)} . \frac{V}{\left(\frac{RR_0}{2R + R_0}\right) + \frac{R_0}{2}}$$ ½

$$= \frac{2RV}{R_0 + 4R}$$ **[CBSE Marking Scheme, 2017]**

***16. Define the term 'amplitude modulation'. Explain any two factors which justify the need for modulating a low frequency base-band signal. 3**

17. (i) Find equivalent capacitance between A and B in the combination given below. Each capacitor is of 2 μF capacitance.



(ii) If a dc source of 7 V is connected across AB, how much charge is drawn from the source and what is energy stored in the network? 3

Ans. (i) Calculation of equivalent capacitance 1

(ii) Calculation of charge and energy stored 1+1

(i) Capacitors C_2, C_3 and C_4 are in parallel

$\therefore$ $C_{234} = C_2 + C_3 + C_4$

$\therefore$ $C_{234} = 6\mu F$ ½

Capacitors C_1, C_{234} and C_5 are in series

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_{234}} + \frac{1}{C_5} = \frac{1}{2} + \frac{1}{6} + \frac{1}{2}$$

$$= \frac{7}{6}\mu F$$

$$C_{eq} = \frac{6}{7}\mu F$$ ½

(ii) Charge drawn from the source

$$Q = C_{eq}V,$$

$$= \frac{6}{7} \times 7\mu C = 6\mu C$$ ½

Energy stored

$$U = \frac{Q^2}{2C}$$ ½

$$= \frac{6 \times 6 \times 10^{-12} \times 7}{2 \times 6 \times 10^{-6}} = 21\ \mu J$$

½ + ½

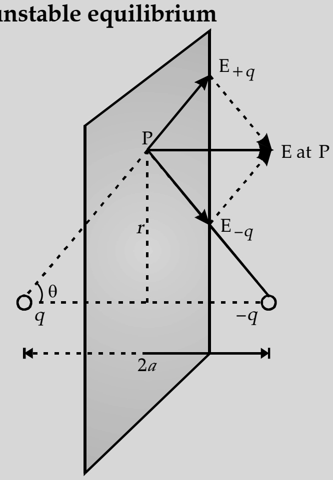
[CBSE Marking Scheme, 2017]

18. (i) Derive the expression for electric field at a point on the equatorial line of an electric dipole.

(ii) Depict the orientation of the dipole in (i) stable, (ii) unstable equilibrium in a uniform electric field. 3

Ans. (i) Derivation of expression of electric field on the equatorial line of the dipole 2

(ii) Depiction of orientation for stable and unstable equilibrium ½ + ½



(i) Let the point 'P' be at a distance 'r' from the mid point of the dipole.

$$E_{+q} = \frac{q}{4\pi\varepsilon_0(r^2 + a^2)}$$

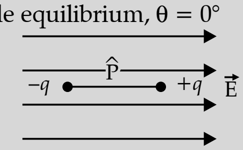
$$E_{-q} = \frac{q}{4\pi\varepsilon_0(r^2 + a^2)}$$ ½

Both are equal and their directions are as shown in the figure. Hence net electric field

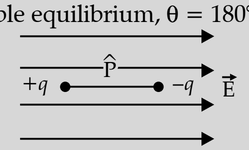
$$E_{+q} = [-(E_{+q} + E_{-q})\cos\theta]\ \hat{p}$$

$$E_p = -\frac{2qa}{4\pi\varepsilon_0(r^2 + a^2)^{\frac{3}{2}}}\hat{p}$$ ½

(ii) Stable equilibrium, θ = 0° ½



Unstable equilibrium, θ = 180° ½



[CBSE Marking Scheme, 2017]

19. (i) A radioactive nucleus 'A' undergoes a series of decays as given below:

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

The mass number and atomic number of A_2 are 176 and 71 respectively.

* *Out of Syllabus*

Determine the mass and atomic numbers of A_4 and A.

(ii) Write the basic nuclear processes underlying β^+ and β^- decays. 3

Ans. (i) Determining the mass and atomic number of A_4 and A **½ × 4**

(ii) Basic nuclear processes of β^+ and β^- decays **½ + ½**

(i) A_4 : Mass Number : 172 ½

Atomic Number : 69 ½

A : Mass Number : 180 ½

Atomic Number : 72 ½

[Alternatively : Give full credit if student considers decay and find atomic and mass numbers accordingly

$$^{180}_{72}A \xrightarrow{\alpha} {}^{176}_{70}A_1 \xrightarrow{\beta^+} {}^{176}_{71}A_2 \xrightarrow{a} {}^{172}_{69}A_3 \xrightarrow{\gamma} {}^{172}_{69}A_4$$

Gives the values quoted above. ½

If the student takes β^+ decay ½

$$^{180}_{74}A \xrightarrow{\alpha} {}^{176}_{72}A_1 \xrightarrow{\beta^+} {}^{176}_{71}A_2 \xrightarrow{a} {}^{172}_{69}A_3 \xrightarrow{\gamma} {}^{172}_{69}A_4$$

This would give the answers: (A_4 : 172, 69); (A : 180, 74)] ½ + ½

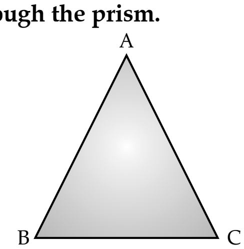
(ii) Basic nuclear process for β^+ decay $p \rightarrow n + {}^{0}_{1}e + \nu$ ½

For β^- decay $n \rightarrow p + {}^{0}_{-1}e + \bar{\nu}$

[**Note:** Give full credit of this part, if student writes the processes as conversion of proton into neutron for decay and neutron into proton for decay.] ½

[CBSE Marking Scheme, 2017]

20. (i) A ray of light incident on face AB of an equilateral glass prism, shows minimum deviation of 30°. Calculate the speed of light through the prism.



(ii) Find the angle of incidence at face AB so that the emergent ray grazes along the face AC. 3

Ans. (i) Calculation of speed of light **1½**

(ii) Calculation of angle of incidence at face AB **1½**

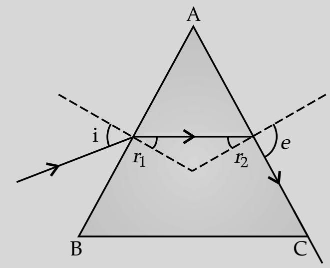
(i)
$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$= \frac{\sin\left(\frac{60^\circ+30^\circ}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)} = \sqrt{2}$$ ½

Also $\mu = \frac{c}{v} \Rightarrow v = \frac{3\times10^8}{\sqrt{2}}$ m/s ½

$v = 2.122 \times 10^8$ m/s ½

(ii)



At face AC, let the angle of incidence be r_2. For grazing ray, $e = 90^\circ$

$\Rightarrow \quad \mu = \frac{1}{\sin r_2} \Rightarrow r_2 = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^\circ$

Let angle of refraction at face AB be r_1. Now $r_1 + r_2 = A$ ½

$\therefore \quad r_1 = A - r_2 = 60^\circ - 45^\circ = 15^\circ$ ½

Let angle of incidence at this face be i

$$\mu = \frac{\sin i}{\sin r_1}$$

$\Rightarrow \quad \mu = \sqrt{2} = \frac{\sin i}{\sin 15^\circ}$

$\therefore \quad i = \sin^{-1}(\sqrt{2}.\sin 15^\circ)$ ½

[CBSE Marking Scheme, 2017]

21. For a CE-transistor amplifier, the audio signal voltage across the collector resistance of 2 kΩ is 2V. Given the current amplification factor of the transistor is 100, find the input signal voltage and base current, if the base resistance is 1 kΩ. 3

Ans. Calculation of collector current I_e base current I_B and input signal voltage V_i **1+1+1**

Given $R_e = 2k\Omega$

$= 2 \times 10^3\ \Omega$

$V_{CE} = I_C R_C$ ½

$I_C = \frac{V_{CE}}{R_C} = \frac{2}{2\times10^3} A$

$= 10^{-3}$A

$= 1mA$ ½

Current gain $= \frac{I_C}{I_B}$

$\therefore \quad 100 = \frac{10^{-3}}{I_B}$

$\therefore \quad I_B = 10^{-5}$ A ½

Input signal voltage

$V_i = I_B R_B$ ½

$= 1 \times 10^{-5} \times 10^{3}\Omega$ ½

$= 10^{-2}\, V$ ½

[**Note :** Give full credit if student calculates the required quantities by any other alternative method]

[CBSE Marking Scheme, 2017]

22. Describe the working principle of a moving coil galvanometer. Why is it necessary to use (i) a radial magnetic field and (ii) a cylindrical soft iron core in a galvanometer?

Write the expression for current sensitivity of the galvanometer.

Can a galvanometer as such be used for measuring the current? Explain. 3

OR

(a) Define the term 'self-inductance' and write its S.I. unit.

(b) 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 number of turns per unit length, when a current I is set up in the outer solenoid S_2. 3

Ans. Principle and working : A current carrying coil, placed in a uniform magnetic field, can experience a torque.

Consider a rectangular coil for which no. of turns $= N_i$

Area of cross-section $= l \times b = A$,

Intensity of the uniform magnetic field $= B$,

Current through the coil $= I$

$\therefore$ Deflecting torque $= BIl \times b = BIA$

For N turns, $\tau = NBIA$

Restoring torque in the spring $= k\theta$ ½

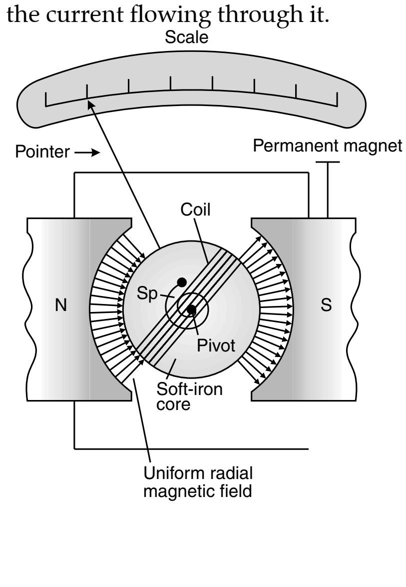
(k = restoring torque per unit twist)

$\therefore \quad NBIA = k\theta$

$\therefore \quad I = \left(\frac{k}{NBA}\right)\theta$

$\therefore \quad I \propto \theta$

The deflection of the coil is therefore, proportional to the current flowing through it. ½



(i) Need for a radial magnetic field :

The relation between the current (i) flowing through the galvanometer coil, and the angular deflection (ϕ) of the coil (from its equilibrium position), is

$$\phi = \left(\frac{NABI \sin\theta}{k}\right)$$

where θ is the angle between the magnetic field $\vec{B}$ and the equivalent magnetic moment $\vec{\mu}_m$ of the current carrying coil.

Thus I is not directly proportional to ϕ. We can ensure this proportionality by having $\theta = 90°$. This is possible only when the magnetic field $\vec{B}$, is a radial magnetic field. In such a field, the plane of the rotating coil is always parallel to $\vec{B}$.

To get a radial magnetic field, the pole pieces of the magnet, are made concave in shape. Also a soft iron cylinder is used as the core.

The soft iron core not only makes the field radial but also increases the strength of the magnetic field. **1**

A galvanometer has low resistance and allow only a very small current. When high current is passed the coil will burn hence galvanometer as such is not used for measuring current.

(ii) We have

Current sensitivity $= \frac{\theta}{I} = NBA/k$ **1**

OR

(a) Definition of self inductance and its SI unit 1 + ½

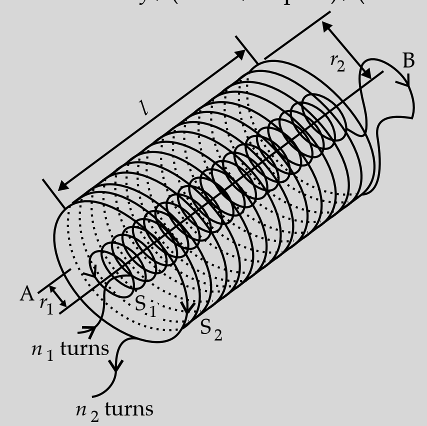
(b) Derivation of expression for mutual inductance 1 ½

Self inductance of a coil equals the magnitude of the magnetic flux, linked with it, when a unit current flows through it.

Alternatively

Self inductance of a coil, equals the magnitude of the emf induced in it, when the current in the coil, is changing at a unit rate.

SI unit: henry / (weber/ampere) / (ohm second.)



When current I_2 is passed through coil, it in turn sets up a magnetic flux through S_1:

$$\phi = n_1 \times \mu_0 \frac{n_2}{l} \times I_2 \times \pi r_1^2$$

$$= \left(\mu_0 \frac{n_1 n_2}{l} \pi r_1^2\right) I_2 = M_{12} I_2$$

where $M_{12} = \mu_0 \frac{n_1 n_2}{l} \pi r_1^2$

[**Note :** If the student derives the correct expression, without giving the diagram of two coaxial coils, full credit can be given]

[CBSE Marking Scheme, 2017]

SECTION -D

23. Mrs. Rashmi Singh broke her reading glasses. When she went to the shopkeeper to order new spectacles, he suggested that she should get spectacles with plastic lenses instead of glass lenses. On getting the new spectacles, she found that the new ones were thicker that the earlier ones. She asked this question to the shopkeeper but he could not offer satisfactory explanation for this. At home, Mrs. Singh raised the same question to her daughter Anuja who explained why plastic lenses were thicker.

(a) Write two qualities displayed each by Anuja and her mother.

(b) How do you explain this fact using lens maker's formula? 4

Ans. (a) Two qualities each of Anuja and her mother ½ × 4

(b) Explanation, using lens maker's formula 2

(a) **Anuja :** Scientific temperament, co-operative, knowledgeable (any two) ½ + ½

Mother : Inquisitive, scientific temper/keen to learn/has no airs (any two)(or any other two similar values) ½ + ½

(b) $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ½

As the refractive index of plastic material is less than that of glass material therefore, for the same power $\left(= \frac{1}{f}\right)$, the radius of aperture of plastic material is small. ½+½

Therefore plastic lens is thicker. ½

Alternatively, If student just writes that plastic has a different refractive index than glass, award one mark for this part.

[CBSE Marking Scheme, 2017]

SECTION -E

24. (a) Draw a labelled diagram of AC generator. Derive the expression for the instantaneous value of the emf induced in the coil.

(b) A circular coil of cross-sectional area 200 cm^2 and 20 turns is rotated about the vertical diameter with angular speed of 50 rad s^{-1} in a uniform magnetic field of magnitude 3.0 × 10^{-2} T. Calculate the maximum value of the current in the coil.

OR

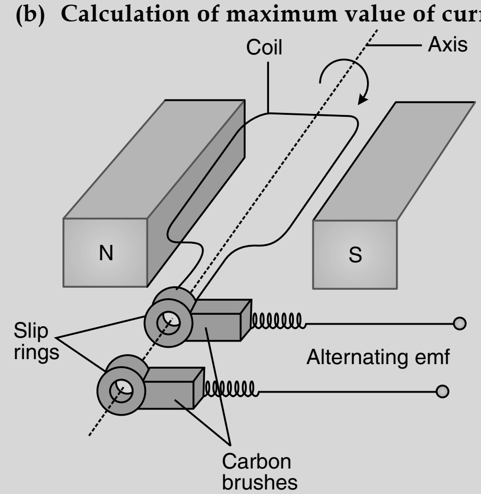
(a) Draw a labelled diagram of a step-up transformer. Obtain the ratio of secondary to primary voltage in terms of number of turns and currents in the two coils.

(b) 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. 5

Ans. (a) Labelled diagram of AC generator 1½

Expression for instantaneous value of induced emf. 1½

(b) Calculation of maximum value of current 2



[Deduct ½ mark, if diagram is not labelled] 1½

When the coil is rotated with constant angular speed the angle θ between the magnetic field and area vector of the coil, at instant t, is given by

$$\theta = \omega t,$$

Therefore, magnets flux, (ϕ_B), at this instant, is $\phi_B = BA \cos \omega t$ ½

Induced emf $e = -N\frac{d\phi_B}{dt}$ ½

$$e = NBA\, \omega \sin \omega t$$

$$e = e_0 \sin \omega t$$

where $e_0 = NBA\,\omega$ ½

(b) Maximum value of emf

$$e_0 = NBA\,\omega$$

$$= 20 \times 200 \times 10^{-4} \times 3 \times 10^{-4} \times 50\text{V}$$

$$= 600 \text{ mV}$$ 1½

Maximum induced current

$$i_0 = \frac{e_0}{R} = \frac{600}{R}\text{mA}$$ ½

[**Note 1:** If the student calculates the value of the maximum induced emf and says that "since R is not given, the value of maximum induced current cannot be calculated", the ½ mark, for the last part, of the question, can be given.]

[**Note 2:** The direction of magnetic field has not been given. If the student takes this direction along the axis of rotation and hence obtains the value of induced emf and, therefore, maximum current, as zero, award full marks for this part.]

[CBSE Marking Scheme, 2017]

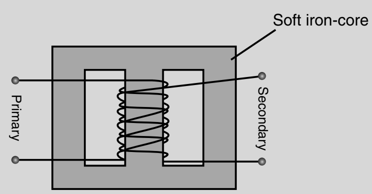
OR

(a) **Labelled diagram of a step up transformer** **1½**

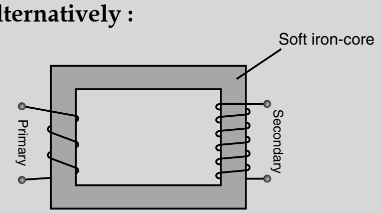
Derivation of ratio of secondary and primary voltage **2**

(b) **Calculation of number of turns in the secondary** **1½**

(a)



Alternatively :



½

[Note: Deduct ½ mark, if labelling is not done]

When ac voltage is applied to primary coil the resulting current produces an alternating magnetic flux, which also links the secondary coil.

The induced emf, in the secondary coil, having Ns turns, is

$$e_s = -N_s \frac{d\varphi}{dt}$$

This flux, also induces an emf, called back emf, in the primary coil.

$$e_s = -N_s \frac{d\varphi}{dt} \qquad ½$$

But $e_p = V_p$

and $e_s = V_s$ ½

$$\Rightarrow \quad \frac{V_s}{V_p} = \frac{N_s}{N_p} \qquad ½$$

For an ideal transformer

$$l_p V_p = i_s V_s \qquad ½$$

$$\Rightarrow \quad \frac{V_s}{V_p} = \frac{i_p}{i_s} \qquad ½$$

(b)

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} \qquad ½$$

$$\frac{N_s}{3000} = \frac{220}{2200}$$

$$\therefore \quad N_s = 300 \qquad ½$$

[CBSE Marking Scheme, 2017]

25. (a) Distinguish between unpolarised light and linearly polarized light. How does one get linearly polarised light with the help of a polaroid?

(b) A narrow beam of unpolarised light of intensity I_0 is incident on a polaroid P_1. The light transmitted by it is then incident on a second polaroid P_2 with its pass axis making angle of 60° relative to the pass axis of P_1. Find the intensity of the light transmitted by P_2.

OR

(a) Explain two features to distinguish between the interference pattern in Young's double slit experiment with the diffraction pattern obtained due to a single slit.

(b) A monochromatic light of wavelength 500 nm is incident normally on a single slit of width 0.2 mm to produce a diffraction pattern. Find the angular width of the central maximum obtained on the screen.

Estimate the number of fringes obtained in Young's double slit experiment with angular fringe width 0.5, which can be accommodated within the region of total angular spread of the central maximum due to single slit. **5**

Ans. (a) Distinction between unpolarised and linearly polarized light **2**

Obtaining linearly polarized Light **1**

(b) Calculation of intensity of light **2**

(a) In an unpolarised light, the oscillations of the electric field, are in random directions in planes perpendicular to the direction of propagation. For a polarized light, the oscillations are aligned along one particular direction. **2**

Alternatively

Polarized light can be distinguished from unpolarised light when it is allowed to pass through a polaroid. Polarized light can show change in its intensity, on passing through a Polaroid; intensity remains same in case of unpolarised light.

When unpolarised light wave is incident on a polaroid, then the electric vectors along the direction of its aligned molecules, get absorbed; the electric vector, oscillating along a direction perpendicular to the aligned molecules, pass through. This light is called linearly polarized light. **1**

(b) According to Malus' Law:

$$I = I_0 \cos^2 \theta$$

$$I = \left(\frac{I_0}{2}\right)\cos^2 \theta,$$

where I_0 is the intensity of unpolarised light.

$$\theta = 60° \text{ (given)}$$

$$I = \frac{I_0}{2}\cos^2 60° = \frac{I_0}{2} \times \left(\frac{1}{2}\right)^2$$

$$= \frac{I_0}{8}$$ **2**

[CBSE Marking Scheme, 2017]

OR

(a) Explanation of two features (distinguishing between interference pattern and diffraction pattern.) **2**

(b) Calculation of angular width of central maxima **2**

Estimation of number of fringes **1**

(a)

Interference Pattern	Diffraction pattern
(i) All fringes are of equal width.	**(i)** Width of central maxima is twice the width of higher order bands.
(ii) Intensity of all bright bands is equal.	**(ii)** Intensity goes on decreasing for higher order of diffraction bands.

[Note : Also accept any other two correct distinguishing features.] **1 + 1**

(b) Angular width of central maximum

$$\omega = \frac{2\lambda}{a}$$

$$= \frac{2 \times 500 \times 10^{-9}}{0.2 \times 10^{-3}} \text{ radian}$$

$$= 5 \times 10^{-3} \text{ radian}$$

$$\beta = \frac{\lambda D}{d}$$ **1**

Linear width of central maxima in the diffraction pattern

$$\omega' = \frac{2\lambda D}{a}$$

Let 'n' be the number of interference fringes which can be accommodated in the central maxima

$\therefore \quad n \times \beta = \omega'$

$$n = \frac{2\lambda D}{a} \times \frac{d}{\lambda D}$$

$$n = \frac{2d}{a}$$ **1½**

[**Note :** Award the last ½ mark if the student writes the answers as 2 (taking $d = a$), or just attempts to do these calculation.]

[CBSE Marking Scheme, 2017]

26. (i) Derive an expression for drift velocity of electrons in a conductor. Hence deduce Ohm's law.

(ii) A wire whose cross-sectional area is increasing linearly from its one end to the other, is connected across a battery of V volts. Which of the following quantities remain constant in the wire?

(a) drift speed **(b) current density**

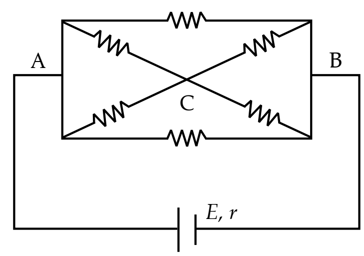
(c) electric current **(d) electric field**

Justify your answer.

OR

(i) State the two Kirchhoff's laws. Explain briefly how these rules are justified.

(ii) The current is drawn from a cell of emf E and internal resistance r connected to the network of resistors each of resistance r as shown in the figure. Obtain the expression of (i) the current drawn from the cell and (ii) the power consumed in the network. **5**



Ans. (i) Derivation of the expression for drift velocity **2**

Deduction of Ohm's law **2**

(ii) Name of quantity and justification **½ + ½**

Let an electric field E be applied the conductor. Acceleration of each electron is

$$a = -\frac{eE}{m}$$

Velocity gained by the electron

$$v = -\frac{eE}{m}t$$

Let the conductor contain n electrons per unit volume. The average value of time 't', between their successive collisions, is the relaxation time, 'τ'.

Hence average drift velocity

$$v_d = \frac{-eE}{m}\tau$$ **2**

The amount of charge, crossing area A, in time Δt is

$$neAv_d\Delta t = I\Delta t$$

Substituting the value of v_d, we get

$$I\Delta t = neA\left(\frac{e^2E\tau}{m}\right)\Delta t$$

$$\therefore \quad I = \left(\frac{e^2A\tau n}{m}\right)$$

$$J = \sigma E, \left(\sigma = \frac{e^2\tau n}{m} \text{ is the conductivity}\right)$$

But $I = JA$, where J is the current density

$$\Rightarrow \quad J = \left(\frac{e^2\tau n}{m}\right)E$$

$$\Rightarrow \quad J = \sigma E$$ **2**

This is Ohm's law

[**Note:** Credit should be given if the student derives the alternative form of Ohm's law by substituting $E = \frac{V}{\ell}$]

(ii) Electric current well remain constant in the wire.

All other quantities, depend on the cross sectional area of the wire.

[CBSE Marking Scheme, 2017]

OR

(i) Statement of Kirchhoff's laws **1+1**

Justification **½ + ½**

(ii) Calculation of (A) current drawn and **1**

(B) Power consumed **1**

(i) Junction Rule: At any Junction, the sum of currents, entering the junction, is equal to the sum of currents leaving the junction. **1**

Loop Rule: The algebraic sum, of changes in potential, around any closed loop involving resistors and cells, in the loop is zero. **1**

$$\Sigma(\Delta V) = 0$$

Justification : The first law is in accord with the law of conservation of charge. ½

The Second law is in accord with the law of conservation of energy. ½

(ii) Equivalent resistance of the loop

$$R = \frac{r}{3}$$ ½

Hence current drawn from the cell

$$I = \frac{E}{\frac{r}{3}+r} = \frac{3E}{4r}$$ ½

Power consumed

$$P = I^2\left(\frac{r}{3}\right)$$

$$= \frac{9E^2}{16r^2}\times\frac{4r}{3} = \frac{3E^2}{4r}$$

[**Note:** Award the last 1 ½ marks for this part, if the calculations, for these parts, are done by using (any other) value of equivalent resistance obtained by the student.)

[CBSE Marking Scheme, 2017]

Delhi Set II — Code No. 55/1/2

Note: Except these, other questions are from Delhi Set-I.

SECTION -B

6. Find the wavelength of the electron orbiting in the first excited state in hydrogen atom. **2**

Ans. Calculation of wavelength of electron in first excited state **2**

Radius of n^{th} orbit

$r = r_0 n^2 = 0.53n^2 \times$ Å

$= 0.53 \times 4$Å [$\because$ Here $n = 2$]

$= 2.12$Å ½

For an electron revolving in n^{th} orbit, according to de Broglie relation

$2\pi r_n = n\lambda,$

For 1st excited state $n = 2$ ½

$2 \times 3.14 \times 2.12 \times 10^{-10} = 2\lambda$ ½

$\lambda = 3.14 \times 2.12 \times 10^{-10}$ ½

$= 6.67$Å

Alternatively

$$\lambda = \frac{h}{p} = \frac{h}{m_e v}$$ ½

velocity of electron in first excited state,

$v = 1.1 \times 10^6$ m/s ½

$$\lambda = \frac{6.63\times10^{-34}}{9\times10^{-31}\times1.1\times10^6}$$ ½

$= 6.67$Å ½

Alternatively

Let λ_n be the wavelength of the electron in the n^{th} orbit. We then have

$2\pi r_n = n\lambda_n$ **1**

$\therefore \lambda_2 = \pi r_2$ ½

Also $r_2 = 4r_0$

(r_2 = radius of the ground state orbit)

$\therefore \lambda_2 = 4\pi r_0$ ½

Alternatively,

Let λ_2 be the wavelength of the electron in the n^{th} orbit. We then have

$$\lambda_n = \frac{h}{mv_n}$$ ½

But $v_n = \frac{v_0}{n}$ ½

$$\therefore \lambda_2 = \frac{2h}{mv_0}$$ **1**

where v_0 is the velocity of electron in ground state. **[CBSE Marking Scheme, 2017]**

7. Distinguish between a transducer and a repeater. **2**

Ans. Distinction between transducer and repeater **2**

Transducer : A device which converts one form of energy into another. **1**

Repeater : A combination of receiver and transmitter. It picks signals from a receiver, amplifies and retransmits them. **1**

[CBSE Marking Scheme, 2017]

10. Why should the objective of a telescope have large focal length and large aperture? Justify your answer. **2**

Ans. Reasons for having large focal length and large aperture of objective of telescope and their justification. **1+1**

Large focal length : to increase magnifying power ½

$$\left(\because m = \frac{f_0}{f_e}\right)$$ ½

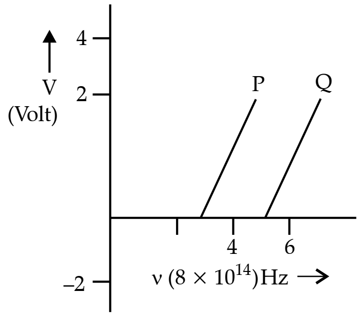
Large aperture : to increase resolving power. ½

$$\left(\because \text{RP} = \frac{2a}{1.22\lambda}\right)$$ ½

[CBSE Marking Scheme, 2017]

SECTION -C

12. In the study of a photoelectric effect the graph between the stopping potential V and frequency ν of the incident radiation on two different metals P and Q is shown below : **3**



(i) Which one of the two metals has higher threshold frequency?

(ii) Determine the work function of the metal which has greater value.

(iii) Find the maximum kinetic energy of electron emitted by light of frequency 8×10^{14} Hz for this metal.

Ans. Identification of metal which has higher threshold frequency ½

Determination of the work function of the metal which has greater value **1½**

Calculation of maximum kinetic energy (K_{max}) of electron emitted by light of frequency 8×10^{14} Hz **1**

(i) Q has higher threshold frequency ½

(ii) Work function $\phi_0 = h\nu_0$ ½

$$h\nu_0 = (6.6\times10^{-34})\times\frac{5\times10^{14}}{1.6\times10^{-19}}\text{eV}$$ ½

$$= 2\text{eV}$$ ½

$$K_{max} = h(\nu - \nu_0)$$ ½

$$= \frac{6.6\times10^{-34}\times3\times10^{14}}{1.6\times10^{-19}}\text{eV}$$

$$K_{max} = 0.83\text{eV}$$ ½

[CBSE Marking Scheme, 2017]

13. A 12 pF capacitor is connected to a 50 V battery. How much electrostatic energy is stored in the capacitor? If another capacitor of 6 pF is connected in series with it with the same battery connected across the combination, find the charge stored and potential difference across each capacitor. **3**

Ans. Calculation of electrostatic energy in 12 pF capacitor **1**

Total charge stored in combination **1**

Potential difference across each capacitor ½ + ½

Energy stored, in the capacitor of capacitance 12 pF,

$$U = \frac{1}{2}C_1V^2$$ ½

$$= \frac{1}{2}\times12\times10^{-12}\times50\times50\text{ J}$$ ½

$$= 1.5 \times 10^{-8}\text{ J}$$

C = Equivalent capacitance of 12 pF and 6 pF, in series, is given by ½

$$\frac{1}{C_{eq}} = \frac{1}{12}+\frac{1}{6} = \frac{1+2}{12}$$

$$\therefore \quad C_{eq} = 4\text{ pF}$$

$\therefore$ Charge stored across each capacitor ½

$$q = C_{eq}V$$
$$= 4 \times 10^{-12} \times 50\text{ C}$$
$$= 2 \times 10^{-10}\text{ C}$$

Charge on each capacitor 12 pF as well as 6 pF

$\therefore$ Potential difference across capacitor C_1

$$\therefore \quad V_1 = \frac{2\times10^{-10}}{12\times10^{-12}}\text{ volt} = \frac{50}{3}V$$ ½

Potential difference across capacitor C_2

$$\therefore \quad V_2 = \frac{2\times10^{-10}}{6\times10^{-12}}\text{ volt} = \frac{100}{3}V$$ ½

[CBSE Marking Scheme, 2017]

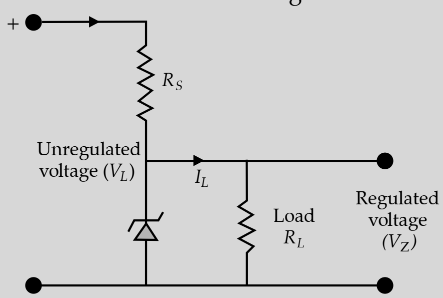
18. A zener diode is fabricated by heavily doping both *p*- and *n*- sides of the junction. Explain, why? Briefly explain the use of zener diode as a dc voltage regulator with the help of a circuit diagram. **3**

Ans. Explanation of heavily doping of both *p* and *n* sides of Zener diode **1**

Circuit diagram of Zener diode as a *d*c voltage regulator **1**

Explanation of the use of Zener diode as a *dc* voltage regulator. **1**

By heavily doping both *p* and *n* sides of the junction, depletion region formed is very thin, *i.e.* < 10^{-6} m. Hence, electric field, across the junction is very high (even for a small reverse bias. This can lead to a 'breakdown' during reverse biasing. **1**



Zener diode as DC voltage regulator **1**

If the input voltage increases/decreases, current through resister R_s, and Zener diode, also increases/decreases. This increases/decreases the voltage drop across R_s without any change in voltage across the Zener diode. **1**

This is because, in the breakdown region, Zener voltage remains constant even though the current through the Zener diode changes.

[CBSE Marking Scheme, 2017]

21. A electron of mass m_e revolves around a nucleus of charge + *Ze*. Show that it behaves like a tiny magnetic dipole. Hence prove that the magnetic moment associated with it is expressed as $\vec{\mu} = \frac{e}{2m_e}\vec{L}$, where $\vec{L}$ is the orbital angular momentum of the electron. Give the significance of negative sign. **3**

Ans. (i) Behaviour of revolving electron as a tiny magnetic dipole **1**

(ii) Proof of the relation $\vec{\mu} = -\frac{e}{2m_e}\vec{L}$ **½**

(iii) Significance of negative sign

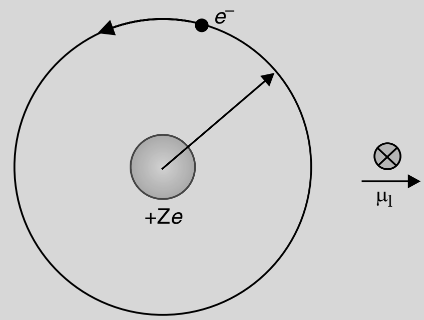
Electron, in circular motion around the nucleus, constitutes a current loop which behaves like a magnetic dipole.

Current associated with the revolving electron :

$$I = \frac{e}{T}$$

and $$T = \frac{2\pi r}{v}$$

$\therefore$ $$I = \frac{e}{2\pi r}v$$



Magnetic moment of the loop, $\mu = IA$

$$\mu = IA = \frac{ev}{2\pi r}\pi r^2 = \frac{evr}{2} = \frac{e.m_e vr}{2m_e}$$ ½

Orbital angular momentum of the electron

$$L = m_e vr$$ ½

$$\vec{\mu} = \frac{-e}{2m_e}\vec{L}$$

–ve sign signifies that the angular momentum of the revolving electron is opposite in direction to the magnetic moment associated with it. ½

[CBSE Marking Scheme, 2017]

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

(ii) Depict the equipotential surfaces due to an electric dipole. **3**

Ans. (i) Derivation of expression for the electric potential due to an electric dipole at a point on the axial line. **2**

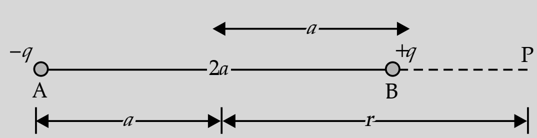
(ii) Depiction of equipotential surfaces due to an electric dipole. **1**

Potential due to charge at A,

$$V_A = \frac{1}{4\pi\varepsilon_0}\frac{-q}{(r+a)}$$ **1**

Potential due to charge at B,

$$V_B = \frac{1}{4\pi\varepsilon_0}\frac{+q}{(r-a)}$$



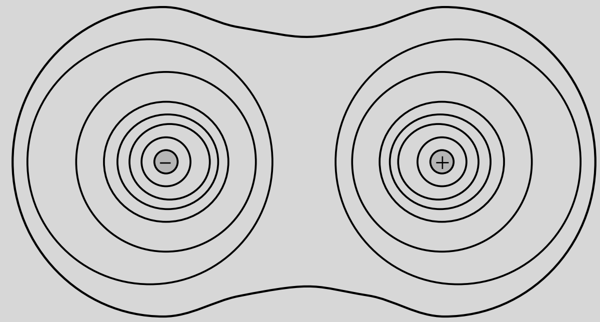
∴ Potential at point P,

$V = V_B + V_A$

∴ Net Potential at P

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{-1}{(r+a)} + \frac{1}{(r-a)}\right]$$ **1**

[**Note :** Also accept any other alternative correct method.] **1**



[CBSE Marking Scheme, 2017]

Delhi Set III — Code No. 55/1/3

Note: Except these, other questions are from Delhi Set-I & II.

SECTION -B

7. When are two objects just resolved? Explain. How can the resolving power of a compound microscope be increased? Use relevant formula to support your answer. **2**

Ans. **Condition, when two objects are just resolved** **½**

For increasing the resolving power of a compound microscope **1½**

Two objects are said to be just resolved when, in their diffraction patterns, central maxima of one object coincides with the first minima, of the diffraction pattern of the second object.

Limit of resolution of compound microscope

$$d_{min} = \frac{1.22}{2n\sin\beta}$$

Resolving power is the reciprocal of limit of resolution (d_{min}) ½

Therefore, to increase resolving power can be reduced and refractive index can be increased. **1½**

[CBSE Marking Scheme, 2017]

***8. (i) What is the line of sight communication?**

(ii) Why is it not possible to use sky waves for transmission of TV signals? Upto what distance can a signal be transmitted using an antenna of height '*h*'? **2**

9. An α-particle and a proton are accelerated through the same potential difference. Find the ratio of their de Broglie wavelengths. **2**

Ans. **Finding the ratio of de Broglie wavelength** $\left(\frac{\lambda\alpha}{\lambda p}\right)$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mqV}}$$ ½

$$\therefore \frac{\lambda\alpha}{\lambda p} = \frac{h}{\sqrt{2m_\alpha q_\alpha V}} \times \frac{\sqrt{2m_p q_p V}}{h}$$ ½

$$\frac{\lambda_\alpha}{\lambda_p} = \frac{\sqrt{m_p q_p}}{\sqrt{m_\alpha q_\alpha}} = \frac{\sqrt{m_p q_p}}{\sqrt{4m_p 2q_p}} = \frac{1}{2\sqrt{2}}$$ ½

$\lambda_\alpha : \lambda p = 1 : 2\sqrt{2}$ ½

[CBSE Marking Scheme, 2017]

SECTION -C

14. (i) State two important features of Einstein's photoelectric equation.

(ii) Radiation of frequency 10^{15} Hz is incident on two photosensitive surfaces P and Q. There is no photoemission from surface P. Photoemission occurs from surface Q but photoelectrons have zero kinetic energy. Explain these observations and find the value of work function for surface. **3**

Ans. (i) Two important features of Einstein's photo electric equation **½ + ½**

(ii) Explanation of observations and finding value of work function of surface Q **1+1**

(i) Maximum kinetic energy (K_{max}), of emitted electrons, depends linearly on frequency of incident radiations

$K_{max} = h\nu - h\nu_0$

Existence of threshold frequency for the metal surface $\phi_0 = h\nu_0$

(Any other relevant feature) ½+½

(ii) Since no photoelectric emission takes place from P it means frequency of incident radiation (10^{15} Hz) is less than its threshold frequency $(\nu_0)_p$. ½

Photo emission takes place from Q but kinetic energy of photoelectrons is zero. This implies that frequency of incident radiation is just equal to the threshold frequency of Q. ½

* *Out of Syllabus*

For Q,
work function

$\phi_0 = h\nu_0$

$= \dfrac{6.6 \times 10^{-34} \times 10^{15}}{1.6 \times 10}$ eV ½

$= 4.125$eV ½

[CBSE Marking Scheme, 2017]

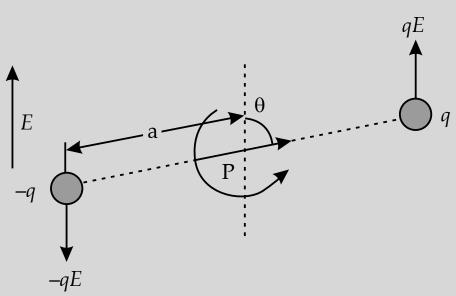
16. (i) Obtain the expression for the torque $\vec{\tau}$ experienced by an electric dipole of dipole moment $\vec{p}$ in a uniform electric field, $\vec{E}$.

(ii) What will happen if the field were not uniform? 3

Ans. (i) Obtaining of the expression for torque experienced by an electric dipole 2

(ii) Effect of non-uniform electric field 1

(i)



Force on + q, $\vec{F} = q\vec{E}$

Force on – q, $\vec{F} = -q\vec{E}$

Magnitude of torque

$\tau = qE \times 2a \sin\theta$

$= 2qa\, E \sin\theta$

$\vec{\tau} = \vec{p} \times \vec{E}$ **2**

(ii) If the electric field is non uniform, the dipole experiences a translatory force as well as a torque. **1**

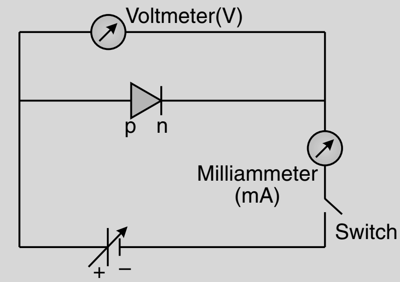
[CBSE Marking Scheme, 2017]

17. Explain briefly with the help of necessary diagrams, the forward and the reverse biasing of a *p-n* junction diode. Also draw their characteristic curves in the two cases. 3

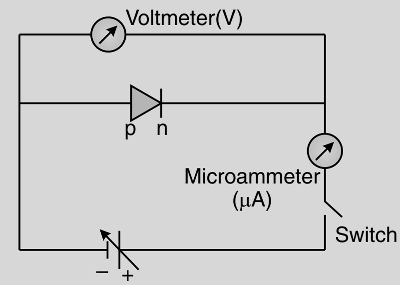
Ans. Circuit diagrams of *p n* junction under forward bias and reverse bias ½ + ½

Explanation of *p n* junction working for forward and reverse bias ½ + ½

Characteristic curves for the two cases ½ + ½



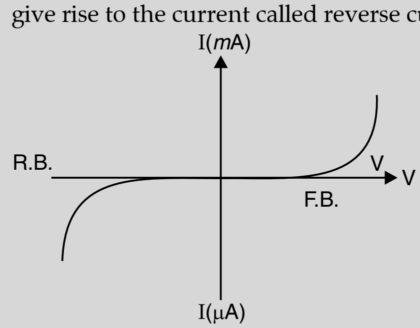
½



½

In forward bias, applied voltage does not support potential barrier. As a result, the depletion layer width decreases and barrier height is reduced. Due to the applied voltage, electrons from *n* side cross the depletion region and reach *p* side. Similarly holes from *p* side cross the junction and reach the *n* side. The motion of charged carriers, on either side, give rise to current. ½

In reverse bias, applied voltage support potential barrier. As a result, barrier height is increased, depletion layer widens. This suppresses the flow of electrons from $n \to p$ and holes from $p \to n$. Diffusion current decreases. The electric field direction of the junction is such that if electrons on *p* side or holes on *n* side in their random motion comes close to the junction, they will be swept to its majority zone. This drift of carriers give rise to the current called reverse current. ½



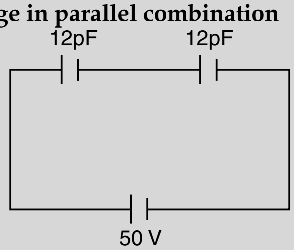
½+½

[CBSE Marking Scheme, 2017]

20. Two identical capacitors of 12 pF each are connected in series across a battery of 50 V. How much electrostatic energy is stored in the combination? If these were connected in parallel across the same battery, how much energy will be stored in the combination now?

Also find the charge drawn from the battery in each case. 3

Ans. **Equivalent capacitance in series** ½
Energy in series combination ½
Charge in series combination ½
Equivalent capacitance in parallel combination ½
Energy in parallel combination ½
Charge in parallel combination ½



In series combination :

$$\frac{1}{C_s} = \left(\frac{1}{12}+\frac{1}{12}\right)(\text{pF})^{-1}$$ ½

$C_s = 6 \times 10^{-12}$pF

$U_s = \frac{1}{2}C_sV^2$

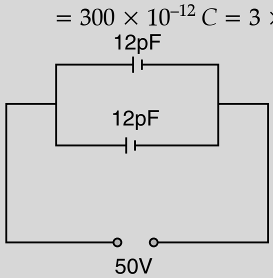
$U_s = \frac{1}{2}\times 6\times 10^{-12}\times 50\times 50$ J

$U_s = 75 \times 10^{-10}\, J$ ½

$q_s = C_sV$

$= 6 \times 10^{-12} \times 50$

$= 300 \times 10^{-12}\, C = 3 \times 10^{-10}$ C ½



In parallel combination :

$C_p = (12 + 12)$ pF

$\therefore \quad C_p = 24 \times 10^{-12}$ F

$U_p = \frac{1}{2}\times 24\times 10^{-12}\times 2500$ J

$U_s = 3 \times 10^{-8}\, J$ ½

$q_p = C_pV$

$q_p = 24 \times 10^{-12} \times 50$ C ½

$q_p = 1.2 \times 10^{-9}$ C x ½

[CBSE Marking Scheme, 2017] 3

21. (a) Write the expression for the force $\vec{F}$ acting on a particle of mass m and charge q moving with velocity $\vec{V}$ in a magnetic field $\vec{B}$. Under what conditions will it move in (i) a circular path and (ii) a helical path?

(b) Show that the kinetic energy of the particle moving in magnetic field remains constant. **3**

Ans. (a) Expression for force acting on charged particle **1**
(i) Condition for circular path ½
(ii) Condition for helical path ½
(b) Showing Kinetic energy is constant **1**

(a) $\vec{F} = q(\vec{v}\times\vec{B})$ **1**

(i) When velocity of charged particle and magnetic field are perpendicular to each other. ½

(ii) When velocity is neither parallel nor perpendicular to the magnetic field. ½

(b) The force, experienced by the charged particle, is perpendicular to the instantaneous velocity, at all instants. Hence the magnetic force cannot bring any change in the speed of the charged particle. Since speed remains constant, the kinetic energy also stays constant. **1**

[CBSE Marking Scheme, 2017]

Outside Delhi Set I — Code No. 55/1/3

SECTION -A

1. Nichrome and copper wires of same length and same radius are connected in series. Current I is passed through them. Which wire gets heated up more? Justify your answer. **1**

Ans. (i) Nichrome ½
(ii) $R_{Ni} > R_{Cu}$ (or $\text{Resistivity}_{Ni} > \text{Resistivity}_{Cu}$) ½

[CBSE Marking Scheme, 2017]

2. Do electromagnetic waves carry energy and momentum? **1**

Ans. Yes **1**

[CBSE Marking Scheme, 2017]

3. How does the angle of minimum deviation of a glass prism vary, if the incident violet light is replaced by red light? Give reason. **1**

Ans. (i) Decreases ½
(ii) $n_{\text{Violet}} > n_{\text{Red}}$ ½
(Also accept if the student writes $\lambda_V < \lambda_R$)

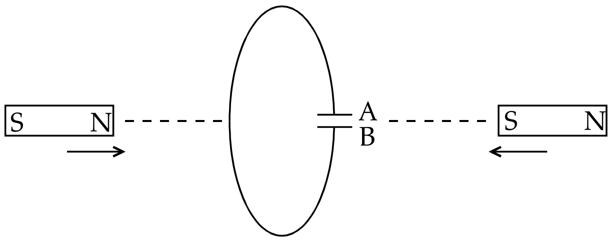
[CBSE Marking Scheme, 2017] 1

4. Name the phenomenon which shows the quantum nature of electromagnetic radiation. **1**

Ans. Photoelectric Effect (Raman Effect/ Compton Effect) **1**

[CBSE Marking Scheme, 2017]

5. Predict the polarity of the capacitor in the situation described below : **1**



Ans. A is positive and ½
B is negative ½
(Also accept: A is negative and B is positive) **1**
[CBSE Marking Scheme, 2017]

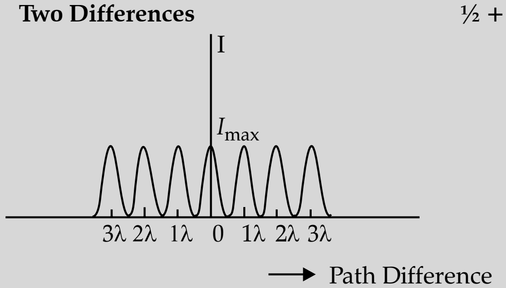
SECTION -B

6. Draw the intensity pattern for single slit diffraction and double slit interference. Hence, state two differences between interference and diffraction patterns.

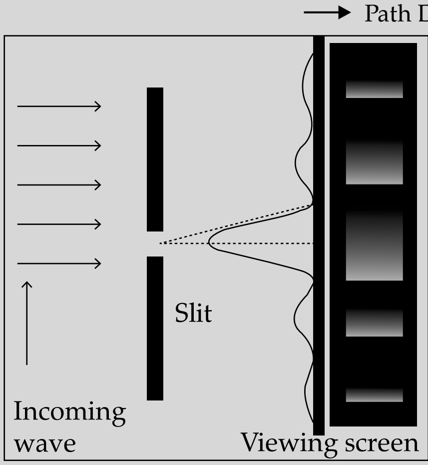
OR

Unpolarised light is passed through a polaroid P_1. When this polarised beam passes through another polaroid P_2 and if the pass axis of P_2 makes angle θ with the pass axis of P_1, then write the expression for the polarised beam passing through P_2. Draw a plot showing the variation of intensity when θ varies from 0 to 2π. **2**

Ans. Interference pattern ½
Diffraction pattern ½
Two Differences ½ + ½



½



½

Differences:

Interference	Diffraction
All maxima have equal intensity.	Maxima have different (rapidly decreasing) intensity.
All fringes have equal width.	Different (changing) width.
Superposition of two wavefronts.	Superposition of wavelets from the same wavefront.

(Any two) ½ +½
[CBSE Marking Scheme, 2017]

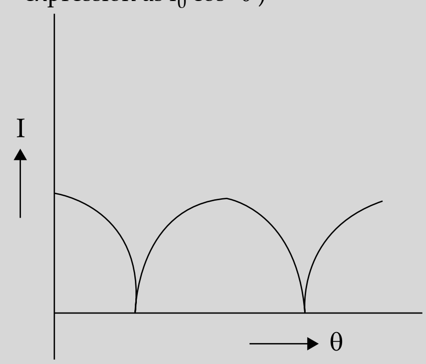
OR

Ans. Expression for intensity of polarized beam **1**
Plot of intensity variation with angle **1**

Intensity is $\frac{I_0}{2}\cos^2\theta$ (if I_0 is the intensity of unpolarised light.)

Intensity is $I\cos^2\theta$ (if I is the intensity of polarized light.)

(Award ½ mark if the student writes the expression as $I_0\cos^2\theta$) **1**



1

[CBSE Marking Scheme, 2017

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

Ans. (a) Identification ½ + ½
(b) Uses ½ + ½
(a) X – rays ½
Used for medical purposes.
(Also accept UV rays and gamma rays and any one use of the e.m. wave named) ½
(b) Microwaves ½
Used in radar systems.
(Also accept short radio waves and any one use of the e.m. wave named) ½
[CBSE Marking Scheme, 2017]

8. Find the condition under which the charged particles moving with different speeds in the presence of electric and magnetic field vectors can be used to select charged particles of a particular speed. 2

Ans. Condition

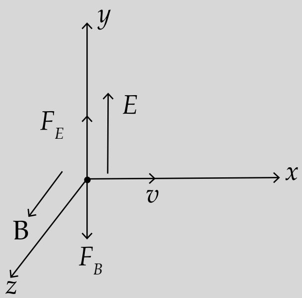
(i)For directions of $\vec{E}, \vec{B}, \vec{v}$ **1**

(ii)For magnitudes of $\vec{E}, \vec{B}, \vec{v}$ **1**

(i) The velocity $\vec{v}$, of the charged particles, and the $\vec{E}$ and $\vec{B}$ vectors, should be mutually perpendicular.

Also the forces on q, due to $\vec{E}$ and $\vec{B}$, must be oppositely directed. ½

(Also accept if the student draws a diagram to show the directions.)



½

(ii) $qE = qvB$

or $v = \frac{E}{B}$

[Alternatively, The student may write : Force due to electric field = $q\vec{E}$

Force due to magnetic field = $q(\vec{v} \times \vec{B})$ ½

The required condition is

$$q\vec{E} = -q(\vec{v} \times \vec{B})$$

[or $\vec{E} = -(\vec{v} \times \vec{B}) = (\vec{B} \times \vec{v})$ ½

(**Note :** Award 1 mark only if the student just writes : "The forces, on the charged particle, due to the electric and magnetic fields, must be equal and opposite to each other.")

[CBSE Marking Scheme, 2017]

9. A 12.5 eV electron beam is used to excite a gaseous hydrogen atom at room temperature. Determine the wavelengths and the corresponding series of the lines emitted. 2

Ans. (i) Writing $E_n \propto \frac{1}{n^2}$ ½

(ii) Identifying the level to which the electron is emitted. ½

(iii) Calculating the wavelengths and identifying the series of atleast one of the three possible lines, that can be emitted. ½ + ½

(i) We have $E_n \propto \frac{1}{n^2}$ ½

(ii) $\therefore$ The energy levels are

-13.6 eV, -3.4 eV, -1.5 eV ½

$\therefore$ The 12.5 eV electron beam can excite the electron up to n=3 level only.

(iii) Energy values, of the emitted photons, of the three possible lines are

$3 \rightarrow 1 : (-1.5 + 13.6)\text{eV} = 12.1 \text{ eV}$

$2 \rightarrow 1 : (-3.4 + 13.6)\text{eV} = 10.2 \text{ eV}$

$3 \rightarrow 2 : (-1.5 + 3.4)\text{eV} = 1.9 \text{ eV}$

The corresponding wavelengths are : 102 nm, 122 nm and 653 nm ½ + ½

$$\left(\lambda = \frac{hc}{E}\right)$$

(**Note :** Award this 1 mark if the student draws the energy level diagram and shows (and names the series) the three lines that can be emitted) (Award these (½ + ½) marks if the student calculates the energies of the three photons those can be emitted and names their series also.)

[CBSE Marking Scheme, 2017]

10. Write two properties of a material suitable for making (a) a permanent magnet, and (b) an electromagnet. 2

Ans. (a) For making permanent magnet:

(i) High retentivity

(ii) High coercivity

(iii) High permeability **(Any two)** ½+ ½

(b) For making electromagnet:

(i) High permeability

(ii) Low retentivity

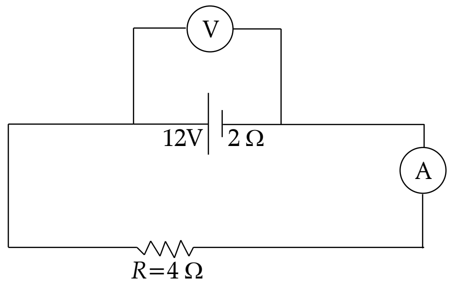
(iii) Low coercivity **(Any two)**½+ ½

[CBSE Marking Scheme, 2017]

SECTION -C

11. (a) The potential difference applied across a given resistor is altered so that the heat produced per second increases by a factor of 9. By what factor does the applied potential difference change? 1

(b) In the figure shown, an ammeter A and a resistor of 4Ω are connected to the terminals of the source. The emf of the source is 12 V having an internal resistance of 2 Ω. Calculate the voltmeter and ammeter readings. 2



Ans. (a) The factor by which the potential difference changes **1**
(b) Voltmeter reading **1**
Ammeter Reading **1**

(a) $\left(H = \frac{V^2}{R}\right)$ ½

$\therefore$ V increases by a factor of $\sqrt{9} = 3$ ½

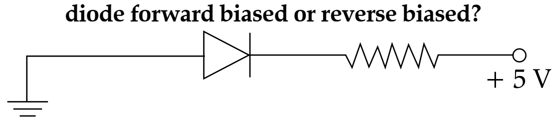
(b) Ammeter Reading $I = \frac{V}{R+r}$ ½

$= \frac{12}{4+2}$ A = 2A ½

Voltmeter Reading $V = E - Ir$ ½
$= [12 - (2 \times 2)]$ V = 8V ½
(Alternatively, $V = iR = 2 \times 4$V = 8V)
[CBSE Marking Scheme, 2017]

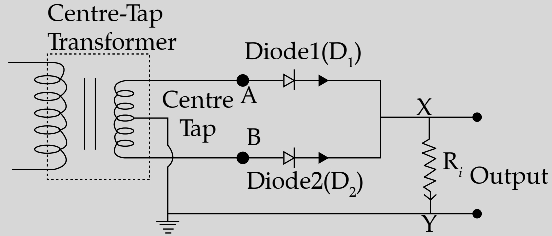
***12. (a) How is amplitude modulation achieved?** **1**
(b) The frequencies of two side bands in an AM wave are 640 kHz and 660 kHz respectively. Find the frequencies of carrier and modulating signal. What is the bandwidth required for amplitude modulation? **2**

13. (a) In the following diagram, is the junction diode forward biased or reverse biased? **1**



(b) Draw the circuit diagram of a full wave rectifier and state how it works. **2**

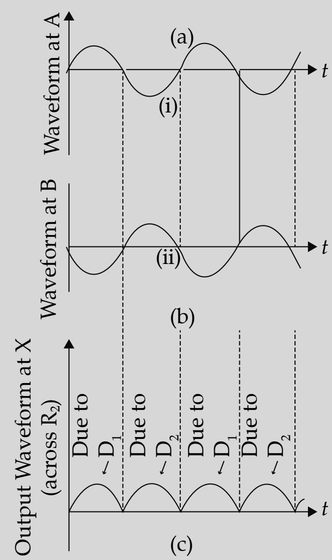
Ans. (a) The nature of biasing **1**
(b) Diagram of full wave rectifier **1**
Working **1**
(a) Reverse Biased
(b) Diagram of full wave rectifier



1

Working: The diode D_1 is forward biased during one half cycle and current flows through the resistor, but diode D_2 is reverse biased and no current flows through it. During the other half of the signal, D_1 gets reverse biased and no current passes through it, D_2 gets forward biased and current flows through it. In both half cycles current, through the resistor, flows in the same direction. ½

(**Note:** If the student just draws the following graphs (but does not draw the circuit diagram), award ½ mark only. ½



[CBSE Marking Scheme 2017]

14. Using photon picture of light, show how Einstein's photoelectric equation can be established. Write two features of photoelectric effect which cannot be explained by wave theory. **3**

Ans. Photon picture plus Einstein's photoelectric equation **½ + 1½**
Two features **½ + ½**

In the photon picture , energy of the light is assumed to be in the form of photons, each carrying an energy hν.

Einstein assumed that photoelectric emission occurs because of a single collision of a photon with a free electron.

The energy of the photon is used to

(i) Free the electrons from the metal.
[For this, a minimum energy, called the work function (=W) is needed].
And ½

* *Out of Syllabus*

(ii) Provide kinetic energy to the emitted electrons.

Hence

$$(\text{K.E.})_{max} = h\nu - W$$

$$\left(\frac{1}{2}mv^2_{max} = h\nu - W\right)$$

This is Einstein's photoelectric equation **1½**

Two features (which cannot be explained by wave theory):

(i) 'Instantaneous' emission of photoelectrons

(ii) Existence of a threshold frequency

(iii) 'Maximum kinetic energy' of the emitted photoelectrons, is independent of the intensity of incident light ½+½

(Any two)

[CBSE Marking Scheme, 2017]

15. (a) Monochromatic light of wavelength 589 nm is incident from air on a water surface. If μ for water is 1.33, find the wavelength, frequency and speed of the refracted light. 1

(b) A double convex lens is made of a glass of refractive index 1.55, with both faces of the same radius of curvature. Find the radius of curvature required, if the focal length is 20 cm. 2

Ans. (a) Calculation of wavelength, frequency and speed **½ + ½ + ½**

(b) Lens Maker's Formula **½**

Calculation of *R* **1**

(a) $\lambda = \frac{589\,\text{nm}}{1.33} = 442.8\,\text{nm}$ ½

Frequency $\nu = \frac{3\times10^8\,\text{ms}^{-1}}{589\,\text{nm}}$

$= 5.09 \times 10^{12}$ Hz ½

Speed $v = \frac{3\times10^8}{1.33}$ m/s = 2.25×10^8 m/s ½

(b) $\frac{1}{f} = \left[\frac{\mu_2}{\mu_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ ½

$\therefore \frac{1}{20} = \left[\frac{1.55}{1} - 1\right]\frac{2}{R}$ ½

$\therefore R = (20 \times 1.10)\text{cm} = 22$ cm ½

[CBSE Marking Scheme, 2017]

16. (a) Define mutual inductance between a pair of coils. Derive an expression for the mutual inductance of two long coaxial solenoids of same length wound one over the other. 3

OR

(b) Define self-inductance of a coil. Obtain the expression for the energy stored in an inductor *L* connected across a source of emf. 3

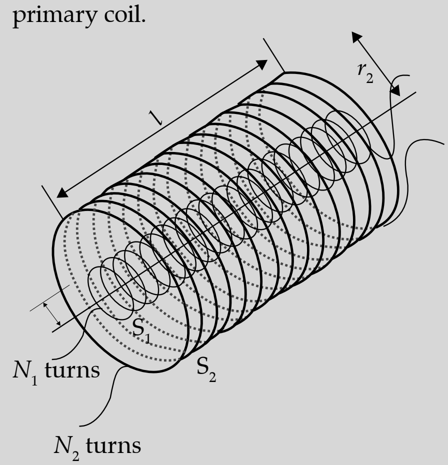
Ans. Definition of mutual inductance **1**

Derivation of mutual inductance for two long solenoids **2**

(i) Mutual inductance is numerically equal to the induced emf in the secondary coil when the current in the primary coil changes by unity. **1**

Alternatively : Mutual inductance is numerically equal to the magnetic flux linked with one coil/secondary coil when unit current flows through the other coil / primary coil. ½

(ii)



½

Let a current, i_2, flow in the secondary coil

$$\therefore B_2 = \frac{\mu_0 N_2 i_2}{l}$$ ½

$\therefore$ Flux linked with the primary coil

$$= N_1 A_1 B_2 = \frac{\mu_0 N_2 N_1 A_1 i_2}{l} = M_{12} i_2$$ ½

$$M_{12} = \frac{\mu_0 N_2 N_1 A_1 i_2}{l}$$ ½

$$= \mu_0 n_2 n_1 A_1 l \left(n_1 = \frac{N_1}{l}; n_2 = \frac{N_2}{l}\right)$$

[CBSE Marking Scheme, 2017]

OR

Ans. Definition of self inductance **1**

Expression for energy stored **2**

(i) Self inductance, of a coil, is numerically equal to the emf induced in that coil when the current in it changes at a unit rate. **1**

(**Alternatively :** The self inductance of a coil equals the flux linked with it when a unit current flows through it.)

(ii) The work done against back /induced emf is stored as magnetic potential energy. ½

The rate of work done, when a current *i* is passing through the coil, is

$$\frac{dW}{dt} = |\varepsilon| i = \left(L\frac{di}{dt}\right)i$$ ½

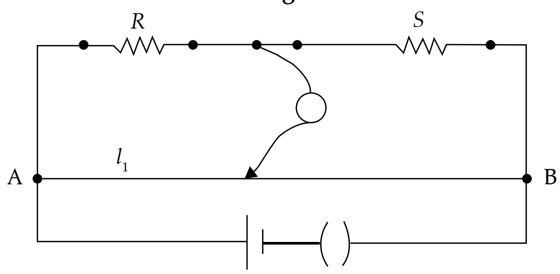
$$\therefore W = \int dW = \int_0^I Lidi$$ ½

$$= \frac{1}{2}Li^2$$ ½

[CBSE Marking Scheme, 2017]

17. (a) Write the principle of working of a metre bridge. 1

(b) In a metre bridge, the balance point is found at a distance l_1 with resistances R and S as shown in the figure.



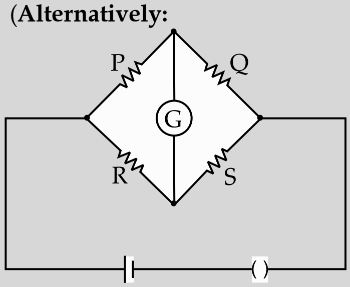
An unknown resistance X is now connected in parallel to the resistance S and the balance point is found at a distance l_2. Obtain a formula for X in terms of l_1, l_2 and S. 2

Ans. (a) Principle of meter bridge 1

(b) Relation between l_1, l_2, and S 2

(a) The principle of working of a meter bridge is same as that of a balanced Wheatstone bridge.

(**Alternatively:**



When, $i_g = 0$, then $\frac{P}{Q} = \frac{R}{S}$

(ii) $\frac{R}{S} = \frac{l_1}{100 - l_1}$

When X is connected in parallel

$$\frac{R}{\left(\frac{XS}{X+S}\right)} = \frac{l_2}{100 - l_2}$$

On solving, we get

$$X = \frac{l_1 S(100 - l_2)}{100(l_2 - l_1)}$$

[CBSE Marking Scheme, 2017]

*** 18. Draw a block diagram of a generalized communication system. Write the functions of each of the following: 3**

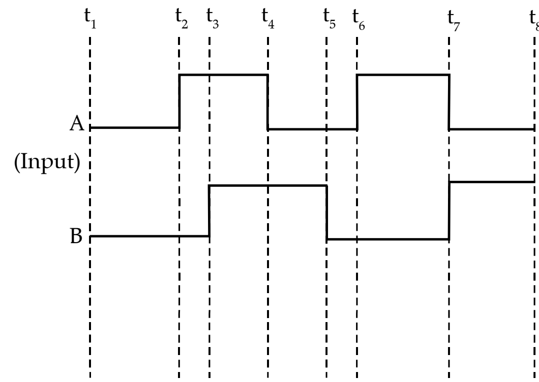
(a) Transmitter

(b) Channel

(c) Receiver

*** 19. (a) Write the functions of the three segments of a transistor. 1½**

(b) The figure shows the input waveforms A and B for 'AND' gate. Draw the output waveform and write the truth table for this logic gate. 1½



20. (a) Draw a ray diagram depicting the formation of the image by an astronomical telescope in normal adjustment.

(b) You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope? Give reason.

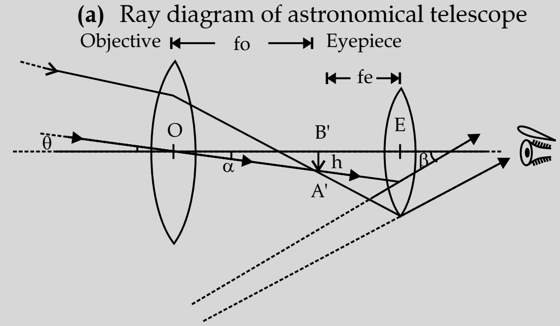
Lenses	Power (*D*)	Aperture (cm)
L_1	3	8
L_2	6	1
L_3	10	1

Ans. (a) Ray diagram for astronomical telescope in normal adjustment 1 ½

(b) Identification of lenses for objective and eyepiece 1

Reason ½

(a) Ray diagram of astronomical telescope



(**Note :** Deduct ½ mark if the 'arrows' are not marked)

(b) Objective Lens : Lens L_1

Eyepiece Lens : Lens L_2

* *Out of Syllabus*

Reason :
The objective should have large aperture and large focal length while the eyepiece should have small aperture and small focal length.

[CBSE Marking Scheme, 2017]

21. (a) State Biot – Savart law and express this law in the vector form. 1½

(b) Two identical circular coils, P and Q each of radius *R*, carrying currents 1 A and $\sqrt{3}$ A respectively, are placed concentrically and perpendicular to each other lying in the XY and YZ planes. Find the magnitude and direction of the net magnetic field at the centre of the coils. 1½

Ans. (a) Statement of Biot Savart law 1

Expression in vector form ½

(b) Magnitude of magnetic field at centre 1

Direction of magnetic field ½

(a) It states that magnetic field strength, $d\vec{B}$, due to a current element, $I\vec{dl}$, at a point, having a position vector *r* relative to the current element, is found to depend (i) directly on the current element, (ii) inversely on the square of the distance $|r|$, (iii) directly on the sine of angle between the current element and the position vector *r*. **1**

In vector notation,

$$\overrightarrow{dB} = \frac{\mu_0}{4\pi}\frac{\overrightarrow{Idl}\times\vec{r}}{|\vec{r}|^3}$$ ½

Alternatively,

$$\left(\overrightarrow{dB} = \frac{\mu_0}{4\pi}\frac{\overrightarrow{Idl}\times\hat{r}}{|\vec{r}|^2}\right)$$

(b) $B_\pi = \frac{\mu_0 \times 1}{2R} = \frac{\mu_0}{2R}$ (along z − direction) ½

$B_Q = \frac{\mu_0 \times \sqrt{3}}{2R} = \frac{\mu_0\sqrt{3}}{2R}$ (along *x* − direction)

$\therefore B = \sqrt{B_p^2 + B_Q^2} = \frac{\mu_0}{R}$ ½

This net magnetic field *B*, is inclined to the field B_p, at an angle θ, where

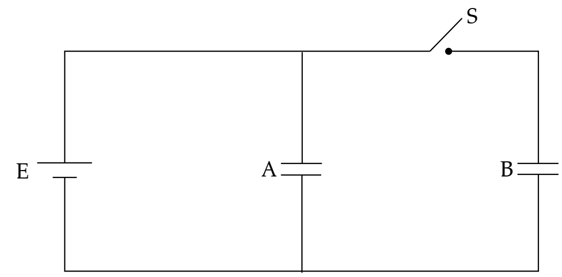
$\tan\theta = \sqrt{3}$

$(\theta = \tan^{-1}\sqrt{3} = 60°)$

(in XZ plane) ½

[CBSE Marking Scheme, 2017]

22. 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. 3



Ans. Formula for energy stored ½

Energy stored before 1

Energy stored after 1

Ratio ½

Energy stored $= \frac{1}{2}CV^2\left(=\frac{1}{2}\frac{Q^2}{C}\right)$ ½

Net capacitance with switch S closed

$= C + C = 2C$ ½

$\therefore$ Energy stored $= \frac{1}{2}\times 2C\times V^2 = CV^2$ ½

After the switch S is opened, capacitance of each capacitor = *KC*

$\therefore$ Energy stored in capacitor $A = \frac{1}{2}KCV^2$

For capacitor B,

Energy stored $= \frac{1}{2}\frac{Q^2}{KC} = \frac{1}{2}\frac{C^2V^2}{KC} = \frac{1}{2}\frac{CV^2}{K}$ ½

$\therefore$ Total Energy stored

$= \frac{1}{2}KCV^2 + \frac{1}{2}\frac{CV^2}{K} = \frac{1}{2}CV^2\left(K + \frac{1}{K}\right)$

$= \frac{1}{2}CV^2\left(\frac{K^2+1}{K}\right)$ ½

$\therefore$ Required ratio $= \frac{2CV^2.K}{CV^2(K^2+1)} = \frac{2K}{(K^2+1)}$ ½

[CBSE Marking Scheme, 2017]

SECTION -D

23. Asha's mother read an article in the newspaper about a disaster that took place at Chernobyl. She could not understand much from the article and asked a few questions from Asha regarding the article. Asha tried to answer her mother's questions based on what she learnt in Class XII Physics.

(a) What was the installation at Chernobyl where the disaster took place? What, according to you, was the cause of this disaster?

(b) Explain the process of release of energy in the installation at Chernobyl.

(c) What, according to you, were the values displayed by Asha and her mother? 4

Ans. (a) Name of the installation, the cause of disaster ½ + ½

(b) Energy release process 1

(c) Values shown by Asha and mother 1+1

(a) (i) Nuclear Power Plant 'Set-up' for releasing Nuclear Energy/Energy Plant ½

(Also accept any other such term)

(ii) Leakage in the cooling unit/ Some defect in the set up. ½

(b) Nuclear Fission/Nuclear Energy 1

Break up (Fission) of Uranium nucleus into fragments

(c) Asha: Helpful, Considerate, Keen to Learn, Modest 1

Mother: Curious, Sensitive, Eager to Learn, Has no airs 1

(Any one such value in each case)

[CBSE Marking Scheme, 2017]

SECTION - E

24. (a) Derive an expression for the electric field E due to a dipole of length '$2a$' at a point distant r from the centre of the dipole on the axial line. 2

(b) Draw a graph of E versus r for $r >> a$. 1

(c) If this dipole were kept in a uniform external electric field E_0, diagrammatically represent the position of the dipole in stable and unstable equilibrium and write the expressions for the torque acting on the dipole in both the cases. 2

OR

(a) Use Gauss's theorem to find the electric field due to a uniformly charged infinitely large plane thin sheet with surface charge density σ. 3

(b) An infinitely large thin plane sheet has a uniform surface charge density +σ. Obtain the expression for the amount of work done in bringing a point charge q from infinity to a point, distant r, in front of the charged plane sheet. 2

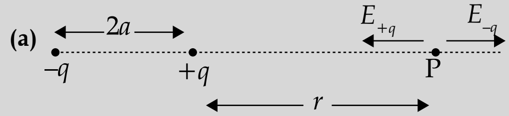
Ans. (a) Derivation of E along the axial line of dipole 2

(b) Graph between E vs r 1

(c) (i) Diagrams for stable and unstable equilibrium of dipole ½ + ½

(ii) Torque on the dipole in the two cases ½ + ½

(a)



Electric field at P due to charge $+q$ is $E_1 = \frac{1}{4\pi\varepsilon_o}\frac{1}{(r-a)^2}$ ½

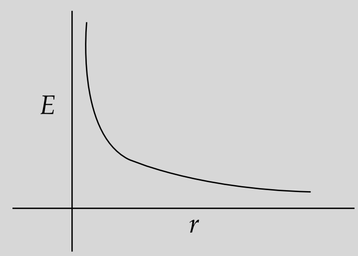
Electric field at P due to charge $-q$ is $E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$ ½

Net electric Field at P

$$E_1 - E_2 = \frac{1}{4\pi\varepsilon_o}\frac{q}{(r-a)^2} - \frac{1}{4\pi\varepsilon_o}\frac{q}{(r-a)^2} \quad ½$$

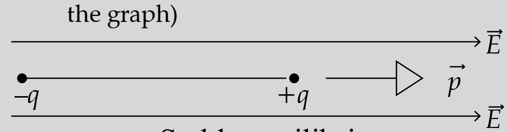
$$= \frac{1}{4\pi\varepsilon_0}\frac{2pr}{(r^2-a^2)^2} \quad (p = q.2a)$$

Its direction is parallel to $\vec{p}$. ½

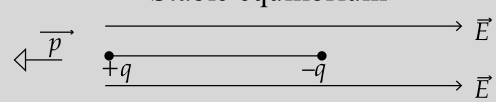


1

(Note: Award ½ mark if the student just writes: For short Dipole $= \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$ without drawing the graph)



Stable equilibrium ½



Unstable equilibrium ½

(Note: Award ½ mark only if the student does not draw the diagrams but just writes:

(i) For stable Equilibrium: $\vec{p}$ is parallel to $\vec{E}$.

(ii) For unstable equilibrium: $\vec{p}$ is antiparallel to $\vec{E}$)

Torque = 0 for (i) as well as case (ii).

(Also accept, $\vec{\tau} = \vec{p} \times \vec{E}$ / $\tau = pE \sin\theta$) ½+½

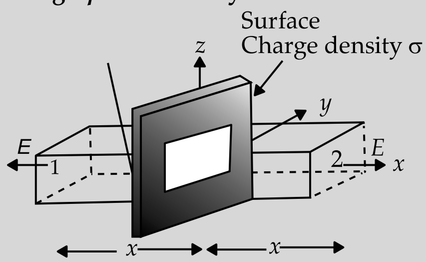
[CBSE Marking Scheme, 2017]

OR

(a) Using Gauss's theorem to find E due to an infinite plane sheet of charge 3

(b) Expression for the work done to bring charge q from infinity to r **2**

(a)



$$\oint E.ds = \frac{q}{\varepsilon_0}$$

The electric field E points outwards normal to the sheet. The field lines are parallel to the Gaussian surface except for surfaces 1 and 2.

Hence the net flux $= \oint E.ds = \frac{q}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0} = 2EA$

where A is the area of each of the surface 1 and 2. **1**

$$\therefore \oint E.ds = \frac{q}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0} = 2EA$$

$$E = \frac{\sigma}{2\varepsilon_0}$$

1

(b) $W = q\int_{\infty}^{r} \vec{E}.\vec{dr}$ ½

$= q\int_{\infty}^{r}(-Edr)$ ½

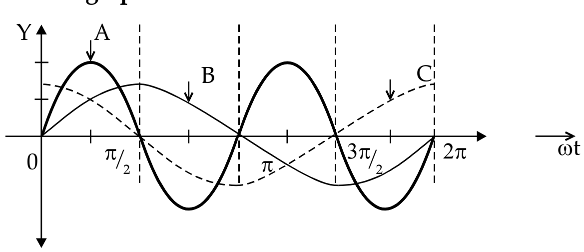
$= -q\int_{\infty}^{r}\left(\frac{\sigma}{2\varepsilon_0}\right)dr$ ½

$= \frac{q\sigma}{2\varepsilon_0}|\infty - r|$

$= (\infty)$ ½

[CBSE Marking Scheme, 2017]

25. A device 'X' is connected to an ac source $V = V_0 \sin \omega t$. The variation of voltage, current and power in one cycle is shown in the following graph:



(a) Identify the device 'X'. **½**

(b) Which of the curves A, B and C represent the voltage, current and the power consumed in the circuit? Justify your answer. **1½**

(c) How does its impedance vary with frequency of the ac source? Show graphically. **1**

(d) Obtain an expression for the current in the circuit and its phase relation with ac voltage. **2**

OR

(a) Draw a labelled diagram of an ac generator. Obtain the expression for the emf induced in the rotating coil of N turns each of cross-sectional area A, in the presence of a magnetic field $\vec{B}$.

(b) A horizontal conducting rod 10 m long extending from east to west is falling with a speed 5·0 ms^{-1} at right angles to the horizontal component of the Earth's magnetic field, 0·3 × 10^{-4} Wb m^{-2}. Find the instantaneous value of the emf induced in the rod.

Ans. (a) Identification **½**

(b) Identifying the curves **1**

Justification **½**

(c) Variation of Impedance with frequency **½**

Graph **½**

(d) Expression for current **1½**

Phase relation **½**

(a) The device X is a capacitor ½

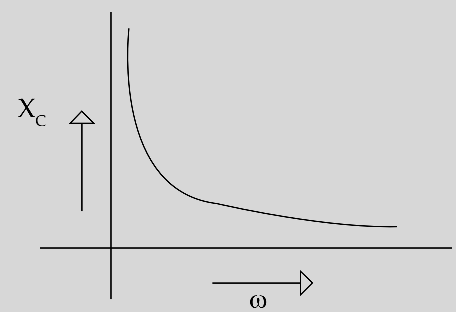
(b) Curve B ⟶ voltage

Curve C ⟶ current ½

Curve A ⟶ power ½

Reason: The current leads the voltage in phase, by $\pi/2$ for a capacitor. ½

(c) $X_c = \frac{1}{\omega c}$ $(X_c \propto \frac{1}{\omega})$ ½



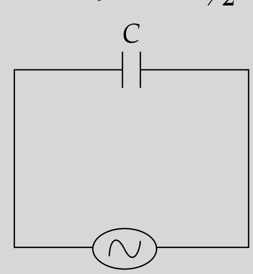
½

$V = V_o \sin \omega t$

$q = CV = CV_o \sin \omega t$ ½

$I = \frac{dq}{dt} = \omega c V_o \cos\omega t$ ½

$= I_o \sin(\omega t + \pi/2)$ ½



$v = v_c \sin wt$ ½

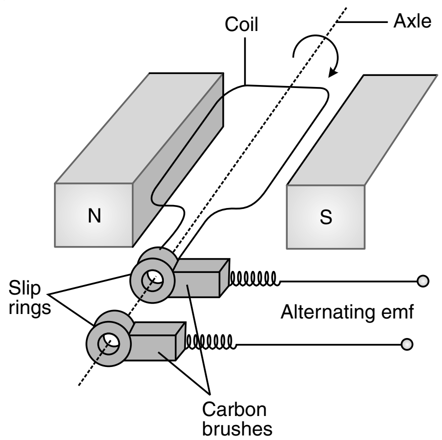
Current leads the voltage, in phase , by $\neq/2$

(**Note:** If the student identifies the device X as an Inductor but writes correct answers to parts (c) and (d) (in terms of an inductor), the student be given full marks for (only) these two parts)

[CBSE Marking Scheme, 2017]

OR

Ans. (a)



When the coil rotates in a magnetic field, its effective area, *i.e.*, $A\cos\theta$, (*i.e.*, area normal to the magnetic field) keeps on changing. Hence magnetic flux $\phi = NBA\cos\theta$, keeps on changing. Let the coil be rotating with angular velocity 'ω', at any instant 't' when the normal to the plane of the coil makes an angle θ with the magnetic field. Hence magnetic flux, ½

$$\phi = NBA\cos\omega t,$$

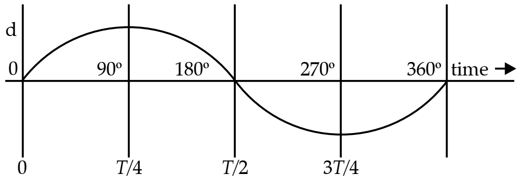
Therefore induced emf $\varepsilon = -\dfrac{d\phi}{dt}$ ½

$\Rightarrow \quad \varepsilon = NBA\,\omega\sin\omega t$ ½

induced emf will be maximum when $\omega t = 90^\circ$. ½

Hence, $\varepsilon_{max} = NBA\omega$

The direction of induced emf can be determined using Fleming's right hand rule.



(b) $l = 10$ m, $u = 5$ m/s, $B = 0.3\times10^{-4}$ Wb/m^2

$\therefore \quad \varepsilon = Blv$ **1**

$= 0.3\times10^{-4}\times10\times5$

$= 15\times10^{-4}$ V **1**

26. (a) Define wavefront. Use Huygens' principle to verify the laws of refraction. 3½

(b) How is linearly polarised light obtained by the process of scattering of light? Find the Brewster angle for air – glass interface, when the refractive index of glass = 1·5. 1½

OR

(a) Draw a ray diagram to show the image formation by a combination of two thin convex lenses in contact. Obtain the expression for the power of this combination in terms of the focal lengths of the lenses. 3

(b) A ray of light passing from air through an equilateral glass prism undergoes minimum deviation when the angle of incidence is $\frac{3}{4}$ th of the angle of prism. Calculate the speed of light in the prism. 2

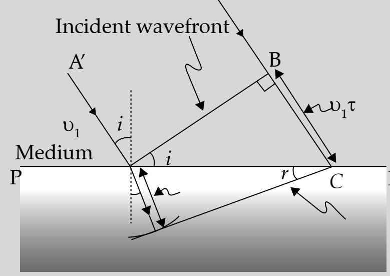
Ans. (a) Definition of wavefront ½

Verifying laws of refraction by Huygen's principle 3

(b) Polarisation by scattering ½

Calculation of Brewster's angle 1

(a) The wavefront is the common locus of all points which are in phase(surface of constant phase) ½



1

Let a plane wavefront be incident on a surface separating two media as shown. Let v_1 and v_2 be the velocities of light in the rarer medium and denser medium respectively. From the diagram $BC = v_1t$ and $AD = v_2t$ ½

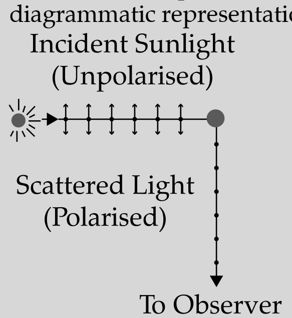
$\sin i = \dfrac{BC}{AC}$ and $\sin r = \dfrac{AD}{AC}$ ½

$\therefore \dfrac{\sin i}{\sin r} = \dfrac{BC}{AD} = \dfrac{v_1t}{v_2t}$ ½

$= \dfrac{v_1}{v_2}$ a constant ½

This proves Snell's law of refraction.

(b) When unpolarised light gets scattered by molecules, the scattered light has only one of its two components in it. (Also accept diagrammatic representation)



½

We have, $\mu = \tan i_B$ ½

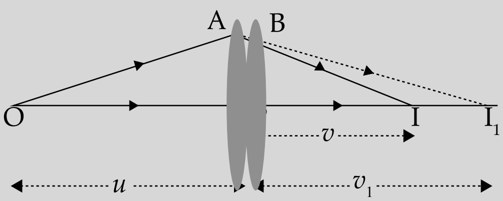
$\therefore \tan i_B = 1.5$

$\therefore i_B = \tan^{-1} 1.5 = 56.3^\circ$ ½

[CBSE Marking Scheme, 2017]

OR

(a)	**Ray diagram**	**1**
	Expression for power	**2**
(b)	**Formula**	**½**
	Calculation of speed of light	**1 ½**



1

Two thin lenses, of focal length f_1 and f_2 are kept in contact. Let O be the position of object and let u be the object distance. The distance of the image (which is at I_1), for the first lens is v_1.

This image serves as object for the second lens. ½

Let the final image be at I. We then have

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$$ ½

$$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$$ ½

Adding, we get

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$P = P_1 + P_2$ ½

(b) At minimum deviation

$r = A/2 = 30^\circ$ ½

We are given that

$i = \frac{3}{4}A = 45^\circ$ ½

$\therefore \mu = \frac{\sin 45^\circ}{\sin 30^\circ} = \sqrt{2}$ ½

$\therefore$ Speed of light in the prism $= \frac{c}{\sqrt{2}}$

$(\cong 2.1 \times 10^8 \text{ ms}^{-1})$ ½

[**Note :** Award ½ mark if the student writes the formula:

$$\mu = \frac{\sin(A + D_m)/2}{\sin\left(A/2\right)}$$

but does not do any calculations.]

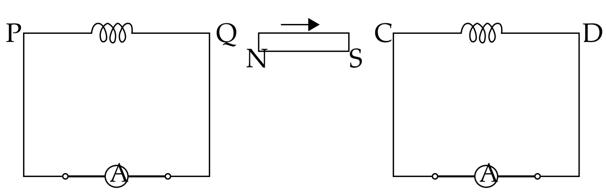
[CBSE Marking Scheme, 2017]

Outside Delhi Set II — Code No. 55/2/2

Note: Except these, other questions are from Outside Delhi Set-I.

SECTION -A

1. **A bar magnet is moved in the direction indicated by the arrow between two coils PQ and CD. Predict the direction of the induced current in each coil.** **1**



Ans. Q to P through ammeter and ½

D to C through ammeter ½

(**Alternatively:** Anticlockwise as seen from left in coil PQ clockwise as seen from left in coil CD)

[CBSE Marking Scheme, 2017]

2. **Write the relation for the speed of electromagnetic waves in terms of the amplitudes of electric and magnetic fields.** **1**

Ans. Speed of electromagnetic wave, $c = \frac{E_0}{B_0}$. 1

[CBSE Marking Scheme, 2017]

SECTION -B

7. **Identify the electromagnetic waves whose wavelengths lie in the range** **1**

(a) 10^{-11} m < λ < 10^{-14} m

(b) 10^{-4} m < λ < 10^{-6} m

Write one use of each. **1**

Ans. **(a) Identification** ½ + ½

(b) One use each ½ + ½

(a) X-rays/ Gamma rays ½

One use of the name given ½

(b) Infrared/Visible/Microwave ½

One use of the name given ½

(**Note :** Award ½ mark for each correct use (relevant to the name chosen) even if the names chosen are incorrect.)

[CBSE Marking Scheme, 2017]

9. The short wavelength limit for the Lyman series of the hydrogen spectrum is 913·4 Å. Calculate the short wavelength limit for Balmer series of the hydrogen spectrum. 2

Ans. Formula ½

Calculation 1½

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \quad ½$$

$\therefore$ For Balmer Series: $(\lambda_B)_{short} = 4/R$ ½

and For Lyman Series: $(\lambda_L)_{short} = 1/R$ ½

$\therefore \lambda_B = 913.4 \times 4$ Å $= 3653.6$ Å ½

[CBSE Marking Scheme, 2017]

SECTION -C

12. (a) Draw a ray diagram showing the formation of image by a reflecting telescope. 2

(b) Write two advantages of a reflecting telescope over a refracting telescope. 1

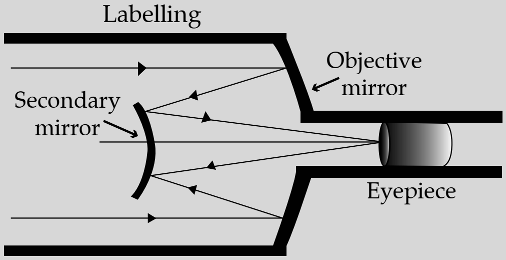
Ans. (a) Ray Diagram for reflecting Telescope 2

(b) Two advantages of it over refracting type of telescope ½ + ½

(a) Ray Diagram 1

Arrow marking ½

Labelling ½



2

(b) Advantages

(i) Spherical aberration is absent.

(ii) Chromatic aberration is absent.

(iii) Mounting is easier.

(iv) Polishing is done on only one side.

(v) Light gathering power is more.

(Any two) ½ + ½

[CBSE Marking Scheme, 2017]

15. Explain giving reasons for the following:

(a) Photoelectric current in a photocell increases with the increase in the intensity of the incident radiation. 1

(b) The stopping potential (V_0) varies linearly with the frequency (ν) of the incident radiation for a given photosensitive surface with the slope remaining the same for different surfaces. 1

(c) Maximum kinetic energy of the photoelectrons is independent of the intensity of incident radiation. 1

Ans. (a) Variation of photocurrent with intensity of radiation 1

(b) Stopping potential versus frequency for different materials 1

(c) Independence of maximum kinetic energy of the emitted photoelectrons 1

(a) The collision of a photon can cause emission of a photoelectron (above the threshold frequency). As intensity increases, number of photons increases. Hence the current increases. 1

(b) We have, $eV_S = h(\nu - \nu_0)$

$$\therefore V_s = \frac{h}{e}(\nu) + \left(-\frac{h\nu_0}{e}\right) \quad ½$$

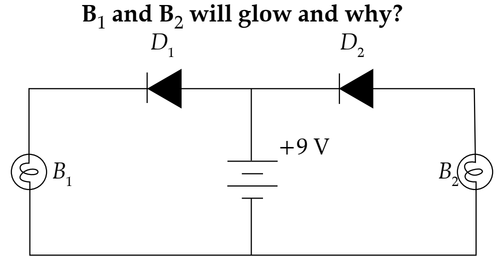
$\therefore$ Graph of V_s with ν is a straight line and slope $\left(= h/e\right)$ is a constant. ½

(c) Maximum for different surfaces KE $= h(\nu - \nu_0)$ ½

Hence, it depends on the frequency and not on the intensity of the incident radiation. ½

[CBSE Marking Scheme, 2017]

16. (a) In the following diagram, which bulb out of B_1 and B_2 will glow and why?



(b) Draw a diagram of an illuminated *p-n* junction solar cell.

(c) Explain briefly the three processes due to which generation of emf takes place in a solar cell.

Ans. (a) Identification of the bulb and reason ½ + ½

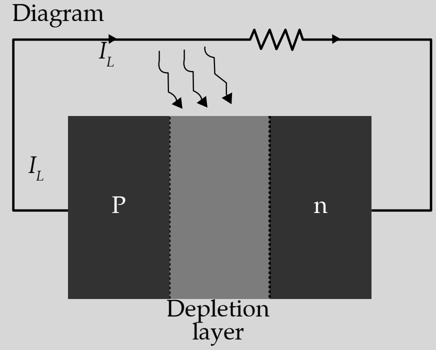
(b) Diagram of solar cell ½

(c) Names of the processes ½ + ½ + ½

(a) Bulb B_1 glows ½

Diode D_1 is forward biased. ½

(b) Diagram

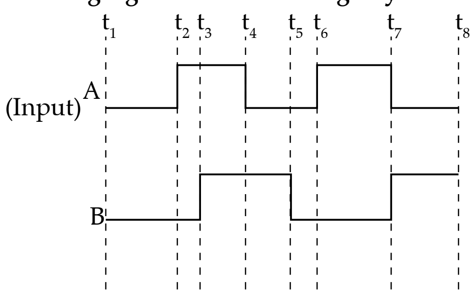


½

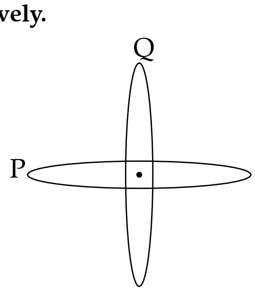
(c) Generation: Incident light generates electron-hole pairs. ½
Separation: Electric field of the depletion layer separates the electrons and holes. ½
Collection: Electrons and holes are collected at the *n* and *p* side contacts. ½
[CBSE Marking Scheme, 2017]

*** 19. (a) Draw the circuit diagram for studying the characteristics of a transistor in common emitter configuration. Explain briefly and show how input and output characteristics are drawn.**

*** (b) The figure shows input waveforms A and B to a logic gate. Draw the output waveform for an OR gate. Write the truth table for this logic gate and draw its logic symbol.**



20. Two identical loops P and Q each of radius 5 cm are lying in perpendicular planes such that they have a common centre as shown in the figure. Find the magnitude and direction of the net magnetic field at the common centre of the two coils, if they carry currents equal to 3 A and 4 A respectively. **3**



Ans. Formula ½
Field due to each coil ½ + ½
Magnitude of resultant field 1
Direction of resultant field ½

Field at the centre of a circular coil $= \frac{\mu_0 I}{2R}$ ½

Field due to coil $P = \frac{\mu_0 \times 3}{2 \times 5 \times 10^{-2}}$ *tesla*

$= 12\pi \times 10^{-6}$ tesla ½

Field due to coil Q $= \frac{\mu_0 \times 3}{2 \times 5 \times 10^{-2}}$ *tesla*

$= 16\pi \times 10^{-6}$ tesla ½

$\therefore$ Resultant Field $= (\pi\sqrt{12^2 + 16^2})\mu T$

$= (20\pi)\ \mu$T 1

Let the field make an angle θ with the vertical

$$\tan\theta = \frac{12\pi \times 10^{-6}}{16\pi \times 10^{-6}} = \frac{3}{4}$$

$$\theta = \tan^{-1}\frac{3}{4}$$ ½

(Alternatively: $\theta' = \tan^{-1}\frac{4}{3}$, θ' = angle with the horizontal)

[**Note 1:** Award 2 marks if the student directly calculates B without calculating B_P and B_Q separately.]

[**Note 2:** Some students may calculate the field B_Q and state that it also represents the resultant magnetic field (as coil P has been shown 'broken' and therefore, cannot produce a magnetic field); They may be given 2 ½ marks for their (correct) calculation of B_Q]

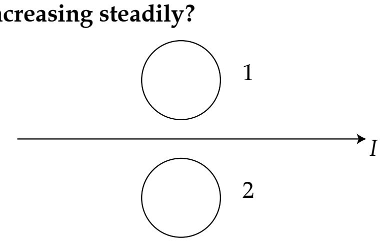
[CBSE Marking Scheme, 2017]

Outside Delhi Set III — Code No. 55/2/3

Note: Except these, other questions are from Outside Delhi Set-I & II.

SECTION -A

3. What is the direction of induced currents in metal rings 1 and 2 when current *I* in the wire is increasing steadily?



Ans. Clockwise in loop 1 ½
Anticlockwise in loop 2 ½
[CBSE Marking Scheme, 2017]

4. In which directions do the electric and magnetic field vectors oscillate in an electromagnetic wave propagating along the x-axis?

Ans. $\vec{E}$ along y- axis and $\vec{B}$ along z-axis

(Alternatively: $\vec{E}$ along z-axis and $\vec{B}$ along y-axis) ½ + ½

[CBSE Marking Scheme, 2017]

* *Out of Syllabus*

SECTION -B

8. **Why does current in a steady state not flow in a capacitor connected across a battery? However momentary current does flow during charging or discharging of the capacitor. Explain.** **2**

Ans. **(a) Reason for no flow of current** **1**
(b) Reason for momentary current **1**

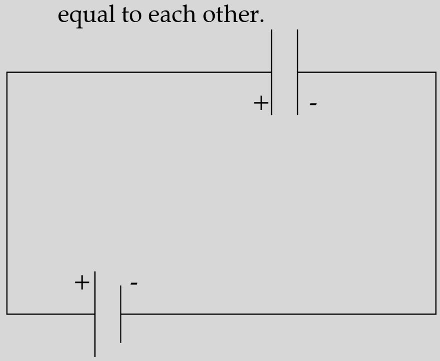
In the steady state, the displacement current and hence the conduction current, is zero as $|\vec{E}|$, between the plates, is constant . **1**

During charging/discharging, the displacement current and hence the conduction current is non zero as $|\vec{E}|$, between the plates , is changing with time. **1**

Alternatively

(i) In the steady state no current flows because, we have two sources (battery and fully charged capacitor) of 'equal potential' connected in opposition. ½

(ii) During charging/discharging there is a momentary flow of current as the 'potentials' of the two 'sources' are not equal to each other.



Alternatively,

Capacitative impedance $X_c = \dfrac{1}{\omega c}$ ½

(iii) During steady state: $\omega = 0$ ½

$\therefore X_c \to \infty$

Hence current is zero.

(iv) During charging /discharging : $\omega \neq 0$

$\therefore$ X_c is finite. ½

Hence current can flow.

[CBSE Marking Scheme, 2017]

9. **The ground state energy of hydrogen atom is – 13·6 eV. If an electron makes a transition from an energy level – 1·51 eV to – 3·4 eV, calculate the wavelength of the spectral line emitted and name the series of hydrogen spectrum to which it belongs.** **2**

Ans. **(a)** Calculation of energy difference ½
(b) Formula ½
(c) Calculation of wavelength ½
(d) Name of the series of spectral lines ½

Energy difference = 3.4 eV − 1.51 eV = 1.89 eV= 3.024×10^{-19} J ½

Energy = $\dfrac{hc}{\lambda} = 3.024 \times 10^{-19} J$ ½

Wavelength = 6.57×10^{-7}m ½

Series is Balmer series. ½

[CBSE Marking Scheme, 2017]

SECTION -C

* 14. **(a) Draw the circuit diagram of an *n-p-n* transistor amplifier in common emitter configuration.** **1**
(b) Derive an expression for voltage gain of the amplifier and hence show that the output voltage is in opposite phase with the input voltage. **2**

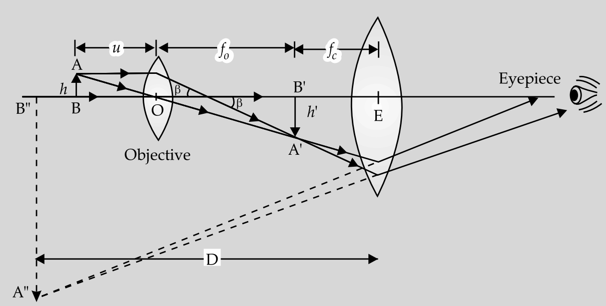
17. **(a) Draw a ray diagram for the formation of image by a compound microscope.**
(b) You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct a compound microscope?

Lenses	**Power (D)**	**Aperture (cm)**
L_1	3	8
L_2	6	1
L_3	10	1

(c) Define resolving power of a microscope and write one factor on which it depends. **3**

Ans. **(a) Ray diagram for compound microscope** **1**
(b) Identification of objective and eye piece **1**
(c) Resolving power of microscope ½
(d) One factor affecting the resolving power ½

(a) Ray Diagram for compound microscope



1

(b) Objective: Lens L_3 ½
Eye Piece: Lens L_2 ½

(c) $R_p = \dfrac{2\mu \sin\beta}{1.22\lambda}$ ½

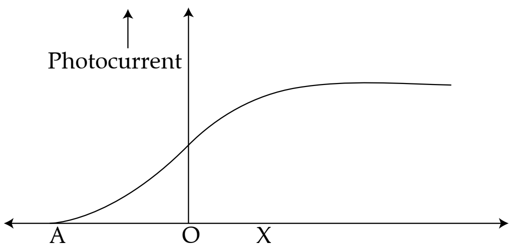
* *Out of Syllabus*

(d) Any one factor

1. It depends on the wavelength of the light used.v
2. Semi angle of cone of incident light.
3. Aperture of the objective
4. Refractive index of the medium. ½

[CBSE Marking Scheme, 2017]

18. The following graph shows the variation of photocurrent for a photosensitive metal :



(a) Identify the variable X on the horizontal axis. ½

(b) What does the point A on the horizontal axis represent? ½

(c) Draw this graph for three different values of frequencies of incident radiation ν_1, ν_2 and ν_3($\nu_1 > \nu_2 > \nu_3$) for same intensity. 1

(d) Draw this graph for three different values of intensities of incident radiation I_1, I_2 and I_3 ($I_1 > I_2 > I_3$) having same frequency. 1

Ans. **(a) Identification of X** ½

(b) Identification of point A ½

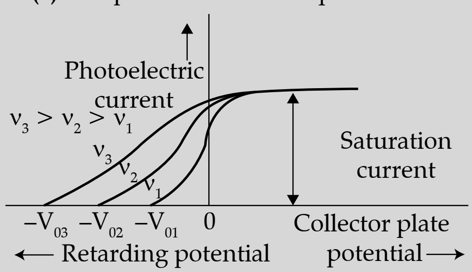
(c) Graph for three different frequencies 1

(d) Graph for three different intensities. 1

(a) X is collector plate potential. ½

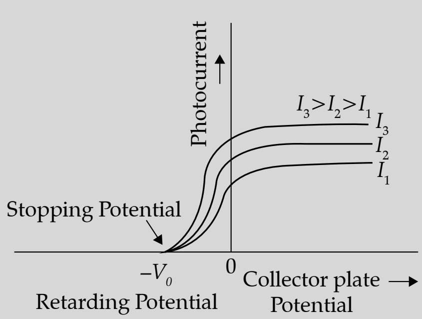
(b) A is stopping potential. ½

(c) Graph for different frequencies



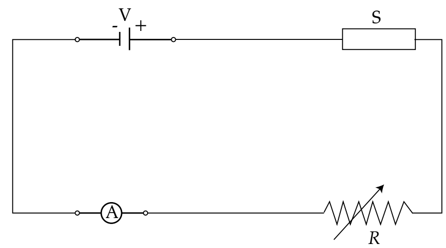
1

(d) Graph for three different Intensities



[CBSE Marking Scheme, 2017]

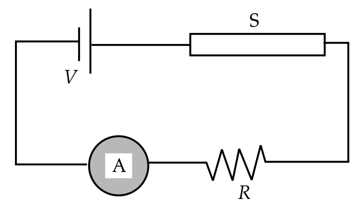
21. (a) In the following diagram 'S' is a semiconductor. Would you increase or decrease the value of *R* to keep the reading of the ammeter A constant when S is heated? Give reason for your answer. 1



(b) Draw the circuit diagram of a photodiode and explain its working. Draw its *I* – *V* characteristics. 2

Ans.

(a)



1

When you heat the semiconductor, the resistance in the circuit will decrease. On making current fixed, we have to increase the resistance in the circuit to keep the reading of ammeter A constant.

(b)

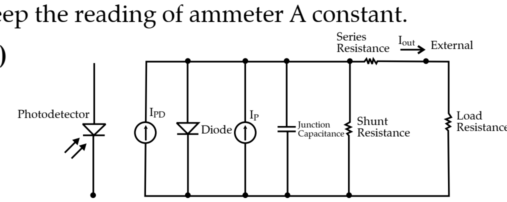
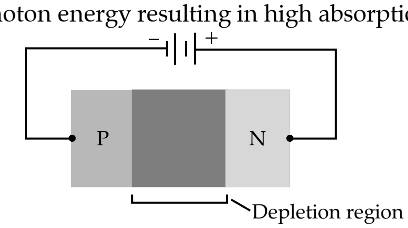


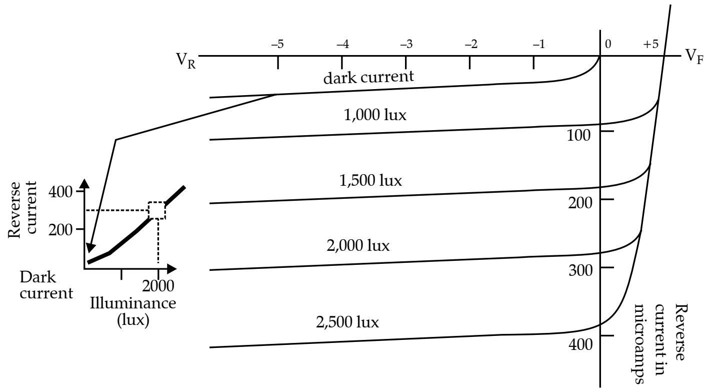
Photo diode is light sensitive electronic device that converts light into voltage signal or current signal. It carries two terminals – anode and cathode showing light rays reflection in form of photo detector. It works normally on principle of photo electric effect.

Working : In this, the photons hit the diode resulting in electron hole pairs where intensity of photon absorption is based on photon energy where less photon energy resulting in high absorption.



In the *p-n* junction as shown, in case of absorption in depletion region, the hole pairs are removed from the *p-n* junction due to inside electric field in depletion region that makes the holes to move towards anode and electrons toward cathode forming photocurrent. Here, total photocurrents and dark currents flowing with/without light is sum of current through photodiode.

***V-I* Characteristics**



2

❑❑