Solved Paper 2016
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 :*

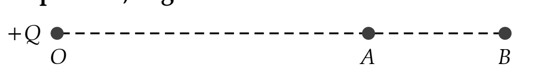
$$c = 3 \times 10^{8}\ m/s$$
$$h = 6.63 \times 10^{-34}\ \text{Js}$$
$$e = 1.6 \times 10^{-19}\ \text{C}$$
$$\mu_0 = 4\pi \times 10^{-7}\ T\,m\,\text{A}^{-1}$$
$$\varepsilon_0 = 8.854 \times 10^{-12}\ \text{C}^2\,\text{N}^{-1}\,m^{-2}$$
$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}\ \text{N m}^2\,\text{C}^{-2}$$

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

Delhi Set I **Code No. 55/1/1/D**

SECTION -A

1. A point charge +*Q* is placed at point O as shown in the figure. Is the potential difference $V_A - V_B$ positive, negative or zero? 1



Ans. Positive **[CBSE Marking Scheme, 2016] 1**

2. How does the electric flux due to a point charge enclosed by a spherical Gaussian surface get affected when its radius is increased? 1

Ans. Electric flux remains unaffected.

[**NOTE:** (As per the Hindi translation), change in Electric field is being asked, hence give credit if student write answer as decreases]

[CBSE Marking Scheme, 2016] 1

3. Write the underlying principle of a moving coil galvanometer. 1

Ans. A current carrying coil, in the presence of magnetic field, experiences a torque, which produces proportionate deflection.

[Alternatively

(deflection) θ α τ (Torque)] **1**

[CBSE Marking Scheme, 2016]

4. Why are microwaves considered suitable for radar systems used in aircraft navigation? 1

Ans. Due to their short wavelengths, (they are suitable for radar system used in aircraft navigation).

[CBSE Marking Scheme, 2016] 1

5. Define 'quality factor' of resonance in series *LCR* circuit. What is its SI unit? 1

Ans. Quality factor $Q = \frac{\omega_0}{2\Delta\omega}$,

Using equation (iii) and (iv)

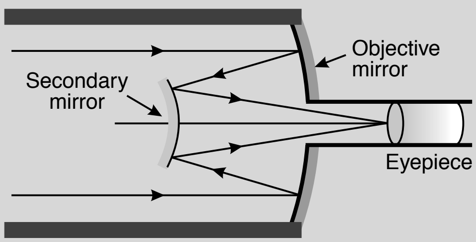
$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

$$\Rightarrow \quad \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2} \qquad \text{½}$$

[CBSE Marking Scheme, 2016]

22. Draw a schematic ray diagram of reflecting telescope showing how rays coming from a distant object are received at the eye-piece. Write its two important advantages over a refracting telescope. **3**

Ans. Drawing of schematic ray diagram **2**
Two advantages **½ + ½**



2

(i) Large gathering power
(ii) Large magnifying power
(iii) No chromatic aberration ½
(iv) Spherical aberration is also removed ½
(v) Easy mechanical support
(vi) Large resolving power **(Any two)**

[CBSE Marking Scheme, 2016]

SECTION -D

23. Meeta's father was driving her to the school. At the traffic signal she noticed that each traffic light was made of many tiny lights instead of a single bulb. When Meeta asked this question to her father, he explained the reason for this.

Answer the following questions based on above information:

(i) What were the values displayed by Meeta and her father?

(ii) What answer did Meeta's father give?

(iii) What are the tiny lights in traffic signals called and how do these operate? **4**

Ans. Answers of part (i) ,(ii), (iii) **1 + 1 + 2**

(i) Values displayed by Meeta: ½
Inquisitive / Keen Observer / Scientific temperament / (Any other value.) Values displayed by Father : ½
Encouraging / Supportive / (Any other value)

(ii) Meeta's father explained that the traffic light is made up of tiny bulbs called light emitting diodes (LED) **1**
(Also accept other relevant answers)

(iii) Light emitting diode :
These diodes (LED's) operate under forward bias, due to which the majority charge carriers are sent from these majority zones to minority zones. Hence recombination occur near the junction boundary, which releases energy in the form of photons of light. **2**

[CBSE Marking Scheme, 2016]

SECTION - E

24. (i) An a.c. source of voltage $V = V_0 \sin \omega t$ is connected to a series combination of L, C and R. Use the phasor diagram to obtain expressions for impedance of the circuit and phase angle between voltage and current. Find the condition when current will be in phase with the voltage. What is the circuit is this condition called?

(ii) In a series LR circuit $X_L = R$ and power factor of the circuit is P_1. When capacitor with capacitance C such that $X_L = X_C$ P_2 is put in series, the power factor becomes

Calculate $\frac{P_1}{P_2}$.

OR

(i) Write the function of a transformer. State its principle of working with the help of a diagram. Mention various energy losses in this device.

(ii) The primary coil of an ideal step up transformer has 100 turns and transformation ratio is also 100. The input voltage and power are respectively 220 V and 1100 W. Calculate :

(a) number of turns in secondary

(b) current in primary

(c) voltage across secondary

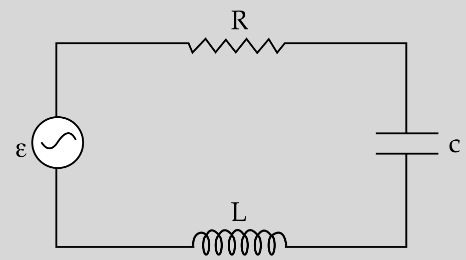
(d) current in secondary

(e) power in secondary **5**

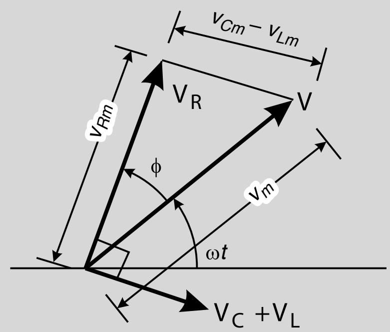
Ans. (i) Obtaining expression for impedance & phase angle **1½ + 1**
Condition of current being in phase with voltage **½**
Naming of circuit condition **½**

(ii) Calculation of $\frac{P_1}{P_2}$ **1½**

(i)



½



From Figure

$$\vec{V} = \vec{V}_L + \vec{V}_R + \vec{V}_C \quad ½$$

where $$|\vec{V}_R| = i_m R$$

$$|\vec{V}_L + \vec{V}_C| = V_{Cm} - V_{Lm} \quad ½$$

$$= i_m(X_C - X_L)$$

$$\Rightarrow \quad V_m^2 = V_{Rm}^2 + (V_{Cm} - V_{Lm})^2$$

$$I_m^2 Z^2 = I_m^2 R^2 + I_m^2 (X_C - X_L)^2$$

$$\Rightarrow \quad Z = \sqrt{R^2 + (X_C - X_L)^2}$$

From Figure

$$\tan \phi = \frac{V_{Cm} - V_{Lm}}{V_{Rm}} \quad ½$$

$$= \frac{i_m (X_C - X_L)}{i_m R} \quad ½$$

$$\phi = \tan^{-1}\left(\frac{X_C - X_L}{R}\right) \quad ½$$

Condition for current and voltage are in phase:

$V_L = V_C$ or $X_L = X_C$ ½

Circuit is called Resonant circuit. ½

(ii) Power factor $P_1 = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + R^2}} = \frac{1}{\sqrt{2}}$

(as $X_L = R$) ½

Power factor when capacitor C of reactance $X_C = X_L$ is put in series in the circuit

$$P_2 = \frac{R}{Z} = \frac{R}{R} = 1$$

as $Z = R$ at resonance ½

$$\therefore \quad \frac{P_1}{P_2} = \frac{\frac{1}{\sqrt{2}}}{1} = \frac{1}{\sqrt{2}} \quad ½$$

[CBSE Marking Scheme, 2016]

OR

Ans. (i) Function of transformer ½

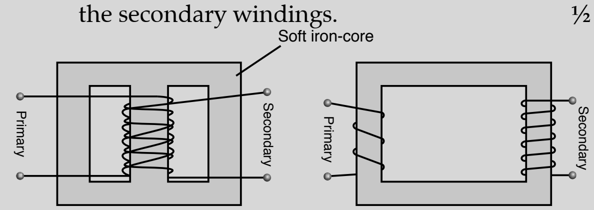
Working principle and diagram ½ + ½

Various energy losses (two) ½ + ½

(ii) Calculation of part (a) , (b), (c), (d) & (e) 2½

(i) Conversion of ac of low voltage into ac of high voltage & vice versa. ½

Mutual induction : When alternating voltage is applied to primary windings, emf is induced in the secondary windings. ½



(a) (b) ½

(Any one of the above diagram)

Energy losses :

(a) Leakage of magnetic flux

(b) Eddy currents

(c) Hysteresis loss

(d) Copper loss ½+ ½ **(Any two)**

(ii) $N_p = 100$

Transformation ratio = 100

(a) Number of turns in secondary coil

$N_S = 100 \times 100 = 10000$ ½

(b) Input Power = Input voltage × current in primary

$$1100 = 220 \times I_p$$

$$\Rightarrow \quad I_p = 5\text{A}$$

(c) $$\frac{V_S}{V_P} = \frac{N_S}{N_P} \quad ½$$

$$\frac{V_S}{220} = 100$$

$$\Rightarrow \quad V_S = 2.2 \times 10^4 \text{ volts} \quad ½$$

(d) $$\frac{I_P}{I_S} = \frac{N_S}{N_P}$$

$$\frac{5}{I_S} = 100$$

$$\Rightarrow \quad I_s = \frac{5}{100} = 0.05 \text{ A} \quad ½$$

(e) Power in secondary = Power in Primary

= 1100 W ½

[CBSE Marking Scheme, 2016]

25. (i) In Young's double slit experiment, deduce the condition for (a) constructive, and (b) destructive interference at a point on the screen. Draw a graph showing variation of intensity in the interference pattern against position 'x' on the screen.

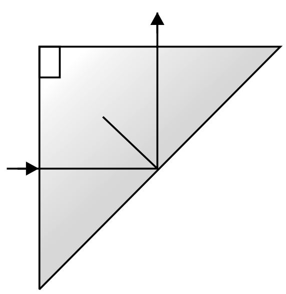
(ii) Compare the interference pattern observed in Young's double slit experiment with single slit diffraction pattern, pointing out three distinguishing features. **5**

OR

(i) Plot a graph to show variation of the angle of deviation as a function of angle of incidence for light passing through a prism. Derive an expression for refractive index of the prism in terms of angle of minimum deviation and angle of prism.

(ii) What is dispersion of light? What is its cause?

(iii) A ray of light incident normally on one face of a right isosceles prism is totally reflected as shown in fig. What must be the minimum value of refractive index of glass? Give relevant calculations. **5**

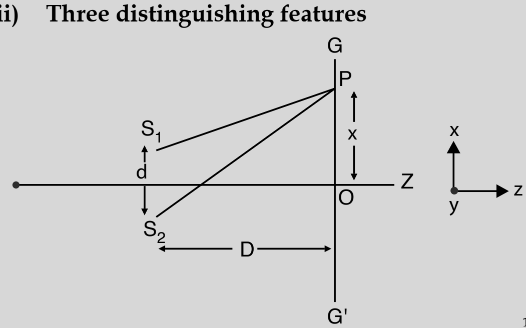


Ans. (i) Deduce the conditions for a) constructive and b) destructive interference **2½**

Graph showing the variation of intensity **1**

(ii) Three distinguishing features **1½**

(i)



½

From figure

Path difference = $(S_2P - S_1P)$ ½

$$(S_2P)^2-(S_1P)^2 = \left[D^2+\left(x+\frac{d}{2}\right)^2\right]-[D^2+(x-\frac{d}{2})^2]$$

$(S_2P + S_1P)\,(S_2P - S_1P) = 2xd$

$$S_2P - S_1P = \frac{2xd}{S_2P+S_1P} \quad ½$$

For $x, d << D$

$S_2P + S_1P = 2D$

$$\therefore \quad S_2P - S_1P = \frac{2xd}{2D} = \frac{xd}{D}$$

For constructive interference $S_2P - S_1P = n\lambda$, $n = 0, 1, 2....$

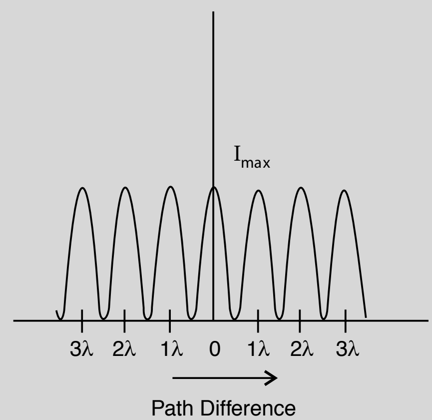
$$\Rightarrow \quad \frac{xd}{D} = n\lambda \quad ½$$

$$\Rightarrow \quad x = \frac{n\lambda D}{d}$$

For destructive interference $S_2P - S_1P = (2n+1)\frac{\lambda}{2}$, $n = 0, 1, 2....$

$$\frac{xd}{D} = (2n+1)\frac{\lambda}{2} \quad ½$$

$$\Rightarrow \quad x = (2n+1)\frac{\lambda D}{2d}$$



1

(ii) (a) The Interference pattern has number of equally spaced bright and dark bands, while in the diffraction pattern the width of the central maximum is twice the width of other maxima. ½

(b) In Interference all bright fringes are of equal intensity, whereas in the diffraction pattern the intensity falls as order of maxima increases. ½

(c) In Interference pattern, maxima occurs at an angle $\frac{\lambda}{a}$, where a is the slit width, whereas in diffraction pattern, at the same angle, first minimum occurs. (Here 'a' is the size of the slit) ½

(Any other distinguishing feature)

[CBSE Marking Scheme, 2016]

OR

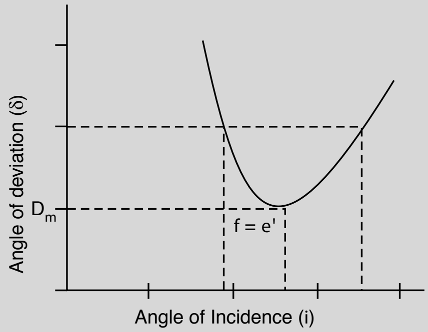
(i) Plot showing the variation of the angle of deviation as a function of angle of incidence **1**

Derivation of expression of refractive index **1½**

(ii) Definition of dispersion and its cause

½ + ½

(iii) Calculation of minimum value of refractive index **1½**



(i) 1

From figure $\delta = D_m$, $i = e$ which implies $r_1 = r_2$

$$2r = A, \text{ or } r = \frac{A}{2}$$

Using $\delta = i + e - A$ ½

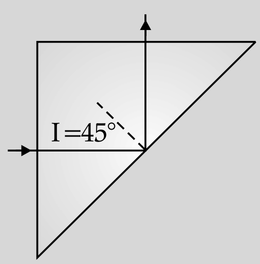
$$D_m = 2i - A$$

$$i = \frac{A + D_m}{2}$$

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

(ii) The phenomenon of splitting of white light into its constituent colours. ½

Cause : Refractive index of the material is different for different colours. According to the equation, $\delta \ncong (\mu - 1)A$, where A is the angle of prism, different colours will deviate through different amount. ½



For total internal reflection,

$$\angle i \geq \angle i_c \text{ (critical angle)}$$

$\Rightarrow$ $45° \geq \angle i_c$, *i.e.*, $\angle i_c \leq 45°$

$$\sin i_c \leq \sin 45°$$ ½

$$\leq \frac{1}{\sqrt{2}}$$

$$\frac{1}{\sin i_c} \geq \sqrt{2}$$

$\Rightarrow$ $\mu \geq \sqrt{2}$ ½

Hence, the minimum value of refractive index must be $\sqrt{2}$ ½

[CBSE Marking Scheme, 2016]

26. (i) Define the term drift velocity.

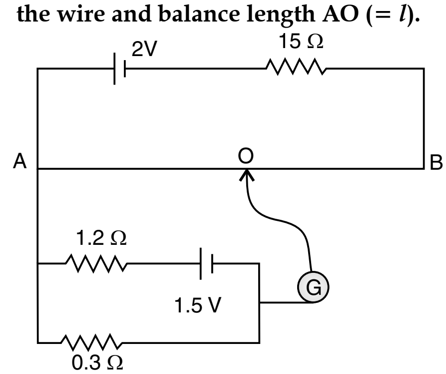
(ii) On the basis of electron drift, derive an expression for resistivity of a conductor in terms of number density of free electrons and relaxation time. On what factors does resistivity of a conductor depend?

(iii) Why alloys like constantan and manganin are used for making standard resistors? **5**

OR

(i) State the principle of working of a potentiometer.

(ii) In the following potentiometer circuit AB is a uniform wire of length 1 m and resistance 10 Ω. Calculate the potential gradient along the wire and balance length AO (= *l*).



5

Ans. (i) Definition of drift velocity **1**

(ii) Derivation of expression of resistivity **2**

Factors affecting resistivity **1**

(iii) Reason of using constantan and manganin **1**

(i) Average velocity acquired by the electrons in the conductor in the presence of external electric field.

[Alternatively: **1**

$v_d = \frac{-eE\tau}{m}$ where τ is the relaxation time.]

(ii) $$v_d = \frac{-eE\tau}{m}$$

We have $E = -\frac{V}{\ell}$, where V is potential across the length l of the conductor

$$v_d = \frac{eV\tau}{m\ell}$$

Current flowing $I = neAv_d$

$$I = neAv_d \frac{eVr}{m\ell}$$

$$= \frac{ne^2AV\tau}{m\ell}$$ ½

$$\frac{I}{V} = \frac{ne^2A\tau}{m\ell} = \frac{1}{R} \quad ...(i)$$

½

Also, $$R = \rho\frac{\ell}{A} \quad ...(ii)$$

½

Comparing (i) and (ii),

$$\rho = \frac{m}{ne^2\tau}$$ ½

Resistivity of the material of a conductor depends on the relaxation time, *i.e.*, temperature and the number density of electrons.

½ + ½

(iii) Because constantan and manganin show very weak dependence of resistivity on temperature. **1**

[CBSE Marking Scheme, 2016]

OR

(i) Working principle of potentiometer **2**
(ii) Calculation of potential gradient and balance length **3**

(i) When constant current flows through a conductor of uniform area of cross section, the potential difference, across a length l of the wire, is directly proportional to that length of the wire. **2**

[$V \propto l$ (Provided current and area are constant]

(ii) Current flowing in the potentiometer wire

$$i = \frac{E}{R_{total}} = \frac{2.0}{15+10} = \frac{2}{25}A$$ ½

∴ Potential difference across the two ends of the wire

$$V_{AB} = \frac{2}{25}\times 10V = \frac{20}{25} = 0.8 \text{ volt}$$ ½

Hence potential gradient

$$K = \frac{V_{AB}}{l_{AB}} = \frac{0.8}{1.0} = 0.8\frac{V}{m}$$ ½

Current flowing in the circuit containing experimental cell,

$$= \frac{1.5}{1.2+0.3} = 1\text{A}$$

Hence, potential difference across length AO of the wire

$$= 0.3 \times 1\text{V} = 0.3\text{V}$$ ½

$$\Rightarrow \quad 0.3 = K \times l_{AO}$$
$$= 0.8 \times l_{AO}$$

$$\Rightarrow \quad l_{AO} = \frac{0.3}{0.8}m = 0.375 \text{ m}$$ ½

$$= 37.5 \text{ cm}$$

[CBSE Marking Scheme, 2016]

Delhi Set II — Code No. 55/1/2/D

Note: All Questions are from Set I.

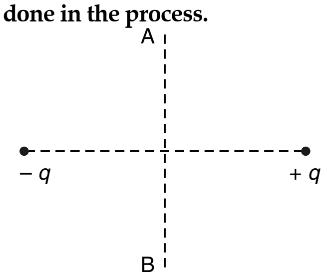
Delhi Set III — Code No. 55/1/3/D

Note: All Questions are from Set I & II.

Outside Delhi Set I — Code No. 55/1/C

SECTION -A

1. A charge 'q' is moved from a point A above a dipole of dipole moment 'p' to a point B below the dipole in equatorial plane without acceleration. Find the work done in the process. **1**



Ans. No work is done

$W = qV_{AB} = q \times 0 = 0$ **1**

[CBSE Marking Scheme, 2016]

2. In what way is the behaviour of a diamagnetic material different from that of a paramagnetic, when kept in an external magnetic field? **1**

Ans. A diamagnetic specimen would move towards the weaker region of the field while a paramagnetic specimen would move to wards the stronger region. A diamagnetic specimen is repelled by a magnet while a paramagnetic specimen move towards the magnet. The paramagnetic get aligned along B and the diamagnetic perpendicular to the field. **[CBSE Marking Scheme, 2016] 1**

***3. Name the essential components of a communication system.** **1**

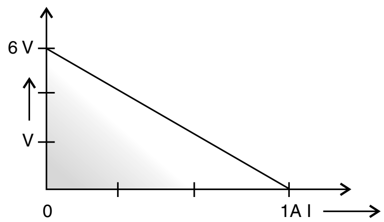
4. Why does sun appear red at sunrise and sunset?1

Ans. It is due to least scattering of red light as it has the longest wavelength.

As per Rayleigh's scattering, the amount of light scattered $\propto \frac{1}{\lambda^4}$ **1**

[CBSE Marking Scheme, 2016]

5. The plot of the variation of potential difference across a combination of three identical cells in series, versus current is shown below. What is the emf and internal resistance of each cell? 1



Ans.

Voltage across cell combination

$$V = E - Ir$$

When current $I = 0 \Rightarrow V = E$

Form graph, when $I = 0$, $V = 6$V

$\Rightarrow$ emf $E = 6$ V

As $I = 1$A, at $V = 0$ (from graph)

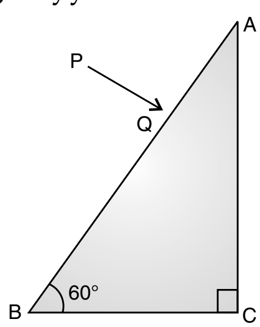
$\therefore V = E - Ir \Rightarrow 0 = 6 - 1r \Rightarrow -6 = -1r$

$r = 6\Omega$ **1**

SECTION -B

*** 6. Define modulation index. Why is it kept low? What is the role of a bandpass filter? 2**

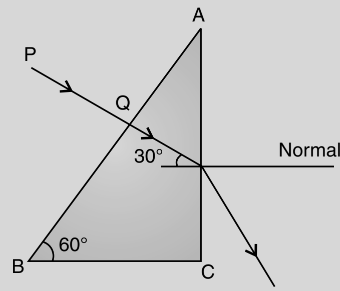
7. A ray PQ incident normally on the refracting face BA is refracted in the prism BAC made of material of refractive index 1.5. Complete the path of ray through the prism. From which face will the ray emerge? Justify your answer. 2



Ans. Path of emergent ray **1**

Naming the face **½**

Justification **½**



½

Face-AC

Here $i_c = \sin^{-1}\left(\frac{2}{3}\right)$ ½

$= \sin^{-1}(0.6)$ ½

$\angle$i on face AC is 30° which is less than $\angle i_c$. Hence the ray get retracted here. ½

[CBSE Marking Scheme, 2016]

8. Calculate the de-Broglie wavelength of the electron orbiting in the $n = 2$ state of hydrogen atom. 2

Ans. Formulae of kinetic energy and de-Broglie a wavelength ½ + ½

Calculation and Result ½ + ½

Kinetic Energy for the second state- ½

$E_k = \frac{13.6eV}{n^2} = \frac{13.6eV}{4} = 3.4 \times 1.6 \times 10–19$ J

de-Broglies wavelength $\lambda = \frac{h}{\sqrt{2mE_k}}$ ½

$= \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-19}}}$ ½

$= 0.067$ nm ½

[CBSE Marking Scheme, 2016]

9. Define ionization energy.

How would the ionization energy change when electron in hydrogen atom is replaced by a particle of mass 200 times that of the electron but having the same charge? 2

OR

Calculate the shortest wavelength of the spectral lines emitted in Balmer series.

[Given Rydberg constant, R = 10^7 m^{-1}] 2

Ans. Definition 1

Formula ½

Calculation and Result ½

The minimum energy, required to free the electron from the ground state of the hydrogen atom, is known as Ionization Energy.

$E_0 = \frac{me^4}{8\varepsilon_0^2 h^2}$ *i.e.*, $E_0 \propto m$

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* *Out of Syllabus*

Therefore, Ionization Energy will become 200 times. **[CBSE Marking Scheme, 2016]**

OR

Ans. Formula 1

Calculation and Result ½+½

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$$ 1

For shortest wavelength, $n = a$ ½

Therefore, $\frac{1}{\lambda} = \frac{R}{4} = \Rightarrow l = \frac{4}{R} = 4 \times 10^{-7}$ m

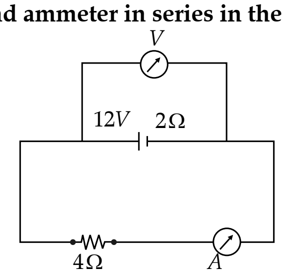
½

[CBSE Marking Scheme, 2016]

10. A battery of emf 12V and internal resistance 2 Ω is connected to a 4 Ω resistor as shown in the figure.

(a) Show that a voltmeter when placed across the cell and across the resistor, in turn, gives the same reading.

(b) To record the voltage and the current in the circuit, why is voltmeter placed in parallel and ammeter in series in the circuit? 2



Ans. **(a) Relation for terminal potential** ½

(b) Justification ½

(c) Explanation (parallel and series) ½ + ½

(a) Effective resistance of the circuit $R_E = 6\Omega$

$\therefore \quad VI = \frac{12A}{6} = 2A$

Terminal potential difference across the cell, $V = E - ir$ ½

Also p.d. across 4Ω resistor = 4 × 2V = 8V

Hence the voltmeter gives the same reading in the two cases. ½

(b) In series - current same ½

In parallel – potential same ½

[CBSE Marking Scheme, 2016]

SECTION -C

11. Define an equipotential surface. Draw equipotential surfaces:

(i) in the case of a single point charge and

(ii) in a constant electric field in Z-direction. Why the equipotential surfaces about a single charge are not equidistant?

(iii) Can electric field exist tangential to an equipotential surface? Give reason. 3

Ans. **Definition:** ½

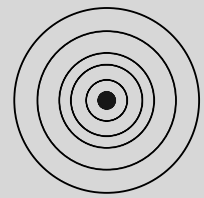
(i) Diagram of Equipotential Surface ½

(ii) Diagram and reason ½ + ½

(iii) Answer and Reason ½ + ½

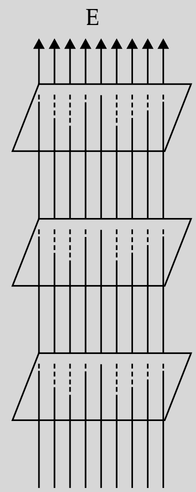
Surface with a constant value of potential at all points on the surface. ½

(i)



½

(ii)



$V \propto \frac{1}{r}$

½

(iii) No ½

If the field lines are tangential, work will be done in moving a charge on the surface which goes against the definition of equipotential surface. ½

[CBSE Marking Scheme, 2016]

12. (i) State law of Malus.

(ii) Draw a graph showing the variation of intensity (*I*) of polarised light transmitted by an analyser with angle (θ) between polariser and analyser.

(iii) What is the value of refractive index of a medium of polarising angle 60°? 3

Ans. **Statement** 1

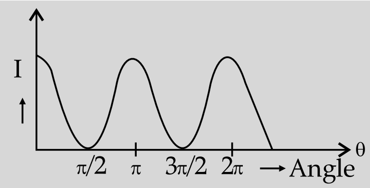
Plotting the graph 1

Calculating value of (μ) refractive index 1

(i) When the pass axis of a polaroid makes an angle θ with the plane of polarisation of polarised light of intensity I_0 incident on it, then the intensity of the transmitted emergent light is given by $I = I_0 \cos^2 \theta$ 1

Note : If the student writes the formula $I = I_0 \cos^2 \theta$ and draws the diagram give 1 mark

(ii)



1

(iii) $\mu = \tan i_\beta$

$= \tan 60° = \sqrt{3} = 1.7$ 1

[CBSE Marking Scheme, 2016]

13. Sketch the graphs showing variation of stopping potential with frequency of incident radiations for two photosensitive materials A and B having threshold frequencies $\nu_A > \nu_B$.

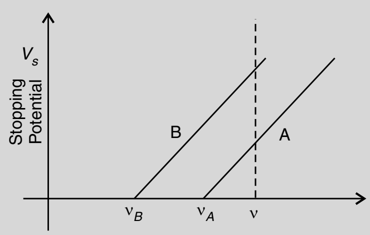
(i) In which case is the stopping potential more and why?

(ii) Does the slope of the graph depend on the nature of the material used? Explain. 3

Ans. Sketch of the Graph 1

(i) Stopping potential and Reason ½ + ½

(ii) Dependence of slope and Explanation ½ + ½



1

(i) For material B

From the graph for the same value of 'ν', stopping potential is more for material 'B'/

$[V_0 = \frac{h}{e}(\nu - \nu_0)]$ 1

$\therefore$ V_0 is higher for lower value of ν_0]

(ii) No

As slope is given by $\frac{h}{e}$ which is constant. 1

[CBSE Marking Scheme, 2016]

14. (a) Write the basic nuclear process involved in the emission of β^+ in a symbolic form, by a radioactive nucleus.

(b) In the reactions given below :

(i) $^{11}_{6}C \rightarrow {}^{z}_{y}B + x + \nu$

(ii) $^{12}_{6}C + {}^{12}_{6}C \rightarrow {}^{20}_{a}Ne + {}^{c}_{b}He$

Find the values of x, y, and z and a, b and c. 3

Ans. (a) Basic nuclear process 1

(b) (i) value of x, y, z 1

(ii) value of a, b, c 1

(a) Basic nuclear reaction

$P \rightarrow n + e^+ + \nu$ 1

(b) (i) $x = \beta^+/{}^{0}_{1}e, y = 5, z = 11$ 1

(ii) $a = 10, b = 2, c = 4$ 1

[CBSE Marking Scheme, 2016]

15. (i) Derive an expression for drift velocity of free electrons.

(ii) How does drift velocity of electrons in a metallic conductor vary with increase in temperature? Explain. 3

Ans. (i) When conductor is subjected to an electric field E, each electron experience a Force.

$$F = -eE$$

and acquires an acceleration

$$a = \frac{F}{m} = -\frac{eE}{m} \quad \text{... (i)}$$

Here m = mass of electron, e = charge,

E = electric field.

The average time difference between two consecutive collisions is known as relaxation time of electron.

$$\bar{\tau} = \frac{\tau_1 + \tau_2 + - - + \tau_n}{n} \quad \text{...(ii)}$$

As $v = u + at$ (from equations of motion.)

The drift velocity v_d is defined as —

$$v_d = \frac{v_1 + v_2 + \cdots + v_n}{n}$$

$$v_d = \frac{(u_1 + u_2 + \cdots + u_n) + a(\tau_1 + \tau_2 + \cdots + \tau_n)}{n}$$

$$v_d = 0 + \frac{a(\tau_1 + \tau_2 + \cdots + \tau_n)}{n} \quad 1\tfrac{1}{2}$$

(average thermal velocity = 0)

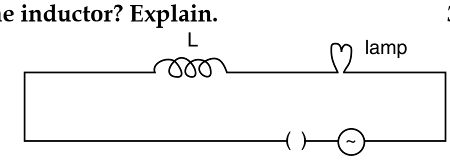
$$\therefore \quad v_d = 0 + a\tau$$

$$v_d = -\left(\frac{eE}{m}\right)\tau \quad \text{[from (i)]}$$

(ii) According to drift velocity expression, relaxation time is the time interval between successive collisions of an electron on increasing temperature, the electrons move faster and more collisions occur quickly. Hence, relaxation time decreases with increase in temperature which implies that drift velocity also decreases with temperature. 1½

16. (i) When an AC source is connected to an ideal inductor show that the average power supplied by the source over a complete cycle is zero.

(ii) A lamp is connected in series with an inductor and an AC source. What happens to the brightness of the lamp when the key is plugged in and an iron rod is inserted inside the inductor? Explain. 3



Ans. **Proof for average power** **1½**
Effect on brightness **½**
Explanation **1**

(i) $P_{av} = I_{av} \times e_{av} \cos\phi$

For an ideal inductor, $\phi = \frac{\pi}{2}$

$$\therefore \quad P_{av} = I_{av} \times e_{av} \cos\frac{\pi}{2}$$

$$P_{av} = 0$$ **1½**

(ii) Brightness decreases **½**

Because as iron rod is inserted inductance increases.

Thus, current decreases and brightness decreases. **1**

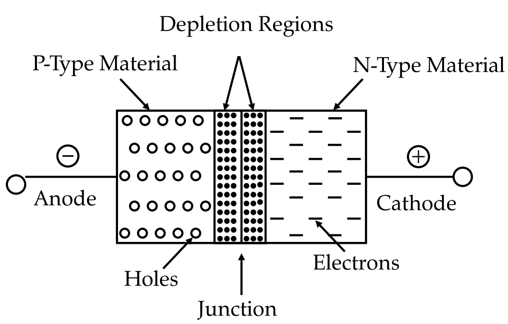
[CBSE Marking Scheme, 2016]

17. (i) Explain with the help of a diagram the formation of depletion region and barrier potential in a *p-n* junction.

(ii) Draw the circuit diagram of a half wave rectifier and explain its working. **3**

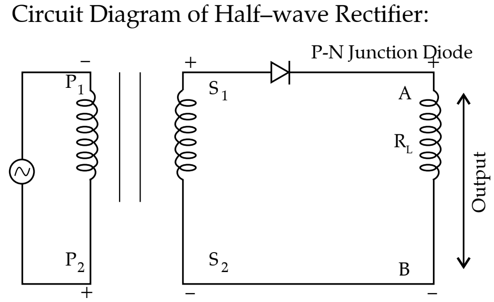
Ans. (i) With the formation of *p*–*n* junction, the holes from *p*–region diffuse into the *n*–region and electrons from *n*–region diffuse into *p*–region and electron hole pair combine and get annihilated. This in turn, produces potential barrier V_B across the junction which opposes the further diffusion through the junction. Thus, small region forms in the vicinity of the junction which is depleted of free charge carriers and has only immobile ions is called the depletion regions.

The potential distribution near the *p*–*n* junction is known as potential barrier.

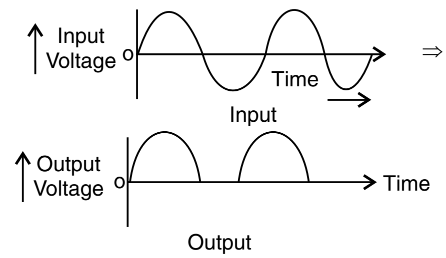


1½

(ii) Circuit Diagram of Half–wave Rectifier:



Working: Diode conducts corresponding to positive half-cycle and does not conduct during negative half-cycle hence AC converted by diode into unidirection pulsating DC. This action is half–wave rectification.



1½

*** 18. (i) Which mode of propagation is used by shortwave broadcast services having frequency range from a few MHz upto 30 MHz? Explain diagrammatically how long distance communication can be achieved by this mode.**

(ii) Why is there an upper limit to frequency of waves used in this mode? **3**

19. (i) Identify the part of the electromagnetic spectrum which is :

(a) suitable for radar system used in aircraft navigation,

(b) produced by bombarding a metal target by high speed electrons.

(ii) Why does a galvanometer show a momentary deflection at the time of charging or discharging a capacitor? Write the necessary expression to explain this observation. **3**

Ans. (i) Identification **1 + 1**
(ii) Momentary deflection of galvanometer
Reason **½**
Expressions **½**

(i) **(a)** Microwaves **1**
(b) X-rays **1**

(ii) Due to conduction current in the connecting wires and a displacement current between the plates **½**

$$I_d = \varepsilon_0 \frac{d\phi_E}{dt}$$ **½**

[CBSE Marking Scheme, 2016]

*** 20. For a CE-transistor amplifier, the audio signal voltage across the collector resistance of 2 kΩ is 2 V. Suppose 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**

21. Define the term wave front. State Huygen's principle.

Consider a plane wave front incident on a thin convex lens. Draw a proper diagram to show how

* *Out of Syllabus*

the incident wave front traverses through the lens and after refraction focuses on the focal point of the lens, giving the shape of the emergent wave front. **3**

OR

Explain the following, giving reasons :

(i) When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency.

(ii) When light travels from a rarer to a denser medium, the speed decreases. Does this decrease in speed imply a reduction in the energy carried by the wave?

(iii) In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave. What determines the intensity in the photon picture of light? **3**

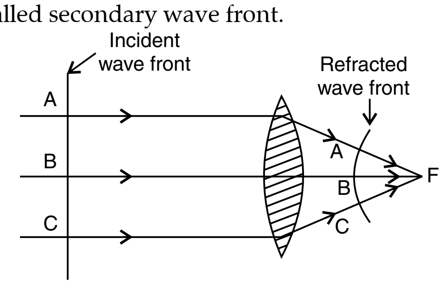
Sol. :

When source of light is a point source, the wave front is a spherical wave front. **1**

Huygen's Principle:

(1) Every point on the given wave front (called primary wave front) acts as a fresh source of new disturbance, called secondary wavelets, which travel in all directions, with the velocity of light, in the medium. **1**

(2) A surface touching these secondary wavelets, tangentially in the forward direction at any instant gives the new wave front at that instant. This is called secondary wave front.



1

OR

(i) The frequency and time period of an electromagnetic wave depends only on the source which produces it. The frequency is independent of the medium through which it travels. But the speed and wavelength depends on the medium through which the wave travels. Because of this, the frequency and time period of sound wave do not change due to change in medium. **1**

(ii) Speed decreases due to decrease of wavelength of wave but energy carried by the light wave depends on the amplitude of electric field vector. **1**

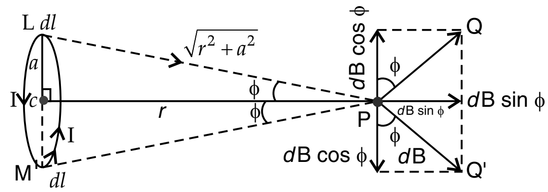
(iii) The number of photons emitted from metal surface depends only on the intensity of the incident light and is independent of its frequency. The number of photons emitted per second is directly proportional to the intensity of the incident light. **1**

22. Use Biot-Savart law to derive the expression for the magnetic field on the axis of a current carrying circular loop of radius *R*.

Draw the magnetic field lines due to a circular wire carrying current *I*. **3**

Sol. :

Let us consider a circular loop of radius a with centre C. Let the plane of the coil be perpendicular to the plane of the paper and current I be flowing in the direction shown. Suppose P is any point on the axis at direction r from the centre.



1½

Let us consider a current element dl on top (L) where, current comes out of paper normally whereas at bottom (M) enters into the plane paper normally.

$$LP \perp dl$$

Also $MP \perp dl$

$$LP = MP = \sqrt{r^2+a^2}$$

Now, magnetic field at P due to current element at L according to Biot-Savart Law,

$$dB = \frac{\mu_o}{4\pi}\cdot\frac{Idl\sin 90°}{(r^2+a^2)}$$

Where, a = radius of circular loop.

r = distance of point P from centre along the axis.

$dB\cos\phi$ components balance each other and net magnetic field is given by

$$B = \oint dB\sin\phi$$

$$= \oint \frac{\mu_o}{4\pi}\left[\frac{Idl}{r^2+a^2}\right]\cdot\frac{a}{\sqrt{r^2+a^2}}$$

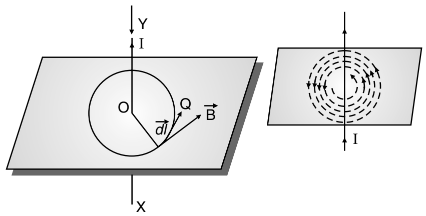
$$\left[\because \sin\phi = \frac{a}{\sqrt{r^2+a^2}} \text{ In } \Delta PCM\right]$$

$$= \frac{\mu_o}{4\pi}\frac{Ia}{(r^2+a^2)^{\frac{3}{2}}}\oint dl$$

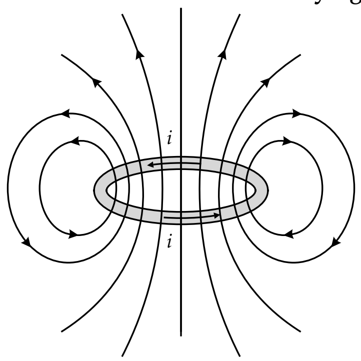
$$B = \frac{\mu_o}{4\pi}\frac{Ia}{(r^2+a^2)^{\frac{3}{2}}}(2\pi a)$$

$$B = \frac{\mu_o I^2 a^2}{2(r^2+a^2)^{\frac{3}{2}}}$$ **1½**

For n turns, $B = \dfrac{\mu_o n I^2 a^2}{2(r^2+a^2)^{\frac{3}{2}}}$



Magnetic field due to circular wire carrying current *I*.



SECTION -D

23. Ram is a student of class X in a village school. His uncle gifted him a bicycle with a dynamo fitted in it. He was very excited to get it. While cycling during night, he could light the bulb and see the objects on the road. He, however, did not know how this device works. He asked this question to his teacher. The teacher considered it an opportunity to explain the working to the whole class.

Answer the following questions:

(a) State the principle and working of a dynamo.

(b) Write two values each displayed by Ram and his school teacher. **4**

Ans. **(a) Principle and working** **1 + 1**

(b) Two values, each, displayed by

(i) Ram ½ + ½

(ii) School teacher ½ + ½

(a) **Principle:**

Whenever a coil is rotated in a magnetic field, an emf is induced in it due to the change in magnetic flux linked with it. **1**

Working–

As the coil rotates, its inclination (θ) with respect to the field changes. Hence sinusoidal/ varying emf ($=e_0 \sin\omega t$) is obtained./May also be explained graphically. **1**

[Note—Give full marks if the student obtains the expression for induced emf mathematically.]

(b) **Values**:

Ram—Scientific aptitude, curiosity, keenness to learn, positive approach, etc (any two) **1**

Teacher— Dedication, concern for students, depth of knowledge, generous, positive attitude towards queries, motivational approach. **(Any two)** **1**

[CBSE Marking Scheme, 2016]

SECTION - E

24. (i) Draw a labelled diagram of a step-down transformer. State the principle of its working.

(ii) Express the turn ratio in terms of voltages.

(iii) Find the ratio of primary and secondary currents in terms of turn ratio in an ideal transformer.

(iv) How much current is drawn by the primary of a transformer connected to 220 V supply when it delivers power to a 110 V – 550 W refrigerator? **5**

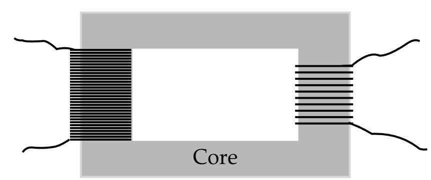
OR

(a) Explain the meaning of the term mutual inductance. Consider two concentric circular coils, one of radius r_1 and the other of radius r_2 ($r_1 < r_2$) placed coaxially with centres coinciding with each other. Obtain the expression for the mutual inductance of the arrangement.

(b) A rectangular coil of area *A*, having number of turns *N* is rotated at '*f*' revolutions per second in a uniform magnetic field *B*, the field being perpendicular to the coil. Prove that the maximum emf induced in the coil is $2\pi f NBA$. **5**

Ans.

(i) **Principle of working:** It works on the principle of mutual induction i.e. if two coils are inductively coupled and when current or magnetic flux is changed through one of the two coils, then induced e.m.f. is produced in the other coil. **1**



(ii) Turns ratio is

$$K = \frac{n_s}{n_p} = \frac{E_s}{E_p}$$

A transformer with a primary winding of 1000 turns and secondary winding of 100 turns has a turns ratio of 1000 : 100 or 10 : 1. Therefore, 100 volts applied to primary winding will produce a secondary voltage of 10 volts. **1**

(iii) $$E_s I_s = E_p I_p$$

(Input Power = Output Power)

$$\Rightarrow \quad \frac{E_s}{E_p} = \frac{I_p}{I_s}$$

$$\Rightarrow \quad \frac{I_p}{I_s} = \frac{n_s}{n_p} = K$$ **1**

(iv) $e_p = 220$ v; $e_s = 110$v, $e_s I_s = 550$ W

Now, $e_p I_p = e_s I_s$

$$I_p = \frac{e_s I_s}{e_p} = \frac{550}{220} = 2.5 \text{ A}$$ **1**

OR

Ans. (a) Meaning of Mutual Inductance **1**

Expression **1½**

(b) Proof **2**

Diagram **½**

(a) Mutual Inductance is the property of a pair of coils due to which an emf induced in one of the coils due to the change in the current in the other coil. **1**

Mathematically $e_2 = \dfrac{Mdi_1}{dt}$

$\therefore \quad M = -\dfrac{e_2}{di_1/dt}$

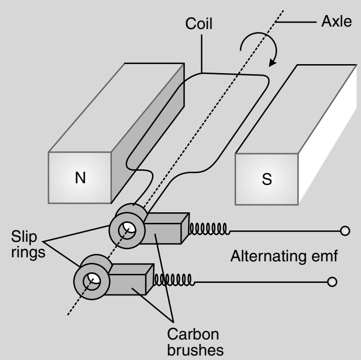
Let a current I_2 flows through the outer circular coil. Then

$$B_2 = \frac{\mu I_2}{2r_2}$$

$$\therefore \quad \phi_1 = \pi r^2 B_2 = \frac{\mu\pi r_1^2}{2r_2} I_2 = M_{12} I_2$$

Thus $$M_{12} = \frac{\mu\pi r_1^2}{2r_2} I_2 = M_{21}$$ **1 ½**

(b)



½

Flux at any time 't'.

$\phi_B = BA\cos\theta = BA\cos\omega t$

From Faraday's Law, induced emf

$$e = -N\frac{d\phi_B}{dt} = NBA\frac{d}{dt}(\cos\omega t)$$

Thus the instantaneous value of emf is

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

For maximum value of emf $\sin\omega t = \pm 1$

i.e., $e_0 = NBA\omega = 2\pi fNBA$ **2**

[CBSE Marking Scheme, 2016]

25. (i) Derive the mathematical relation between refractive indices n_1 and n_2 of two radii and radius of curvature R for refraction at a convex spherical surface. Consider the object to be a point since lying on the principle axis in rarer medium of refractive index n_1 and a real image formed in the denser medium of refractive index n_2. Hence, derive lens maker's formula.

(ii) Light from a point source in air falls on a convex spherical glass surface of refractive index 1.5 and radius of curvature 20 cm. The distance of light source from the glass surface is 100 cm. At what position is the image formed?

OR

(a) Draw a labelled ray diagram to obtain the real image formed by an astronomical telescope in normal adjustment position. Define its magnifying power.

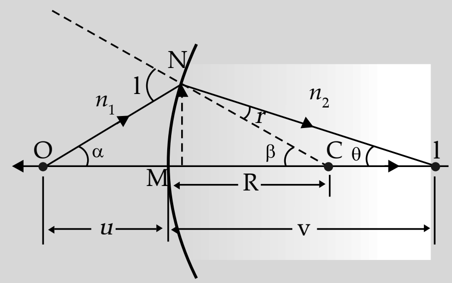
(b) You are given three lenses of power 0.5 D, 4 D and 10 D to design a telescope.

(i) Which lenses should be used as objective and eyepiece? Justify your answer.

(ii) Why is the aperture of the objective preferred to be large? **5**

Ans. **(i)**Derivation of $\dfrac{n_2}{v} - \dfrac{n_1}{u} = \dfrac{(n_2 - n_1)}{R}$ **1½**

$$\frac{1}{f} = \left(\frac{n_2 - n}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ **1½**



Ray diagram showing real image formation as per description

$$\theta_1 = \alpha + \beta$$
$$\theta_2 = \beta - \gamma$$
$$\therefore \quad \gamma = \beta - \theta$$

For paraxial rays θ_1 and θ_2 are small

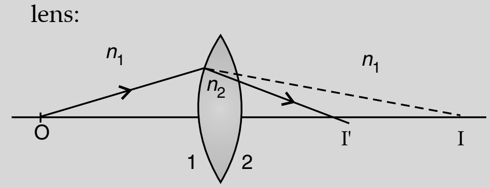
Therefore, $n_2 \sin\theta_2 = n_1 \sin\theta_2$ (Snell's law)

Reduces to

$$\frac{\sin i}{\sin r} \approx \frac{i}{r} = \frac{n_2}{n_1}$$

$$\therefore \quad i \times n_1 = r \times n_2$$
$$(\alpha + \beta)n_1 = (\beta - \gamma)n_2$$
$$n_1\left(\frac{NM}{OM} + \frac{NM}{MC}\right) = \left(\frac{NM}{MC} - \frac{NM}{MI}\right)n_2$$
$$n_2\left(\frac{1}{-u} + \frac{1}{+R}\right) = \left(\frac{1}{+R} - \frac{1}{u}\right)n_2$$
$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$$

Applying above relations to refraction through a lens:



For surface 1

$$\frac{n_2 - n_1}{R_1} = \frac{n_2}{v'} - \frac{n_1}{u} \quad ...(i)$$

For surface 2

$$\frac{n_1 - n_2}{R_2} = \frac{n_1}{v} - \frac{n_2}{v'} \quad ...(ii)$$

Adding eqn. (i) and (ii),

$$(n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = n_1\left(\frac{1}{v} - \frac{1}{u}\right)$$

For $u = \infty$ $v = f$

$$\therefore \quad \frac{n_1}{f} = (n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \quad \frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

(iii) R = 20 cm, $n_2 = 1.5$, $n_1 = 1$, $u = -100$ cm

$$\frac{n_2}{v} = \frac{(n_2 - n_1)}{R} + \frac{n_1}{u}$$

$$= \frac{0.5}{20\,\text{cm}} - \frac{1}{100\,\text{cm}}$$

$$= \frac{1.5}{100}\text{cm}$$

$\Rightarrow$ $v = 100$ cm a real image on the other side, 100 cm away from the surface.

[CBSE Marking Scheme, 2016]

OR

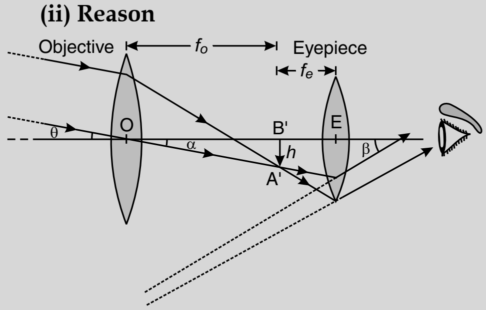
Ans. **(a) Labelled ray diagram of Astronomical Telescope** **1½**

Definition of magnifying power **1**

(b) (i) Identification of lenses **½+½**

Justification **½+½**

(ii) Reason **½**



1½

Definition-It is the ratio of the angle subtended at the eye, by the final image, to the angle which the object subtends at the lens, or the eye. **1**

(b) **(i)** Objective = 5D ½

Eye lens = 10D ½

This choice would give higher magnification as

$$M = \frac{f_0}{f_e} = \frac{P_e}{P_0} \quad \textbf{1}$$

(ii) High resolving power / Brighter image / lower limit of resolution **(Any one)** ½

[CBSE Marking Scheme, 2016]

26. **(i) Use Gauss's law to find the electric field due to a uniformly charged infinite plane sheet. What is the direction of field for positive and negative charge densities?**

(ii) Find the ratio of the potential differences that must be applied across the parallel and series combination of two capacitors C_1 and C_2 with their capacitances in the ratio 1 : 2 so that the energy stored in the two cases becomes the same. **5**

OR

(i) If two similar large plates, each of area A having surface charge densities $+\sigma$ and $-\sigma$ are separated by a distance d in air, find the expressions for

(a) field at points between the two plates and on outer side of the plates.

Specify the direction of the field in each case.

(b) the potential difference between the plates.

(c) the capacitance of the capacitor so formed.

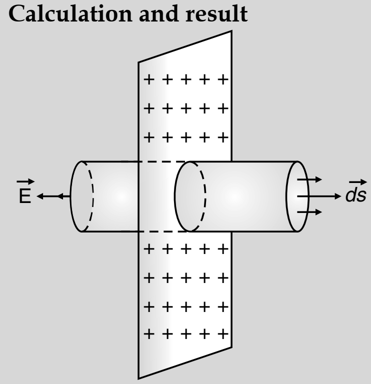
(ii) Two metallic spheres of radii R and $2R$ are charged so that both of these have same surface charge density σ. If they are connected to each other with a conducting wire, in which direction will the charge flow and why? **5**

Ans. **(i) Derivation for electric field due to infinite plane Sheet of charge** **2**

Directions of field **½ + ½**

(ii) Formula **½**

Calculation and result **1½**



Symmetry of situation suggests that $\vec{E}$ is perpendicular to the plane. A Gaussian surface is considered through P like a cylinder of flat caps parallel to the plane and one cap passing through P. The plane being the plane of symmetry for the Gaussian surface.

$$\oint \vec{E}.\vec{ds} = \int_{\text{through caps}} \vec{E}.\vec{ds}$$

$\vec{E} \perp \vec{ds}$ for all over curved surface and hence $\vec{E}.\vec{ds} = 0$

$$\int_{caps} Eds = 2E\Delta s$$

$$\Delta s = \text{area of each cap}$$

By Gauss' law

$$\oint \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0} = \frac{\sigma\Delta s}{\varepsilon_0}$$

$$\therefore \quad 2E\Delta s = \frac{\sigma\Delta s}{\varepsilon_0}$$

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

If σ is positive $\vec{E}$ points normally outwards/away from the sheet

If σ is (–)ve $\vec{E}$ points normally inwards/towards the sheet

$$U_s = \frac{1}{2}C_s V_s^2$$

$$U_p = \frac{1}{2}C_p V_p^2$$

$$\Rightarrow \quad \frac{V_{series}}{V_{parallel}} = \sqrt{\frac{C_{equivalent\ parallel}}{C_{equivalent\ series}}}$$

$$= \sqrt{\frac{C_1 + C_2}{\frac{C_1 C_2}{C_1 + C_2}}}$$

$$= \frac{C_1 + C_2}{\sqrt{C_1 C_2}} = \frac{3}{\sqrt{2}}$$

(Any one)

[CBSE Marking Scheme, 2016]

OR

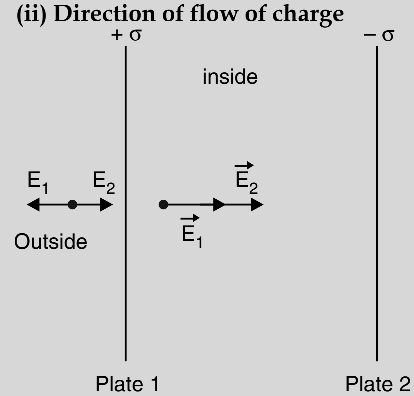
Ans. (i) Deriving the expression for field between the plate & outside ½ + ½

Direction of electric field inside and outside ½ + ½

Potential difference between the plates 1

Capacitance 1

(ii) Direction of flow of charge ½ + ½



½ + ½

Inside

$$\vec{E} = \vec{E_1} + \vec{E_2}$$

$$= \frac{\sigma + \sigma}{2E_0} = \frac{\sigma}{E_0} \qquad ½$$

Outside

$$\vec{E} = \vec{E_2} - \vec{E_1}$$

$$= \frac{\sigma - \sigma}{2\varepsilon_0} = 0 \qquad ½$$

(b) Potential difference between plates

$$V = Ed = \frac{1}{\varepsilon_0}\frac{Qd}{A} \qquad 1$$

(c) Capacitance

$$C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d}$$

(ii) As potential on and inside a charged sphere is given

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r} = \frac{1}{4\pi\varepsilon_0}.\frac{4\pi r^2\sigma}{r}$$

$$\therefore V \propto r$$

Hence, the bigger sphere will be at higher potential, so charge will flow from bigger sphere to smaller sphere. ½ + ½

[CBSE Marking Scheme, 2016]

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

Note: All Answers are from Set I.

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

Note: All Answers are from Set I & II.

❑❑