Solved Paper 2018
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 :*

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

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}

SECTION -A

1. A proton and an electron travelling along parallel paths enter a region of uniform magnetic field, acting perpendicular to their paths. Which of them will move in a circular path with higher frequency? 1

Ans. Electron

(No explanation need to be given. If a student only writes the formula for frequency of charged particle (or $\nu_c \propto \frac{q}{m}$) award ½ mark)

[CBSE Marking Scheme, 2018] 1

2. Name the electromagnetic radiations used for (a) water purification, and (b) eye surgery. 1

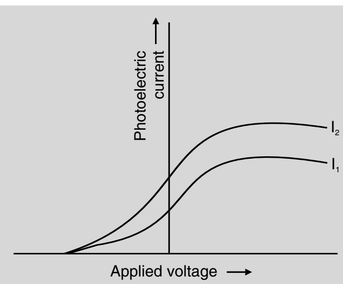
Ans. **(a)** Ultra violet rays ½

(b) Ultra violet rays / Laser ½

[CBSE Marking Scheme, 2018]

3. Draw graphs showing variation of photoelectric current with applied voltage for two incident radiations of equal frequency and different intensities. Mark the graph for the radiation of higher intensity. 1

Ans.



½

The graph I_2 corresponds to radiation of higher intensity [Note: Deduct this ½ mark if the student does not show the two graphs starting from the same point.] (Also accept if the student just puts some indicative marks, or words, (like tick, cross, higher intensity) on the graph itself. ½

[CBSE Marking Scheme, 2018]

4. Four nuclei of an element undergo fusion to form a heavier nucleus, with release of energy. Which of the two — the parent or the daughter nucleus — would have higher binding energy per nucleon? 1

Ans. Daughter nucleus 1

[CBSE Marking Scheme, 2018]

***5. Which mode of propagation is used by short wave broadcast services? 1**

SECTION -B

6. Two electric bulbs P and Q have their resistances in the ratio of 1 : 2. They are connected in series across a battery. Find the ratio of the power dissipation in these bulbs. 2

Ans. Formula ½

Stating that currents are equal ½

Ratio of powers 1

Power = I^2R ½

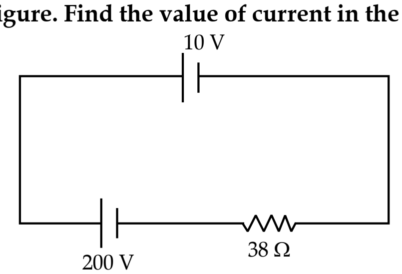
The current, in the two bulbs, is the same as they are connected in series. ½

$$\therefore \quad \frac{P_1}{P_2} = \frac{I^2R_1}{I^2R_2} = \frac{R_1}{R_2} \qquad ½$$

$$= \frac{1}{2} \qquad ½$$

[CBSE Marking Scheme, 2018]

7. A 10 V cell of negligible internal resistance is connected in parallel across a battery of emf 200 V and internal resistance 38 Ω as shown in the figure. Find the value of current in the circuit. 1



OR

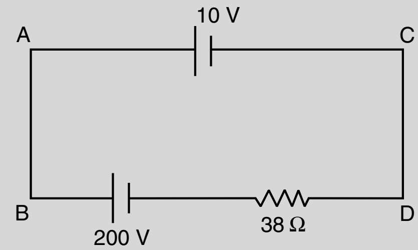
In a potentiometer arrangement for determining the emf of a cell, the balance point of the cell in open circuit is 350 cm. When a resistance of 9 Ω is used in the external circuit of the cell, the balance point shifts to 300 cm. Determine the internal resistance of the cell. 1

Ans. Writing the equation 1

Finding the current 1

By Kirchoff's law, we have, for the loop ABDC, + 200 – 38i – 10 = 0 1

$$\therefore \quad i = \frac{190}{38}A = 5A \qquad 1$$



Alternatively:

Finding the net emf 1

Stating that $I = \frac{V}{R}$ ½

Calculating I ½

The two cells being in 'opposition',

∴ net emf = 200V −10 V=190 V

$$\text{Now} \quad I = \frac{V}{R}$$

$$\therefore \quad I = \frac{190V}{38\Omega} = 5\ A$$

1

[**Note :** Some students may use the formulae

$\frac{\varepsilon}{r} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}$, and ½

$$r = \frac{(r_1r_2)}{(r_1 + r_2)} \qquad ½$$

For two cells connected in parallel

They may then say that r = 0;

ε is indeterminate and hence I is also indeterminate

[Award full marks(2) to students giving this line of reasoning.]

OR

Stating the formula 1

Calculating r 1

We have, $r = \left(\frac{l_1}{l_2} - 1\right)R = \left(\frac{l_1 - l_2}{l_2}\right)R$

$$\therefore \quad r = \left(\frac{350 - 300}{300}\right) \times 9\Omega \qquad ½$$

$$= \frac{50}{300} \times 9\ \Omega = 1.5\ \Omega \qquad ½$$

[CBSE Marking Scheme, 2018]

8. (a) Why are infra-red waves often called heat waves? Explain.

(b) What do you understand by the statement, ''Electromagnetic waves transport momentum''? 2

Ans. (a) Reason for calling IR rays as heat rays 1

(b) Explanation for transport of momentum 1

(a) Infrared rays are readily absorbed by the (water) molecules in most of the substances and hence increases their thermal motion.

* *Out of Syllabus*

(If the student just writes that "infrared ray produce heating effects", award ½ mark only) **1**

(b) Electromagnetic waves can set (and sustain) charges in motion. Hence, they are said to transport momentum.

(Also accept the following: Electromagnetic waves are known to exert 'radiation pressure'. This pressure is due to the force associated with rate of change of momentum. Hence, EM waves transport momentum) **1**

[CBSE Marking Scheme, 2018]

9. If light of wavelength 412.5 nm is incident on each of the metals given below, which ones will show photoelectric emission and why? 2

Metal	Work Function (eV)
Na	1·92
K	2·15
Ca	3·20
Mo	4·17

Ans. Calculating the energy of the incident photon 1

Identifying the metals ½

Reason ½

The energy of a photon of incident radiation is given by

$$E = \frac{hc}{\lambda} \quad ½$$

$$\therefore \quad E = \frac{6{\cdot}63\times10^{-34}\times3\times10^{8}}{(412{\cdot}5\times10^{-9})\times(1{\cdot}6\times10^{-19})}eV$$

$$= 3.01 \text{ eV} \quad ½$$

Hence, only Na and K will show photoelectric emission ½

[Note: Award this ½ mark even if the student writes the name of only one of these metals]

Reason: The energy of the incident photon is more than the work function of only these two metals. ½

[CBSE Marking Scheme, 2018]

10. A carrier wave of peak voltage 15 V is used to transmit a message signal. Find the peak voltage of the modulating signal in order to have a modulation index of 60%. 2

Ans. Formula for modulation index 1

Finding the peak value of the modulating signal 1

We have, $\mu = \frac{A_m}{A_c}$ **1**

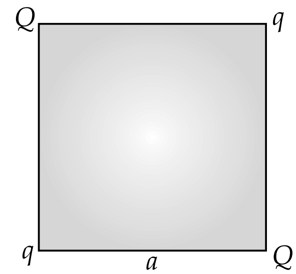
Here, $\mu = 60\% = \frac{3}{5}$ ½

$\therefore \; A_m = \mu A_c = \frac{3}{5}\times 15\,V = 9$ V ½

[CBSE Marking Scheme, 2018]

SECTION -C

11. Four point charges Q, q, Q and q are placed at the corners of a square of side 'a' as shown in the figure.



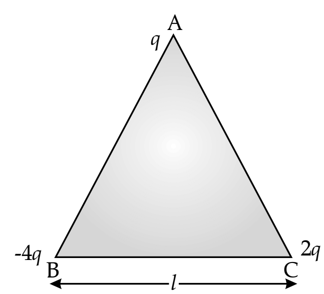
Find the

(a) resultant electric force on a charge Q and 3

(b) potential energy of this system.

OR

(a) Three point charges q, – 4q and 2q are placed at the vertices of an equilateral triangle ABC of side 'l' as shown in the figure. Obtain the expression for the magnitude of the resultant electric force acting on the charge q.



(b) Find out the amount of the work done to separate the charges at infinite distance. 3

Ans. (a) Finding the resultant force on a charge Q 2

(b) Potential Energy of the system 1

(a) Let us find the force on the charge Q at the point C

$$F_1 = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{\left(a\sqrt{2}\right)^2} = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q^2}{2a^2}\right) \text{ (along } AC) \quad ½$$

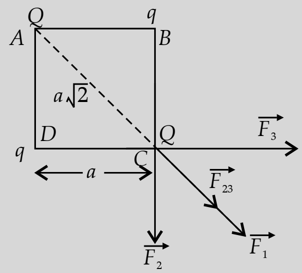
Force due to the charge q (at B),

$$F_2 = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{a^2} \text{ along } BC$$

Force due to the charge q (at D),

$$F_3 = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{a^2} \text{ along } DC \quad ½$$

Resultant of these two equal forces



Force due to the other charge Q

$$F_{23} = \frac{1}{4\pi\varepsilon_0}\frac{qQ(\sqrt{2})}{a^2} \text{ (along } AC) \quad ½$$

∴ **Net force on charge Q (at point C)**

$$\text{F} = F_1 + F_{23} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{a^2}\left[\frac{Q}{2} + \sqrt{2}q\right] \quad ½$$

This force is directed along AC

(For the charge Q, at the point A, the force will have the same magnitude but will be directed along CA)

[**Note :** Don't deduct marks if the student does not write the direction of the net force, F]

(b) Potential energy of the system

$$= \frac{1}{4\pi\varepsilon_0}\left[4\frac{qQ}{a} + \frac{q^2}{a\sqrt{2}} + \frac{Q^2}{a\sqrt{2}}\right]$$

$$= \frac{1}{4\pi\varepsilon_0 a}\left[4qQ + \frac{q^2}{\sqrt{2}} + \frac{Q^2}{\sqrt{2}}\right] \quad 1$$

OR

(a) Finding the magnitude of the resultant force on charge q **2**

(b) Finding the work done **1**

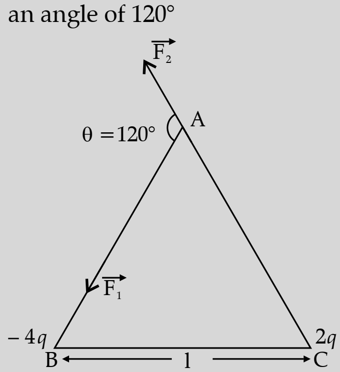
(a) Force on charge q due to the charge – 4q ½

$$F_1 = \frac{1}{4\pi\varepsilon_0}\left(\frac{4q^2}{l^2}\right), \text{ along } AB$$

Force on the charge q, due to the charge 2q

$$F_2 = \frac{1}{4\pi\varepsilon_0}\left(\frac{2q^2}{l^2}\right), \text{ along } CA$$

The forces F_1 and F_2 are inclined to each other at an angle of 120°



Hence, resultant electric force on charge q

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta} \quad ½$$

$$= \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos 120°}$$

$$= \sqrt{F_1^2 + F_2^2 - F_1F_2} \quad ½$$

$$= \left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{l^2}\right)\sqrt{16+4-8}$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{2\sqrt{3}q^2}{l^2}\right) \quad ½$$

(b) Net $P.E.$ of the system

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{l}\left[-4+2-8\right]$$

$$= \frac{(-10)}{4\pi\varepsilon_0}\frac{q^2}{l} \quad ½$$

$$\therefore \text{Work done} = \frac{10\,q^2}{4p\varepsilon_0 l} = \frac{5q^2}{2\pi\varepsilon_0 l} \quad ½$$

[CBSE Marking Scheme, 2018]

12. (a) Define the term 'conductivity' of a metallic wire. Write its SI unit.

(b) Using the concept of free electrons in a conductor, derive the expression for the conductivity of a wire in terms of number density and relaxation time. Hence obtain the relation between current density and the applied electric field E. **3**

Ans. (a) Definition and SI unit of conductivity ½ + ½

(b) Derivation of the expression for conductivity 1½

Relation between current density and electric field ½

(a) The conductivity of a material equals to the reciprocal of the resistance of its wire of unit length and unit area of cross section.

Alternatively : ½

The conductivity (s) of a material is the reciprocal of its resistivity (ρ)]

(Also accept $s = \frac{1}{\rho}$)

Its SI unit is

$$\left(\frac{1}{ohm\text{ - }metre}\right)/\,ohm^{-1}m^{-1}\,/(mho\ m^{-1})/\,\text{siemen } m^{-1}$$

½

(b) The acceleration, $\vec{a} = -\frac{e}{m}\vec{E}$

The average drift velocity, v_d, is given by

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

(τ = average time between collisions/ relaxation time)

If n is the number of free electrons per unit volume, the current I is given by ½

$$I = neA|v_d|$$

$$= \frac{e^2A}{m}\tau n|E| \quad ½$$

But $I = |j|A$ (j = current density)

We, therefore, get

$$|j| = \frac{ne^2}{m}\tau|E|,$$

The term $\frac{ne^2}{m}\tau$ is conductivity

$$\therefore \quad \sigma = \frac{ne^2\tau}{m} \quad ½$$

$$\Rightarrow \quad J = \sigma E \quad ½$$

[CBSE Marking Scheme, 2018]

13. A bar magnet of magnetic moment 6 J/T is aligned at 60° with a uniform external magnetic field of 0.44 T. Calculate (a) the work done in turning the magnet to align its magnetic moment (i) normal to the magnetic field, (ii) opposite to the magnetic field, and (b) the torque on the magnet in the final orientation in case (ii). **3**

Ans. (a) From Ampere's circuital law, we have,

$$\oint \vec{B}\vec{dl} = \mu_0\mu_r I_{enclosed} \quad ...(i) ½$$

For the field inside the ring, we can write

$$\oint \vec{B}\vec{dl} = \oint \vec{B}\vec{dl} = B.2\pi r \quad (r = \text{radius of the ring}) ½$$

Also, $I_{enclosed} = (2\pi rn)I$ using equation (i)

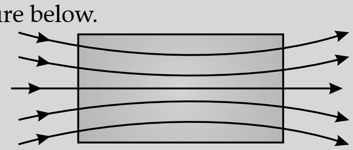
$\therefore \quad B.2\pi r = \mu_0\mu_r.(n.2\pi r)I$

$\therefore \quad B = \mu_0\mu_r nI$

[Award these $\left(\frac{1}{2}+\frac{1}{2}\right)$ marks even if the result is written without giving the derivation] ½

(b) The material is paramagnetic. ½

The field pattern gets modified as shown in the figure below. **1**



[CBSE Marking Scheme, 2018]

Ans. (a) Formula and Calculation of work done in the two cases **1+ 1**

(b) Calculation of torque in case (ii) **1**

(a) Work done = $m_B(\cos\theta_1 - \cos\theta_2)$

(i) $\theta_1 = 60°, \theta_2 = 90°$

$\therefore$ work done = $mB(\cos 60° - \cos 90°)$

$$= mB\left(\frac{1}{2}-0\right) = \frac{1}{2}mB \quad ½$$

$$= \frac{1}{2}\times 6\times 0.44\,J = 1.32\,J \quad ½$$

(ii) $\theta_1 = 60°, \theta_2 = 180°$

$\therefore$ work done = $mB(\cos 60° - \cos 180°)$ ½

$$= mB\left(\frac{1}{2}-(-1)\right) = \frac{3}{2}mB$$

$$= \frac{3}{2}\times 6\times 0{\cdot}44\,J - 3{\cdot}96\,J \quad ½$$

[Also accept calculations done through changes in potential energy.]

(b) Torque = $\left|\vec{m}\times\vec{B}\right| = mB\sin\theta$

For $\theta = 180°$, we have **1**

Torque = $6\times 0.44 \sin 180° = 0$

[If the student straight away writes that the torque is zero since magnetic moment and magnetic field are anti parallel in this orientation, award full] **1**

[CBSE Marking Scheme, 2018]

14. (a) An iron ring of relative permeability μ_r has windings of insulated copper wire of n turns per metre. When the current in the windings is I, find the expression for the magnetic field in the ring.

(b) The susceptibility of a magnetic material is 0.9853. Identify the type of magnetic material. Draw the modification of the field pattern on keeping a piece of this material in a uniform magnetic field. **3**

Ans. (a) Expression for Ampere's circuital law ½

Derivation of magnetic field inside the ring **1**

(b) Identification of the material ½

Drawing the modification of the field pattern **1**

(a) From Ampere's circuital law, we have,

$$\oint \vec{B}\vec{dl} = \mu_0\mu_r I_{enclosed} \quad ...(i) ½$$

For the field inside the ring, we can write

$$\oint \vec{B}\vec{dl} = \oint \vec{B}\vec{dl} = B.2\pi r \quad (r = \text{radius of the ring}) ½$$

Also, $I_{enclosed} = (2\pi rn)I$ using equation (i)

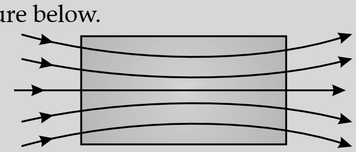
$\therefore \quad B.2\pi r = \mu_0\mu_r.(n.2\pi r)I$

$\therefore \quad B = \mu_0\mu_r nI$

[Award these $\left(\frac{1}{2}+\frac{1}{2}\right)$ marks even if the result is written without giving the derivation] ½

(b) The material is paramagnetic. ½

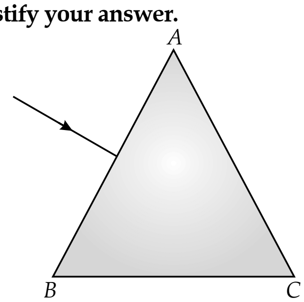
The field pattern gets modified as shown in the figure below. **1**



[CBSE Marking Scheme, 2018]

15. **(a) Show using a proper diagram how unpolarised light can be linearly polarised by reflection from a transparent glass surface.**

(b) The figure shows a ray of light falling normally on the face AB of an equilateral glass prism having refractive index $\frac{3}{2}$, placed in water of refractive index $\frac{4}{3}$. Will this ray suffer total internal reflection on striking the face AC? Justify your answer. **3**



Ans. **(a) Diagram** **½**

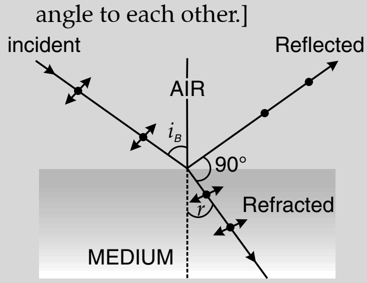
Polarisation by reflection **1**

(b) Justification **1**

Writing yes/no **½**

(a) The diagram, showing polarisation by reflection is as shown.

[Here the reflected and refracted rays are at right angle to each other.] ½



1

$$\therefore \quad r = \left(\frac{\pi}{2} - i_B\right)$$

$$\therefore \mu = \left(\frac{\sin i_B}{\sin r} = \tan i_B\right)$$

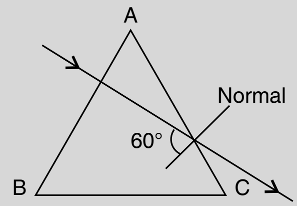
Thus light gets totally polarised by reflection when it is incident at an angle i_B (Brewster's angle), where $i_B = \tan^{-1}\mu$ **1**

(b) The angle of incidence, of the ray, on striking the face AC is $i = 60°$ (as from figure)

Also, relative refractive index of glass, with respect to the surrounding water, is ½

$$\therefore \mu_r = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{9}{8}$$

Also $\sin i = \sin 60° = \frac{\sqrt{3}}{2} = \frac{1{\cdot}732}{2} = 0.866$



½

For total internal reflection, the required critical angle, in this case, is given by

$$\sin i_c = \frac{1}{\mu} = \frac{8}{9} \simeq 0{\cdot}89$$ ½

$\therefore \qquad i < i_c$

Hence the ray would not suffer total internal reflection on striking the face AC

[The student may just write the two conditions needed for total internal reflection without analysis of the given case. The student may be awarded (½ + ½) mark in such a case.]

[CBSE Marking Scheme, 2018]

16. **(a) If one of two identical slits producing interference in Young's experiment is covered with glass, so that the light intensity passing through it is reduced to 50%, find the ratio of the maximum and minimum intensity of the fringe in the interference pattern.**

(b) What kind of fringes do you expect to observe if white light is used instead of monochromatic light? **3**

Ans. **(a) Finding the (modified) ratio of the maximum and minimum intensities** **2**

(b) Fringes obtained with white light **1**

(a) After the introduction of the glass sheet (say, on the second slit),

we have $\frac{I_2}{I_1} = 50\ \% = \frac{1}{2}$ ½

$\therefore$ Ratio of the amplitudes

$$= \frac{a_2}{a_1} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$$ ½

$$\text{Hence } \frac{I_{max}}{I_{min}} = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2$$

$$= \left(\frac{1 + \frac{1}{\sqrt{2}}}{1 - \frac{1}{\sqrt{2}}}\right)^2 = \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2$$ ½

$$(\simeq 34)$$ ½

(b) The central fringe remains white.

No clear fringe pattern is seen after a few (coloured) fringes on either side of the central fringe. **1**

[Note : For part (a) of this question,

The student may

(i) Just draw the diagram for the Young's double slit experiment.

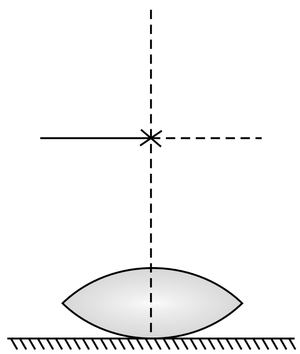
Or

(ii) Just state that the introduction of the glass sheet would introduce an additional phase difference and the position of the central fringe would shift.

For all such answers, the student may be awarded the full (2) marks for this part of this question.

[CBSE Marking Scheme, 2018]

17. A symmetric biconvex lens of radius of curvature *R* and made of glass of refractive index 1.5, is placed on a layer of liquid placed on top of a plane mirror as shown in the figure. An optical needle with its tip on the principal axis of the lens is moved along the axis until its real, inverted image coincides with the needle itself. The distance of the needle from the lens is measured to be *x*. On removing the liquid layer and repeating the experiment, the distance is found to be *y*. Obtain the expression for the refractive index of the liquid in terms of *x* and *y*. 3



Ans. Lens maker's formula ½

Formula for 'combination of lenses' ½

Obtaining the expression for μ **2**

(a) Let μ_1 denote the refractive index of the liquid. When the image of the needle coincides with the lens itself ; its distance from the lens, equals the relevant focal length. ½

With liquid layer present, the given set up, is equivalent to a combination of the given (convex) lens and a concavo plane / plano concave 'liquid lens'.

We have $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ½

and $\frac{1}{f} = \left(\frac{1}{f_1} + \frac{1}{f_2}\right)$ ½

as per the given data, we then have

$$\frac{1}{f_2} = \frac{1}{y} = (1{\cdot}5 - 1)\left(\frac{1}{R} - \frac{1}{(-R)}\right) \quad ½$$

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

$$\therefore \quad \frac{1}{x} = (\mu_l - 1)\left(-\frac{1}{R}\right) + \frac{1}{y} = \frac{-\mu_l}{y} + \frac{2}{y} \quad ½$$

$$\therefore \quad \frac{\propto_l}{y} = \frac{2}{y} - \frac{1}{x} = \left(\frac{2x - y}{xy}\right)$$

$$\text{or} \quad \mu_l = \left(\frac{2x - y}{x}\right) \quad ½$$

[CBSE Marking Scheme, 2018]

18. (a) State Bohr's postulate to define stable orbits in hydrogen atom. How does de Broglie's hypothesis explain the stability of these orbits?

(b) A hydrogen atom initially in the ground state absorbs a photon which excites it to the *n* = 4 level. Estimate the frequency of the photon. 3

Ans. (a) Statement of Bohr's postulate **1**

Explanation in terms of de Broglie hypothesis ½

(b) Finding the energy in the n = 4 level **1**

Estimating the frequency of the photon ½

(a) Bohr's postulate, for stable orbits, states

"The electron, in an atom, revolves around the nucleus only in those orbits for which its angular momentum is an integral multiple of $\frac{h}{2\neq}$ (h = Planck's constant)." ½

[Also accept $mvr = n.\frac{h}{2\neq}$ (n =1,2,3,…….)]

As per de Broglie's hypothesis $\lambda = \frac{h}{p} = \frac{h}{mv}$

For a stable orbit, we must have circumference of the orbit = $n\lambda$ (n =1,2,3,…….)

$\therefore \quad 2\pi r = n.mv$

or $\quad mvr = \frac{nh}{2\neq}$ ½

Thus de –Broglie showed that formation of stationary pattern for integral 'n' gives rise to stability of the atom.

This is nothing but the Bohr's postulate. ½

(b) Energy in the n = 4 level = $\frac{-E_0}{4^2} = -\frac{E_0}{16}$ ½

$\therefore$ Energy required to take the electron from the ground state, to the n = 4 level

$$= \left(-\frac{E_0}{16}\right) - (-E_0)$$

$$= \frac{-1 + 16}{16}E_0 = \frac{15}{16}E_0$$

$$= \frac{15}{16} \times 13.6 \times 1.6 \times 10^{-19}\, J \quad ½$$

Let the frequency of the photon be ν, we have

$$h\nu = \frac{15}{16} \times 13.6 \times 1.6 \times 10^{-19}$$

$$\therefore \nu = \frac{15\times13.6\times1.6\times10^{-19}}{16\times6.63\times10^{-34}} Hz$$ ½

$$\simeq 3.1\times10^{15} \textbf{ Hz}$$

(Also accept 3×10^{15} Hz)

[CBSE Marking Scheme, 2018]

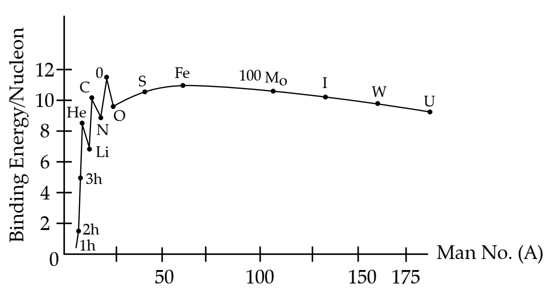
19. (a) Explain the processes of nuclear fission and nuclear fusion by using the plot of binding energy per nucleon (*BE/A*) versus the mass number *A*.

(b) A radioactive isotope has a half-life of 10 years. How long will it take for the activity to reduce to 3.125%? 3

Ans. (a) Plot of binding energy per nucleon is shown in Figure. From BE/nucleon curve, we note that first B.E. increases rapidly and then decreases slowly and B.E is max i.e. 8.8 Mev for ^{56}Fe atom. Again by decreasing slowly B.E. become 8.5 Mev for uranium atom $^{238}_{92}U$. This shows that nucleus with mass number $A < 20$ are less stable, but some nucleus as ^{4}He, ^{12}C, ^{16}O (even–even) nuclei are stable. Thus the nuclei with mass number $A < 20$ shows fusion reaction as ^{2}H and ^{3}H have very low BE/nucleon in comparison to ^{4}He. Thus when two very light nuclei ($A \le 10$ say) fuse to form a heavy nucleus, the B.E/A of fused heavier nucleus is more than the B.E/A of lighter nuclei. This implies release of energy in nuclear fusion.

Similarly, due to fission of a very heavy nucleus, the B.E/A of the product as daughter nuclei increases which implies the release of huge amount of energy.

Thus for lighter nuclei nuclear fusion and for heavier nuclei nuclear fission takes place and huge amount of energy is released. ½+½



1

(b) Let the initial activity is R_0 and final activity is R then we have

$$\frac{R}{R_0} = \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

Given $R = 3.125\%$,

$$R = \frac{3.125}{100} R_o,\quad T_{\frac{1}{2}} = 10 \text{ years.}$$ 1

$$R = 0.03125\, R_0$$

$$\Rightarrow \frac{R}{R_0} = 0.03125 = \left(\frac{1}{2}\right)^5$$

$$\Rightarrow \left(\frac{1}{2}\right)^5 = \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

$$\Rightarrow \frac{t}{T_{\frac{1}{2}}} = 5 \quad \text{or} \quad t = 5T_{\frac{1}{2}}$$

$$t = 5\times10$$

$$\boxed{t = 50 \text{ years}}$$

20. (a) A student wants to use two *p-n* junction diodes to convert alternating current into direct current. Draw the labelled circuit diagram she would use and explain how it works.

(b) Give the truth table and circuit symbol for NAND gate. 3

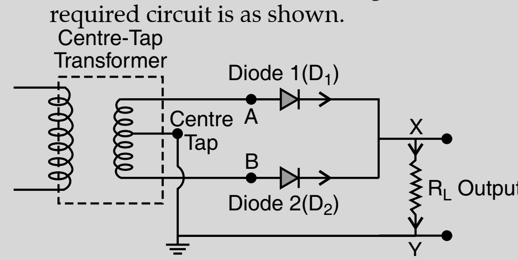
Ans. (a) Drawing the labelled circuit diagram 1

Explanation of working 1

(b) Circuit Symbol and ½ + ½

Truth table of NAND gate

(a) The labelled circuit diagram, for the required circuit is as shown. 1

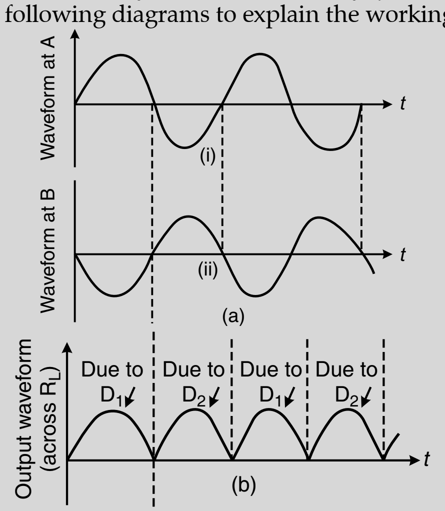


The working of this circuit is as follows:

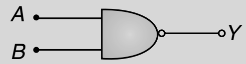
(i) During one half cycle(of the input ac) diode D_1 alone gets forward biased and conducts. During the other half cycle, it is diode D_2 (alone) that conducts. ½

Hence we get a unidirectional/direct current through the load, when the input is alternating current. ½

[Alternatively: The student may just use the following diagrams to explain the working.]



(b) The circuit symbol, and the truth table, for the NAND gate, are given below. ½+½



Input		Output
A	*B*	*Y*
0	0	1
0	1	1
1	0	1
1	1	0

[CBSE Marking Scheme, 2018]

21. Draw the typical input and output characteristics of an *n-p-n* transistor in CE configuration. Show how these characteristics can be used to determine (a) the input resistance (η), and (b) current amplification factor (β). 3

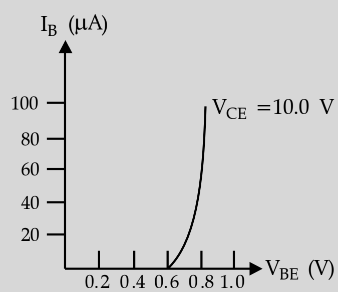
Ans. Input and Output characteristics 1+1

Determination of

(a) Input resistance ½

(b) Current amplification factor ½

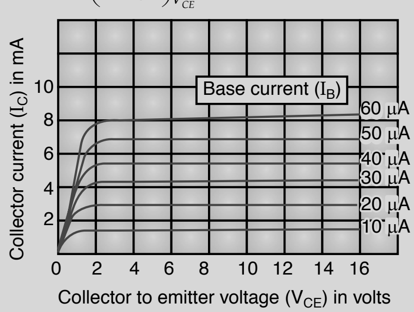
The input and output characteristics, of a *n-p-n* transistor, in its CE configuration, are as shown. **1**



(a) Typical input characteristics

Input resistance **1**

$$r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$$ ½



(b) Typical output characteristics **1**

The relevant values can be read from the input characteristics.

(b) Current amplification factor

$$\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)$$

The relevant values can be read from the output characteristics, corresponding to a given value of V_{CE}. ½

[CBSE Marking Scheme, 2018]

***22. (a) Give three reasons why modulation of a message signal is necessary for long distance transmission.**

(b) Show graphically an audio signal, a carrier wave and an amplitude modulated wave. 3

SECTION -D

23. The teachers of Geeta's school took the students on a study trip to a power generating station, located nearly 200 km away from the city. The teacher explained that electrical energy is transmitted over such a long distance to their city, in the form of alternating current (ac) raised to a high voltage. At the receiving end in the city, the voltage is reduced to operate the devices. As a result, the power loss is reduced. Geeta listened to the teacher and asked questions about how the ac is converted to a higher or lower voltage.

(a) Name the device used to change the alternating voltage to a higher or lower value. State one cause for power dissipation in this device.

(b) Explain with an example, how power loss is reduced if the energy is transmitted over long distances as an alternating current rather than a direct current.

(c) Write two values each shown by the teachers and Geeta. 4

Ans. (a) Name of device ½

One cause for power dissipation ½

(b) Reduction of power loss in long distance transmission 1

(c) Two values each displayed by teacher and Geeta (½ × 4=2)

(a) Transformer ½

Cause of power dissipation

(i) Joule heating in the windings.

(ii) Leakage of magnetic flux between the coils.

(iii) Production of eddy currents in the core.

(iv) Energy loss due to hysteresis.

[Any one / any other correct reason of power loss] ½

(b) ac voltage can be stepped up to high value, which reduces the current in the line during transmission, hence the power loss (I^2R) is reduced considerably while such stepping up is not possible for direct current. **1**

* *Out of Syllabus*

[Also accept if the student explains this through a relevant example.]

(c) Teacher: Concerned, caring, ready to share knowledge . ½+½

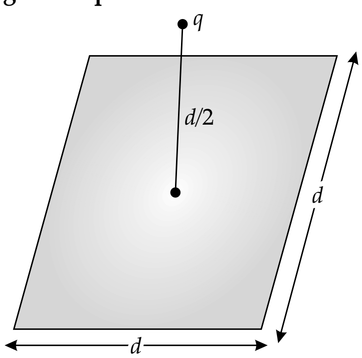
Geeta: Inquisitive, scientific temper, good listener, keen learner (any other two values for the teacher and Geeta) ½+½

[CBSE Marking Scheme, 2018]

SECTION - E

24. (a) Define electric flux. Is it a scalar or a vector quantity? 3

A point charge q is at a distance of $d/2$ directly above the centre of a square of side d, as shown in the figure. Use Gauss' law to obtain the expression for the electric flux through the square.



(b) If the point charge is now moved to a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux will be affected. 2

OR

(a) Use Gauss' law to derive the expression for the electric field $(\vec{E})$ due to a straight uniformly charged infinite line of charge density λ C/m.

(b) Draw a graph to show the variation of E with perpendicular distance r from line of charge.

(c) Find the work done in bringing a charge q from perpendicular distance r_1 to r_2 $(r_2 > r_1)$. 5

Ans. (a) Definition of electric flux 1

Stating scalar/ vector ½

Gauss's Theorem ½

Derivation of the expression for electric flux 1

(b) Explanation of change in electric flux 2

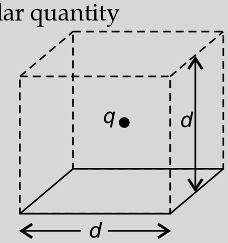
(a) Electric flux through a given surface is defined as the dot product of electric field and area vector over that surface. 1

Alternatively $\phi = \oiint_S \vec{E}.\vec{dS}$

Also accept

Electric flux, through a surface equals the surface integral of the electric field over that surface.

It is a scalar quantity ½



Constructing a cube of side 'd' so that charge 'q' gets placed within of this cube (Gaussian surface)

According to Gauss's law the Electric flux

$$\phi = \frac{\text{Charge enclosed}}{\varepsilon_0}$$

$$= \frac{q}{\varepsilon_0}$$ **1½**

This is the total flux through all the six faces of the cube.

Hence electric flux through the square

$$\frac{1}{6} \times \frac{q}{\varepsilon_0} = \frac{q}{6\varepsilon_0}$$

(b) If the charge is moved to a distance d and the side of the square is doubled the cube will be constructed to have a side $2d$ but the total charge enclosed in it will remain the same. Hence the total flux through the cube and therefore the flux through the square will remain the same as before.

[Deduct 1 mark if the student just writes No change /not affected without giving any explanation.] **1+1**

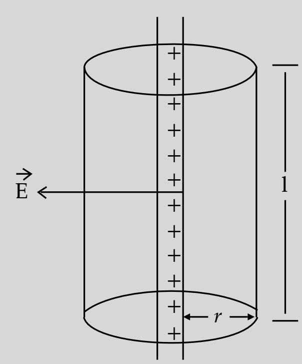
OR

(a) Derivation of the expression for electric field $\vec{E}$ 3

(b) Graph to show the required variation of the electric field 1

(c) Calculation of work done 1

(a)



½

To calculate the electric field, imagine a cylindrical Gaussian surface, since the field is everywhere radial, flux through two ends of the cylindrical Gaussian surface is zero. ½

At cylindrical part of the surface electric field $\vec{E}$ is normal to the surface at every point and its magnitude is constant. Therefore flux through the Gaussian surface.

= Flux through the curved cylindrical part of the surface.

$= E \times 2\pi rl$ ...(i) ½

Applying Gauss's Law

$$\text{Flux } \phi = \frac{q_{enclosed}}{\varepsilon_0}$$

Total charge enclosed = Linear charge density × l

$= \lambda l$

$$\phi = \frac{\lambda L}{\varepsilon_0} \quad \text{....(ii) ½}$$

Using Equations (i) & (ii)

$$E \times 2\pi rl = \frac{\lambda l}{\varepsilon_0}$$

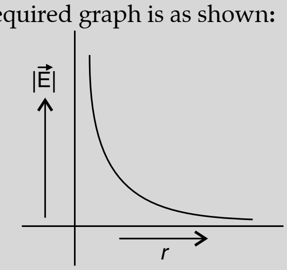
$$\therefore \quad E = \frac{\lambda}{2\pi\varepsilon_0 r} \quad \text{½}$$

In vector notation

$$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{n} \quad \text{½}$$

(where $\hat{n}$ is a unit vector normal to the line charge)

(b) The required graph is as shown: **1**



(c) Work done in moving the charge 'q' through a small displacement 'dr'

$$dW = \vec{F}.\vec{dr}$$

$$dW = q\vec{E}.\vec{dr}$$

$$= qEdr\cos 0°$$

$$dW = q \times \frac{\lambda}{2\pi\varepsilon_0 r}dr \quad \text{½}$$

Work done in moving the given charge from r_1 to r_2 $(r_2 > r_1)$

$$W = \int_{r_1}^{r_2} dW = \int_{r_1}^{r_2} \frac{\lambda q dr}{2\pi\varepsilon_0 r}$$

$$W = \frac{\lambda q}{2\pi\varepsilon_0}[\log_e r_2 - \log_e r_1] \quad \text{½}$$

$$W = \frac{\lambda q}{2\pi\varepsilon_0}\left[\log_e \frac{r_2}{r_1}\right]$$

[CBSE Marking Scheme, 2018]

25. (a) State the principle of an ac generator and explain its working with the help of a labelled diagram. Obtain the expression for the emf induced in a coil having N turns each of cross-sectional area *A*, rotating with a constant angular speed 'ω' in a magnetic field $\vec{B}$, directed perpendicular to the axis of rotation.

(b) An aeroplane is flying horizontally from west to east with a velocity of 900 km/hour. Calculate the potential difference developed between the ends of its wings having a span of 20 m. The horizontal component of the Earth's magnetic field is 5×10^{-4} T and the angle of dip is 30°. 5

OR

A device X is connected across an ac source of voltage $V = V_0 \sin \omega t$. The current through X is given as $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$.

(a) Identify the device X and write the expression for its reactance.

(b) Draw graphs showing variation of voltage and current with time over one cycle of ac, for X.

(c) How does the reactance of the device X vary with frequency of the ac? Show this variation graphically.

(d) Draw the phasor diagram for the device X. 5

Ans. (a) Principle of ac generator ½

working ½

Mark labelled diagram **1**

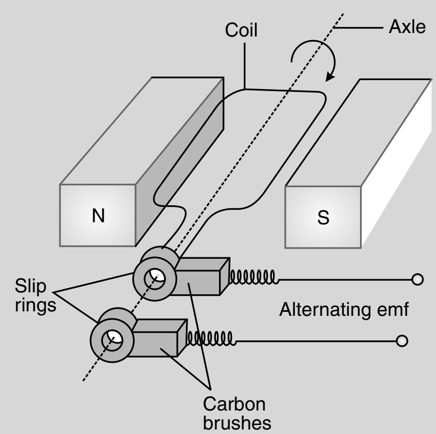
Derivation of the expression for induced emf **1½**

(b) Calculation of potential difference **1½**

(a) The AC Generator works on the principle of electromagnetic induction.

When the magnetic flux through a coil changes, an emf is induced in it. ½

As the coil rotates in magnetic field the effective area of the loop, (*i.e.* $A\cos\theta$) exposed to the magnetic field keeps on changing, hence magnetic flux changes and an emf is induced.½



When a coil is rotated with a constant angular speed 'ω ', the angle 'θ' between the magnetic field vector $\vec{B}$ and the area vector $\vec{A}$, of the coil at any instant '*t*' equals ω*t*; (assuming θ = 0° at *t* = 0) As a result, the effective area of the coil exposed to the magnetic field changes with time ; The flux at any instant '*t*' is given by ½

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

$\therefore$ The induced emf $e = -N \frac{d\phi}{dt}$ ½

$$= -NBA \frac{d\phi}{dt}(\cos \omega t)$$

$$e = NBA\omega \sin \omega t$$ ½

(b) Potential difference developed between the ends of the wings '*e*' = *Blv* ½

Given Velocity *v* = 900km/hour

= 250 m/s

Wing span (*l*) = 20 m

Vertical component of Earth's magnetic field

$B_v = B_H \tan \delta$

$= 5\times10^{-4}$ (tan 30°) Tesla ½

$\therefore$ Potential difference

$= 5\times10^{-4}$ (tan 30°) × 20 × 250

$$= \frac{5\times20\times250\times10^{-4}}{\sqrt{3}}$$

= 1.44 volt ½

OR

(a) Identification of the device X ½

Expression for reactance ½

(b) Graphs of voltage and current with time **1+1**

(c) Variation of reactance with frequency ½

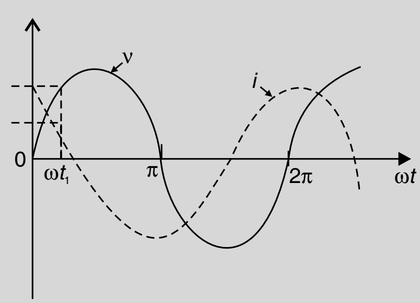
(Graphical variation) ½

(d) Phasor Diagram **1**

(a) **X :** capacitor ½

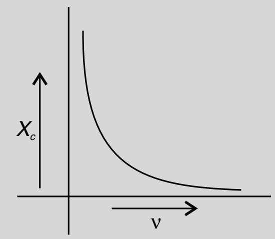
Reactance $X_c = \frac{1}{\omega C} = \frac{1}{2\pi\nu C}$ ½

(b)

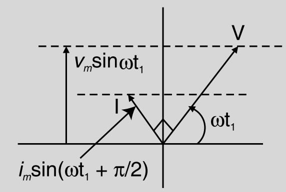


½+½

(c) Reactance of the capacitor varies in inverse proportion to the frequency *i.e.* , $X_c \propto \frac{1}{\nu}$ **1**



1



1

[CBSE Marking Scheme, 2018]

26. (a) Draw a ray diagram to show image formation when the concave mirror produces a real, inverted and magnified image of the object.

(b) Obtain the mirror formula and write the expression for the linear magnification.

(c) Explain two advantages of a reflecting telescope over a refracting telescope. 5

OR

(a) Define a wavefront. Using Huygens' principle, verify the laws of reflection at a plane surface.

(b) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band? Explain.

(c) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the obstacle. Explain why. 5

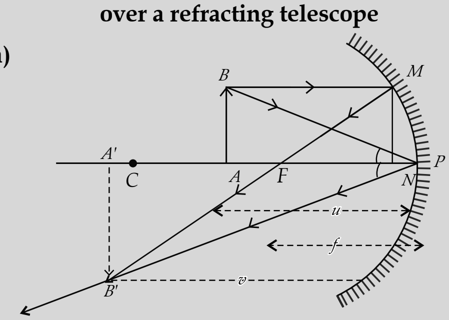
Ans. (a) Ray diagram to show the required image formation 1

(b) Derivation of mirror formula 2 ½

Expression for linear magnification ½

(c) Two advantages of a reflecting telescope over a refracting telescope ½+½

(a)



(b) In the above figure, Δ BAP and ΔB'A'P are similar

$$\Rightarrow \quad \frac{BA}{B'A'} = \frac{PA}{PA'}$$ ...(i) ½

Similarly, Δ MNF and ΔB'A'F are similar

$$\Rightarrow \quad \frac{MN}{B'A'} = \frac{NF}{FA'} \quad ...(ii)$$

As MN = BA

NF ≈ PF

FA' = PA' – PF ½

∴ equation (ii) takes the following form

$$\frac{BA}{B'A'} = \frac{PF}{PA' - PF} \quad ...(iii)$$ ½

Using equation (i) and (iii)

$$\frac{PA}{PA'} = \frac{PF}{PA' - PF}$$ ½

For the given figure, as per the sign convention, PA = – u

PA' = – ν

PF = – f

$$\Rightarrow \quad \frac{-u}{-v} = \frac{-f}{-v-(-f)}$$ ½

$$\frac{u}{v} = \frac{f}{v-f}$$

$uv - uf = vf$

Dividing each term by uvf, we get

$$\frac{1}{f} - \frac{1}{v} = \frac{1}{u}$$

$$\Rightarrow \quad \frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$ ½

Linear magnification = $-\frac{-v}{\mu}$, (alternatively m $= \frac{h_i}{h_o}$) ½

(c) Advantages of reflecting telescope over refracting telescope

(i) Mechanical support is easier. ½+½

(ii) Magnifying power is large.

(iii) Resolving power is large.

(iv) Spherical aberration is reduced.

(v) Free from chromatic aberration.

(Any two)

OR

(a) Definition of wave front ½

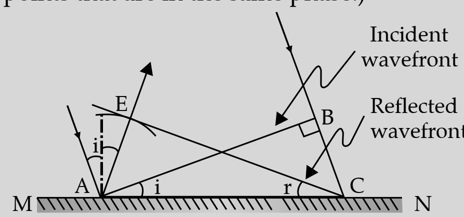
Verification of laws of reflection **2**

(b) Explanation of the effect on the size and intensity of central maxima **1+ 1**

(c) Explanation of the bright spot in the shadow of the obstacle ½

(a) The wave front may be defined as a surface of constant phase. ½

(Alternatively: The wave front is the loci of all points that are in the same phase.)



1

Let the speed of the wave in the medium be 'v'

Let the time taken by the wave front, to advance from point B to point ½

C is τ

Hence BC = $v\tau$

Let CE represent the reflected wave front

Distance AE = $v\tau = BC$

Δ AEC and Δ ABC are congruent

$BAC = \angle ECA$ ½

$\Rightarrow \quad \angle i = \angle r$ ½

(b) Size of central maxima reduces to half, ½

(∴ Size of central maxima = $2\frac{2\lambda D}{\alpha}$)

Intensity increases. ½

This is because the amount of light, entering the slit, has increased and the area, over which it falls, decreases. ½

(Also accept if the student just writes that the intensity becomes four fold.)

(c) This is because of diffraction of light.

[**Alternatively:** Light gets diffracted by the tiny circular obstacle and reaches the centre of the shadow of the obstacle.] ½

[**Alternatively:** There is a maxima, at the centre of the obstacle, in the diffraction pattern produced by it.]

[CBSE Marking Scheme, 2018]

❑❑