SOLVED PAPER	C.B.S.E. 2018 Class–XII	PHYSICS (Theory)

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

General Instructions :

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

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

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

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

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

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

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

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

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

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

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

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

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

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

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

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**

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

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**

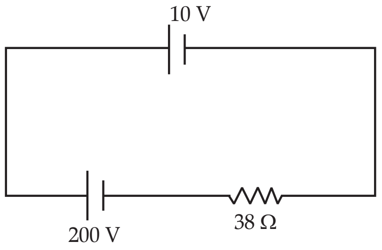
4. Four nuclei of an element undergo fusion to form a heavier nucleus, with release of energy. Which of the two — the parent or the daughter nucleus — would have higher binding energy per nucleon ? **1**

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**

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. **2**



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. **2**

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**

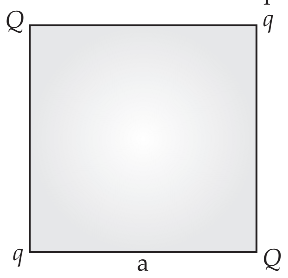
9. If light of wavelength 412·5 nm is incident on each of the metals given below, which ones will show photoelectric emission and why ? **2**

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

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**

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.



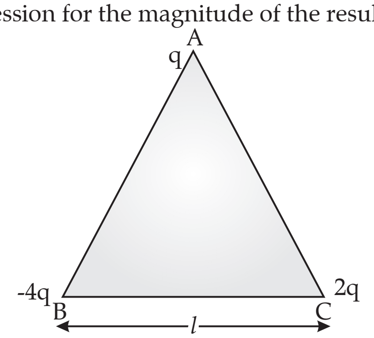
Find the

(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**

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**

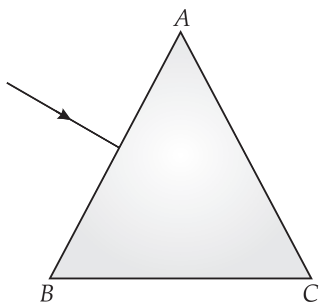
13. A bar magnet of magnetic moment 6 J/T is aligned at 60° with a uniform external magnetic field of 0·44 T. Calculate **(a)** the work done in turning the magnet to align its magnetic moment (i) normal to the magnetic field, (ii) opposite to the magnetic field, and **(b)** the torque on the magnet in the final orientation in case (ii). **3**

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**

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

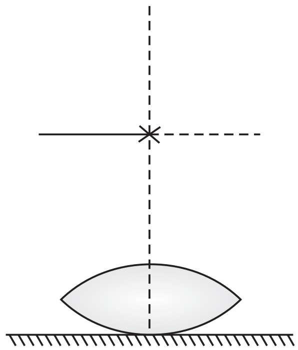
(b) The figure shows a ray of light falling normally on the face AB of an equilateral glass prism having refractive index $\frac{3}{2}$, placed in water of refractive index $\frac{4}{3}$. Will this ray suffer total internal reflection on striking the face AC ? Justify your answer. **3**



16. **(b)** 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**

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**



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**

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**

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**

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 (r_i), and (b) current amplification factor (β).

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.

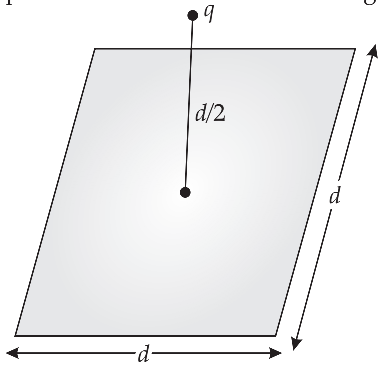
(b) Explain with an example, how power loss is reduced if the energy is transmitted over long distances as an alternating current rather than a direct current.

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

SECTION - E

24. **(a)** Define electric flux. Is it a scalar or a vector quantity ? **5**

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.

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**

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**

26. **(a)** Draw a ray diagram to show image formation when the concave mirror produces a real, inverted and magnified image of the object. **5**

(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.

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**

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CBSE MARKING SCHEME 2018

(Issued by Board)

SECTION - A

1. 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) **1**

[CBSE Marking Scheme, 2018]

Detailed Answer :

Electron move in circular path with higher frequency.

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

$$\omega = \frac{v}{r} = \frac{qB}{m}$$

$$\omega = 2\pi f \Rightarrow \frac{qB}{m} = 2\pi f \Rightarrow f \propto \frac{1}{m}$$ ½

Since $m_e < m_p$, therefore $f_e > f_p$ ½

Thus, electron move in circular path with higher frequency.

2. (a) Ultra violet rays ½

(b) Ultra violet rays / Laser ½

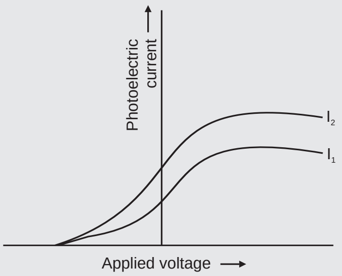
[CBSE Marking Scheme, 2018]

Detailed Answer :

(a) For water purification Ultraviolet Radiation (UV) is used.

(b) For eye surgery Infra-red Radiation is used.

3.



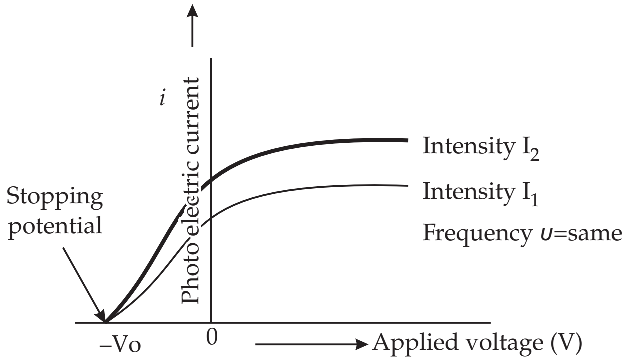
½

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]

Detailed Answer :

The graph between photo electric current i and applied voltage V of equal frequency and different intensity I_1 and I_2, where $I_2 > I_1$, dark line shows higher intensity. ½



½

4. Daughter nucleus **1**

[CBSE Marking Scheme, 2018]

Detailed Answer :

Daughter nucleus have higher binding energy per nucleon.

→ The mass of heavier nucleus (daughter) is less than the sum of masses of combining nuclei. ½

→ So mass defect is more in daughter nuclei, so binding energy per nucleon is more. ½

5. Sky wave propagation **1**

[CBSE Marking Scheme, 2018]

Detailed Answer :

Sky wave propagation is used by short wave broadcast services, i.e. freq = 1710 KHz – 30 MHz for short wave.

SECTION - B

6. Formula ½

Stating that currents are equal ½

Ratio of powers **1**

$$\text{Power} = I^2R \quad ½$$

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

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

$$= \frac{1}{2} \quad ½$$

[CBSE Marking Scheme, 2018]

Detailed Answer :

6. Since in series combination of resistance, the current flowing is same but voltage is different, therefore power dissipation is given by $P = I^2R \Rightarrow P \propto R \Rightarrow \frac{P_1}{P_2} = \frac{R_1}{R_2}$

Now for two Bulbs P and Q, we have $\frac{P_1}{P_2} = \frac{R_1}{R_2} = \frac{1}{2}$ (Since $R_1 : R_2 = 1 : 2$ given).

$\Rightarrow$ Ratio of Power $P_1 : P_2 = 1 : 2$

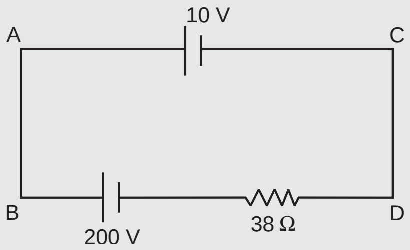
7. Writing the equation **1**

Finding the current **1**

By Kirchoff's law, we have, for the loop $ABCD$,

$$+ 200 - 38i - 10 = 0 \quad \mathbf{1}$$

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



Alternatively :

Finding the Net emf **1**

Stating that $I = \frac{V}{R}$ ½

Calculating I ½

The two cells being in 'opposition',

$$\therefore \text{ net } emf = 200 - 10 \text{ V} = 190 \text{ V}$$

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

$$\therefore \; I = \frac{190\,V}{38\,\Omega} = 5\,A$$ **1**

[**Note :** Some students may use the formulae $\frac{\varepsilon}{r} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}$, and ½

½

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

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

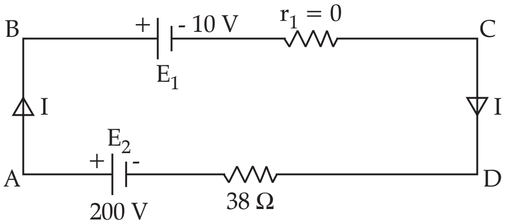
$\therefore$ $$r = \left(\frac{350 - 300}{300}\right) \times 9\Omega$$ ½

$$= \frac{50}{300} \times 9\ \Omega = 1{\cdot}5\ \Omega$$ ½

[CBSE Marking Scheme, 2018]

Detailed Answer :

For given circuit, the equivalent voltage is



Applying KVL to loop ABCDA

$$-10 - 38I + 200 = 0$$

$$38I = 190$$

$$I = \frac{190}{38} = 5A$$

OR

Case I – In open circuit, let balance is $l_1 \Rightarrow V_1 = kl_1$

Case II – when resistance R is used, balance length is $l_2 \Rightarrow V_2 = kl_2$
Now, we know that if r is internal resistance of cell then

$$r = \left(\frac{V_1}{V_2} - 1\right)R = \left(\frac{kl_1}{kl_2} - 1\right)R = \left(\frac{l_1}{l_2} - 1\right)R$$

given $l_1 = 350$ cm , $l_2 = 300$ cm , $R = 9\Omega$ then internal resistance of cell $r = \left(\frac{350}{300} - 1\right) \times 9 = \frac{3}{2} = 1.5\Omega$

$$\Rightarrow r = 1.5\,\Omega$$

8. **(a) Reason for calling IF 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.
(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]

Detailed Answer :

(a) Infra-red waves have ability to vibrate the electrons and whole atom on molecules of a body. This vibration increases the internal energy and temperature of the body.

(b) Electromagnetic waves transport momentum because E.M. waves exerts radiation pressure(P), which is given by $P = \frac{F}{A} = \frac{\Delta p}{A\Delta t}$

where, momentum of E.M. wave is, $p = \frac{\text{energy of wave}}{\text{speed of wave}} = \frac{U}{c}$

8. **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

$$E = \frac{hc}{\lambda}$$ ½

$$\therefore \quad E = \frac{6{\cdot}63 \times 10^{-34} \times 3 \times 10^8}{(412{\cdot}5 \times 10^{-9}) \times (1{\cdot}6 \times 10^{-19})} eV$$

$$= 3{\cdot}01\ eV$$ 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]

Detailed Answer :

9. Given $\lambda = 412.5$ nm $= 412.5 \times 10^{-9}$ m
$\therefore$ Energy of light is given by

$$E_\lambda = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{412.5 \times 10^{-9}} \text{ Joule} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{412.5 \times 10^{-9} \times 1.6 \times 10^{-19}} eV$$

$$E_\lambda = 3.012 \text{ eV} \approx 3.01 \text{ eV}$$

Now for photo electric emission, we should have energy of incident light higher than the work function of metal. Since work function of Na and K is less than E_λ, so these metals Na and K shows photo electric emission.
But for Ca and Mo, work function is more than E_λ, so these metals Ca and Mo, do not show photo electric emission.

Thus, for photo electric emission to take place, we should have $\boxed{E_\lambda > W_K}$

10. 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

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

[CBSE Marking Scheme, 2018]

Detailed Answer :

We know that modulation index μ is given by

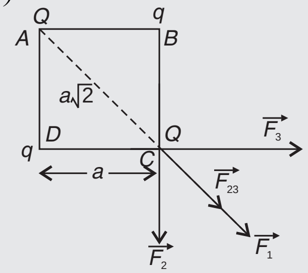
where $A_m \rightarrow$ Peak voltage of modulating signal.
$A_C \rightarrow$ Peak voltage of carrier wave.

$$A_m = \mu \times A_C$$
$$= \frac{60}{100} \times 15 = 9\ V \Rightarrow \boxed{A_m = 9\ V}$$

11. (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
Force due to the other charge Q

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



Force due to the charge q (at B), $F_2 = \frac{1}{4\pi\varepsilon_0} \frac{qQ}{a^2}$ along BC

Force due to the charge q (at D), $F_3 = \frac{1}{4\pi\varepsilon_0} \frac{qQ}{a^2}$ along DC ½

Resultant of these two equal forces

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

$\therefore$ Net force on charge Q (at point C) $\quad F = F_1 + F_{23} = \frac{1}{4\pi\varepsilon_0} \frac{Q}{a^2}\left[\frac{Q}{2} + \sqrt{2}q\right]$ ½

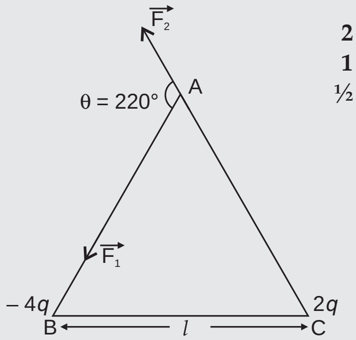
This force is directed along AC
(For the charge Q, at the point A, the force will have the same magnitude but will be directed along CA)
[**Note :** Don't deduct marks if the student does not write the direction of the net force , F]

(b) Potential energy of the system $= \frac{1}{4\pi\varepsilon_0}\left[4\frac{pQ}{a} + \frac{q^2}{a\sqrt{2}} + \frac{Q^2}{a\sqrt{2}}\right] = \frac{1}{4\pi\varepsilon_0 a}\left[4pQ + \frac{q^2}{\sqrt{2}} + \frac{Q^2}{\sqrt{2}}\right]$ **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 $\quad F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$ ½

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

$$= \sqrt{F_1^2 + F_2^2 - F_1F_2}$$ ½

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

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

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

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

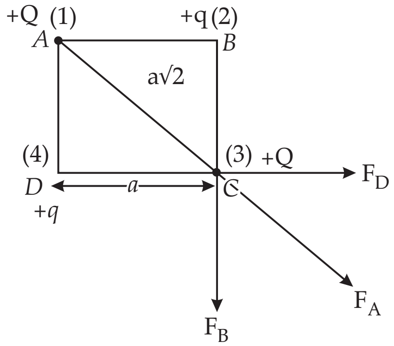
$$= \frac{(-10)}{4\pi\varepsilon_0}\frac{q^2}{l}$$ ½

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

[CBSE Marking Scheme, 2018]

Detailed Answer :

11. (a) The resultant force on charge + Q placed at corner C of a square ABCD of side a is given by–



$$\vec{F}_{eq} = \vec{F}_B + \vec{F}_D + \vec{F}_A = \vec{F} + \vec{F}_A$$

where $|\vec{F}| = \sqrt{F_B^2 + F_D^2 + 2F_B\cdot F_D\cdot\cos 90}$ $\quad$ ($\because$ $\vec{F}_B$ & $\vec{F}_D$ are perpendicular to each other)

$= \sqrt{F_B^2 + F_D^2} = F_B\sqrt{2}$ $\quad$ $\left(\because F_B = F_D = \dfrac{kqQ}{a^2}\right)$

$$\Rightarrow F = \sqrt{2}\cdot\frac{kqQ}{a^2}$$

$$\Rightarrow \quad |F_A| = \frac{kQ^2}{(a\sqrt{2})^2} \quad (\because AC = \sqrt{AD^2 + DC^2} = \sqrt{2a^2} = a\sqrt{2})$$

again $F_A = \dfrac{kQ^2}{2a^2}$

$$\Rightarrow F_{eq} \text{ at C on } Q = \sqrt{2}\cdot\frac{kqQ}{a^2} + \frac{kQ^2}{2a^2}$$

$$\boxed{F_{eq} \text{ at C} = \frac{kQ}{a^2}\left(q\sqrt{2} + \frac{Q}{2}\right)}, \text{where } k = \frac{1}{4\pi\epsilon_0}.$$ 2

(b) The potential energy of system of n charges is

$$U = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\left[\sum_{j(j>i)}^{n}\frac{q_iq_j}{r_{ij}}\right]$$

Therefore for four (04) charges system we have–

$$U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_1q_4}{r_{14}} + \frac{q_2q_3}{r_{23}} + \frac{q_2q_4}{r_{24}} + \frac{q_3q_4}{r_{34}}\right]$$

For the given system of charges we have

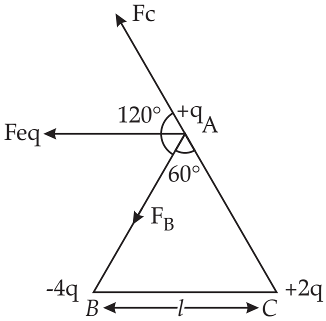
$$U = \frac{1}{4\pi\varepsilon_0}\left[\frac{Qq}{a} + \frac{Q^2}{a\sqrt{2}} + \frac{Qq}{a} + \frac{qQ}{a} + \frac{q^2}{a\sqrt{2}} + \frac{Qq}{a}\right]$$

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

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

OR

(a) The resultant force on charge q at A is



$$F_q \aleph \sqrt{F_C^2 \quad F_B^2 \quad 2F_BF_C\cos\theta}$$

Now,

$$\left|\overline{F_c}\right| = \frac{k\cdot q\cdot 2q}{l^2} = \frac{2kq^2}{l^2} = F_c$$

$$\overrightarrow{F_B} = \frac{kq(-4q)}{l^2} = -\frac{4kq^2}{l^2} \Rightarrow F_B = \frac{4kq^2}{l^2}$$

Now from eqn. (1) and (2)

$$F_B = 2F_c$$

and angle between F_B and F_c is 120°, so force on q is

$$F_q = \sqrt{F_c^2 + (2F_c)^2 + 2\cdot(2F_c)\cdot F_c\cdot\cos 120^\circ}$$

$$= \sqrt{5F_c^2 + 4F_c^2\left(-\frac{1}{2}\right)} = \sqrt{5F_c^2 - 2F_c^2} = F_c\sqrt{3}$$

$$\boxed{F_q = 2\sqrt{3}\,\frac{kq^2}{l^2}} \left[\because \text{from eqn (1)}, F_c = \frac{2kq^2}{l^2}\right]$$ **2**

(b) The amount of work done to separate the charges at infinite distance is equal to the (-ve) potential energy of the given system. Now we know that the potential energy of three (03) charges at the corners of an equilateral triangle ABC of side l is given by

$$U_{PE} = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right]$$

given $q_1 = q$, $q_2 = -4q$, $q_3 = 2q$, $r_{12} = r_{13} = r_{23}$

$$\Rightarrow \qquad U_{PE} = \frac{1}{4\pi\varepsilon_0}\left[\frac{q(-4q)}{l} + \frac{q.2q}{l} + \frac{2q(-4q)}{l}\right] = \frac{1}{4\pi\in_0}\cdot\frac{q^2}{l}[-4+2-8]$$

$$U_{PE} = -\frac{10q^2}{4\pi\varepsilon_0 l}$$

Therefore work done $W = -U_{PE} = -\left(\frac{-10q^2}{4\pi\varepsilon_0 l}\right)$

$$\Rightarrow \qquad \boxed{W = +\frac{10q^2}{4\pi\varepsilon_0 l}}$$

12. (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 the reciprocal of the resistance of its wire of unit length and unit area of cross section.

Alternatively : ½

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

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

Its SI unit is

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

$$I = neA|v_d|$$

$$= \frac{e^2A}{m}\tau n|E| \qquad ½$$

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

We, therefore, get

$$|j| = \frac{ne^2}{m}\tau|E|, \text{ The term } \frac{ne^2}{m}\tau \text{ is conductivity } \therefore \sigma = \frac{ne^2\tau}{m} \qquad ½$$

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

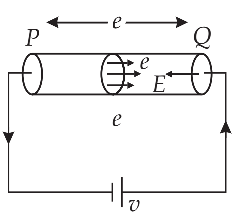
[CBSE Marking Scheme, 2018]

Detailed Answer :

(a) Conductivity of a metallic wire is reciprocal to its resistivity i.e $\sigma = \frac{1}{\rho}$ and it is measured in Ω^{-1} m^{-1} or mho·m^{-1}. **1**

(b) Let n is the number of e per unit volume in a conductor then total number of free electron in conductor PQ of length l and cross section A is $N = n \times$ volume of conductor PQ

$$N = n \times Al \qquad eq. ...(i)$$



let t is the time in which an e moves from P to Q then

$$t = \frac{l}{u_d} \qquad eq....(ii)$$

where u_d is the drift velocity of e in conductor. So the electronic current flowing through conductor is

$$I = \frac{q}{t}$$

(by using eqn. 1 and 2)

$$I = \frac{nAle}{l/u_d} = nAeu_d$$

Now current density

$$J = \frac{I}{A} = neu_d$$ **1½**

Again $u_d = \frac{eE\tau}{m_e}$, where E is the electric field across the conductor and τ is relaxation time

So,

$$J = ne\left(\frac{eE\tau}{m_e}\right) = \frac{ne^2\tau}{m_e}\cdot E$$

Again for a conductor of conductivity σ, we know that

$$J = \sigma E \quad \left(\because \vec{J} \propto \vec{E}\right)$$

comparing eqn. 5 and 6, we get

$$\sigma = \frac{ne^2\tau}{m_e}$$

Again $J = \sigma E = \frac{ne^2\tau}{m_e}E$ in the required relation between J and E. ½

13. (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 = $mB(\cos 60° - \cos 90°)$

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

$$= \frac{1}{2} \times 6 \times 0{\cdot}44\, J = 1{\cdot}32\, J$$ ½

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

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

$$= mB\left(\frac{1}{2} - (-1)\right) = \frac{3}{2}mB$$ ½

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

Torque = $6 \times 0.44 \sin 180° = 0$

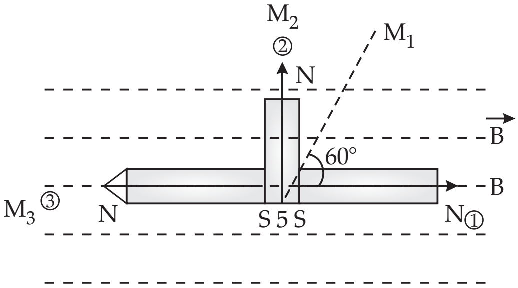
[If the student straight away writes that the torque is zero since magnetic moment and magnetic field are anti parallel in this orientation, award full] ½

[CBSE Marking Scheme, 2018]

Detailed Answer :

Given, $\vec{B} = 0.44$ T

M = 6 J/T



(a) (i) $\theta_1 = 60^{\circ}$, $\theta_2 = 90^{\circ}$ since magnet is placed perpendicular to magnetic field. So, work done in rotating the magnet from θ_1 to θ_2 is

$$W_1 = -MB(\cos\theta_2 - \cos\theta_1)$$

$$= -6 \times 0.44(\cos 90 - \cos 60) = -2.64 \times \left(-\frac{1}{2}\right)$$

W_1 = Joule

(ii) Work done in aligning the magnet opposite to magnetic field. i.e. $\theta_2 = 180°$ $\theta_1 = 60°$

$$W_2 = -MB(\cos 180^{\circ} - \cos 60^{\circ}) = -6 \times 0.44\left[-1 - \frac{1}{2}\right]$$

$$= -2.64 \times \left(-\frac{3}{2}\right) = +3.96 \text{ Joule}$$

$$W_2 = +3.96 \text{ Joule}$$

(b) The Torque on magnet aligned at angle θ_2 is given by t = MB sin θ_2 in case a (ii) $\theta_2 = 180^{\circ}$ therefore

$$\tau = 6 \times 0.44 \times \sin 180^{\circ} = 2.4 \times 0$$

$$\tau = 0$$

$\Rightarrow$ Torque in case a (ii) i.e. at θ_2 = 180 position is zero.

14. (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,

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 \mu_r I_{\text{enclosed}}$$ ...(i) ½

For the field inside the ring, we can write

$$\oint \vec{B} \cdot d\vec{l} = \oint B dl = B \cdot 2\pi r$$ (r = radius of the ring) ½

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

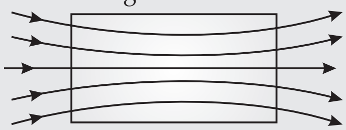
$\therefore$ $B \cdot 2\pi r = \mu_0 \mu_r \cdot (n \cdot 2pr) l$

$\therefore$ $B = \mu_0 \mu_r n I$

[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.

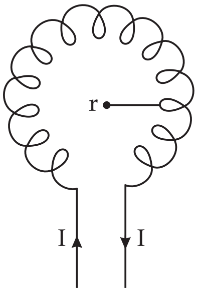


1

[CBSE Marking Scheme, 2018]

Detailed Answer :

(a)



Apply Ampere's Law for the magnetic field due to iron ring wounded by insulating copper wire, having current I, $\oint \overline{B}.\overline{dl} = \mu' \times$ (current enclosed by closed path) ½

or, $B\,dl \cos 0^\circ = \mu' \times (n \times 2 \times r) \times I$

or, $B \times 2 \times r \times 1 = \mu'\, n \times 2 \times r \times I$

or, $B = \mu'\, nI$ ...(i)

But $\mu_r = \dfrac{\mu'}{\mu_o}$ ...(ii)

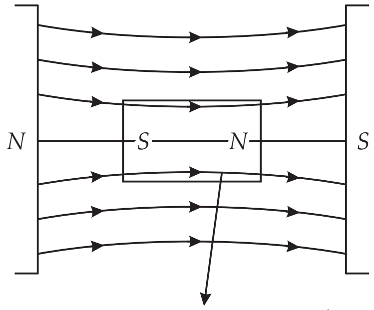
So, $\boxed{B = \mu_o \mu_r nI}$

This is the required expression for magnetic field.
$\mu_r \rightarrow$ relative permeability, $\mu_o \rightarrow$ permeability of free space.
$n \rightarrow$ number of turns per unit length

(b) Given susceptibility $\chi = 0.9853$ since susceptibility χ given is +ve and less than unity i.e. $\chi < +1$

$\Rightarrow$ magnetic material is paramagnetic material. ½

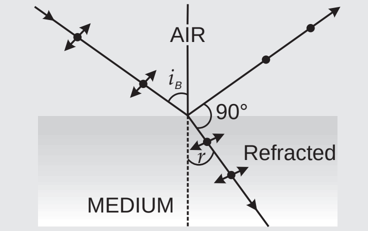
Thus when paramagnetic material is placed in the uniform magnetic field then the modified magnetic field is shown in figure.



Paramagnetic material 1

15. (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

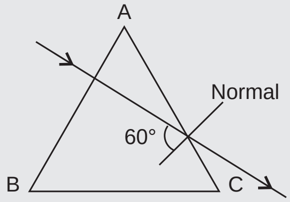
$$\therefore \qquad r = \left(\frac{\pi}{2} - i_B\right)$$

$$\therefore \qquad \mu = \left(\frac{\sin i_B}{\sin r} = \tan i_B\right) \qquad ½$$

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

(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



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

Also $\qquad \sin i = \sin 60° = \frac{\sqrt{3}}{2} = \frac{1.732}{2}$ ½

$$= 0.866$$

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

$$\sin i_c = \frac{1}{\mu} = \frac{8}{9} \simeq 0.89 \qquad ½$$

$$\therefore \qquad i < i_c$$

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.] ½

[CBSE Marking Scheme, 2018]

Detailed Answer :

(a) When an unpolarized ordinary light is incident on a transparent glass surface, the reflected light gets completely plane polarized when the reflected and refracted light are perpendicular to each other i.e.

$$i_p + 90 + r = 180$$

$$\Rightarrow r = 90 - i_p$$

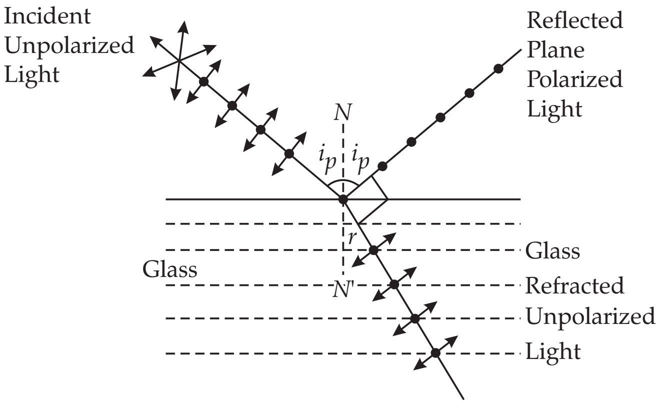
($\because$ let i_p is the incident angle when reflected and refracted light is perpendicular to each other)

So by Snell's law

$$\mu = \frac{\sin i_p}{\sin r} = \frac{\sin i_p}{\sin(90 - i_p)} = \frac{\sin i_p}{\cos i_p}$$

$$\Rightarrow \boxed{\mu = \tan i_p} \qquad \mathbf{1}$$

This is called Brewster's law, and the incident angle i_p is called Brewster's angle, i.e. when an unpolarized light is incident on transparent glass surface at Brewster angle, the reflected light is plane polarized light.

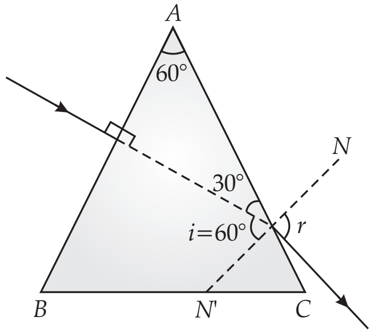


½

(b) Since glass prism is equilateral so angle $\angle A = 60°$. Now we draw a normal to face AC. Thus, from geometry the angle of incidence on face AC is 60° *i.e.*, $i = 60°$. If this angle is critical angle then refractive index of prism in air is

$$\mu_A = \frac{1}{\sin 60} = \frac{1}{\frac{\sqrt{3}}{2}} = \frac{2}{\sqrt{3}} \qquad \left(\because \mu = \frac{1}{\sin i_c} \text{where } i_c \text{ is the critical angle}\right)$$

$$\Rightarrow \mu_A = 1.54.$$



Now if prism is placed in water then refractive index of prism with water

$$\mu_w = \frac{\mu_p}{\mu_w} = \frac{3/2}{4/3} = \frac{9}{8} = 1.125$$

Now for total internal reflection at face AC, we should have $\mu_A < \mu_w$ but in given case $\mu_A > \mu_w$ (since 1.125 < 1.54)

$\Rightarrow$ Critical angle for total internal reflection should be greater than 60°. **1**

$\Rightarrow$ No total internal reflection takes place and light ray gets refracted from prism placed in water. ½

16. (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

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]

Detailed Answer :

(a) We know that $I = ka^2$

$$\frac{\text{Imax}}{\text{Imin}} = \left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2$$

as $I_1 = I \,\&\, I_2 = \frac{I}{2}$

Simplify in equation

$$\boxed{\frac{\text{Imax}}{\text{Imin}} = \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2}$$

(b) If we use white light in place of monochromatic light, then we get coloured fringes instead of black and white fringes. Fringes shape and size will remain the same.

17. 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

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

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

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

$\therefore$ $$\frac{\mu_1}{y} = \frac{2}{y}-\frac{1}{x} = \left(\frac{2x-y}{xy}\right)$$

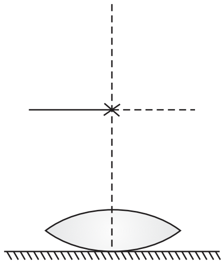
or $$\mu_l = \left(\frac{2x-y}{x}\right)$$ ½

[CBSE Marking Scheme, 2018]

Detailed Answer :

Given, Radius of curvature of convex lens is R and $\mu = 1.5$

When lens is placed on a layer of water then focal length of combination is f. Thus the first measurement gives the focal length of combination i.e. $f = x$.



In second measurement, we get the focal length f_1 of convex lens i.e. $f_1 = y$, therefore the focal length of plano connex lens of water f_2 is given as

$$\frac{1}{f_1}+\frac{1}{f_2}=\frac{1}{f}\Rightarrow\frac{1}{f_2}=\frac{1}{f}-\frac{1}{f_1}=\frac{1}{x}-\frac{1}{y}=\frac{y-x}{xy} \qquad \textbf{(i)}$$

$$\Rightarrow \qquad f_2=\frac{xy}{y-x}$$

For plano convex lens of liquid of refractive index μ, we have

$$\frac{1}{f_2}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)=(\mu-1)\left(-\frac{1}{R}-\frac{1}{\infty}\right) \qquad \textbf{(ii)}$$

$$\Rightarrow \qquad \frac{1}{f_2}=-\frac{(\mu-1)}{R}\Rightarrow\mu=1-\frac{R}{f_2}$$

Now from eqn. (i) and (ii)

$$\mu=1-\frac{R}{xy/y-x}=1-\frac{R(y-x)}{xy} \qquad \textbf{(iii)}$$

Now again for plano convex lens of air, if image coincide at $2f_1$ then for case II we have

$$\Rightarrow \qquad 2f_1=R\Rightarrow f_1=\frac{R}{2}$$

again $y=2f_1=2\times\frac{R}{2}\Rightarrow y=R$ **(iv)**

Now from eqn. (iii) and (iv) we have

$$\mu=1-\frac{y(y-x)}{xy}=1-\frac{y-x}{x}$$

$$\Rightarrow \qquad \mu=\frac{x-y+x}{x}=\frac{2x-y}{x}$$

$$\mu=\frac{2x-y}{x}$$

This is the required expression for the refractive index of liquid.

18. (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 $\frac{h}{2\pi}$ (h = Planck's constant)," ½

[Also accept $mvr = n.\frac{h}{2\pi}$ (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,…….)

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

or $\qquad mvr=\frac{nh}{2\pi}$ 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

∴ Energy required to take the electron from the ground state, to the

$$n = 4\text{ level} = \left(-\frac{E_0}{16}\right)-(-E_0)$$

$$= \frac{-1+16}{16} = \frac{15}{16}E_0 = \frac{15}{16} \times 13.6 \times 1.6 \times 10^{-19} J$$ ½

Let the frequency of the photon be ν, we have

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

$$\therefore \quad v = \frac{15 \times 13.6 \times 1.6 \times 10^{-19}}{16 \times 6.63 \times 10^{-34}} Hz$$ ½

$$\simeq 3.1 \times 10^{15}\,\text{Hz}$$

(Also accept 3×10^{15} Hz)

[CBSE Marking Scheme, 2018]

Detailed Answer :

(a) According to Bohr's postulate of Quantisation condition, electrons can revolve only in those orbits in which its angular momentum $L = mvr$ is an integral multiple of $\frac{h}{2\pi}$ i.e.

$$L = mvr = \frac{nh}{2\pi} \text{ or } 2\pi r = \frac{nh}{mv} = \frac{nh}{p}$$

or $2\pi r = n\lambda$, where $\lambda = \frac{h}{p}$, from de–Broglie's relation.

So, circumference of n^{th} stable orbit for electron can contain exactly n wavelength of de–Broglie $\left(\text{i.e. } \lambda = \frac{h}{p}\right)$ associated with the electron in that orbit.

(b) We know that ground state energy of hydrogen atom is = – 13.6 eV.

Now if atom is excited to $n = 4$ level, then we have

$$E_4 = -\frac{13\cdot6}{4^2} = -\frac{13\cdot6}{16} = -0\cdot85 \text{ ev} \qquad \left(\because \; E_n = -\frac{E_g}{n^2}\right).$$

Now if v is the frequency of photon then

$$\text{h}\nu = \text{E}_4 - E_g \quad \text{OR} \quad \nu = \frac{E_4 - Eg}{h}$$

$$\text{OR} \quad \nu = \frac{[-0.85 - (-13.6)]\; ev}{6.63 \times 10^{-34}\,\text{J-s}} = \frac{12.75 \times 1.6 \times 10^{-19}\text{ Joule}}{6.63 \times 10^{-34}\text{ Joule} - \text{sec}}$$

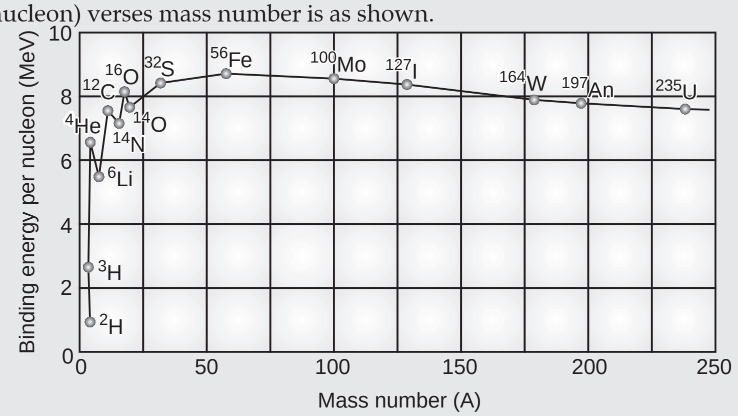
$$\boxed{v = 3.08 \times 10^{15} Hz}$$

19. (a) Drawing the plot 1

Explaining the process of Nuclear fission and Nuclear fusion ½ + ½

(b) Finding the required time 1

(a) The plot of (B.E / nucleon) verses mass number is as shown.



1

[Note : Also accept the diagram that just shows the general shape of the graph]. From the plot we note that

(i) During nuclear fission ½

A heavy nucleus in the larger mass region (A>200) breaks into two middle level nuclei, resulting in an increase in B.E/ nucleon. This results in a release of energy. ½

(ii) During nuclear fusion

Light nuclei in the lower mass region (A<20) fuse to form a nucleus having higher B.E / nucleon. Hence Energy gets released.

[Alternatively: As per the plot: During nuclear fission as well as nuclear fusion, the final value of B.E/ nucleon is more than its initial value. Hence energy gets released in both these processes.]

(b) We have

$$3.125\% = \frac{3.125}{100} = \frac{1}{32} = \frac{1}{2^5}$$ ½

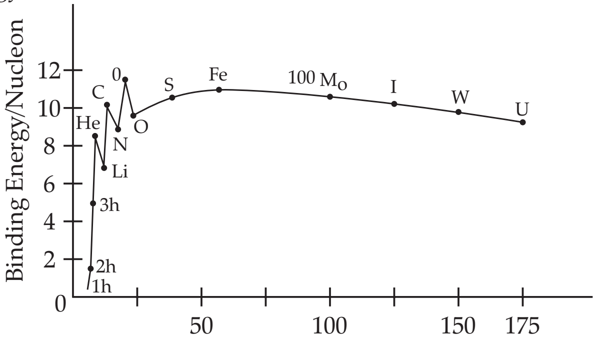
Half life = 10 years

∴ Required time = 5 × 10 years = 50 Years ½

[CBSE Marking Scheme, 2018]

Detailed Answer :

(a) Plot of binding energy per nucleon is shown in Figure. From B–E/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 B-E/nucleon in comparison to ^{4}He. Thus when two very light nuclei (A ≤ 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

$$\frac{R}{R_0} = \left(\frac{1}{2}\right)^{t/T_{½}}$$

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

$$R = 0.03125\ R_0$$

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

$$\Rightarrow \left(\frac{1}{2}\right)^5 = \left(\frac{1}{2}\right)^{t/T_{½}}$$

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

$$t = 5 \times 10$$

$$\boxed{t = 50 \text{ years}}$$ 1

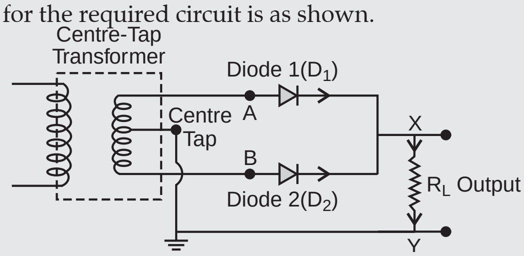
20. (a) Drawing the labelled circuit diagram **1**

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

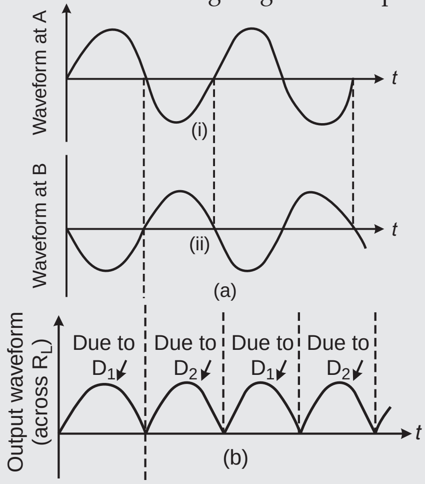
The working of this circuit is as follows:

(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

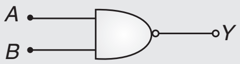
(ii) Because of the use of the center tapped transformer the current though the load flows in the same direction in both the half cycles.

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.



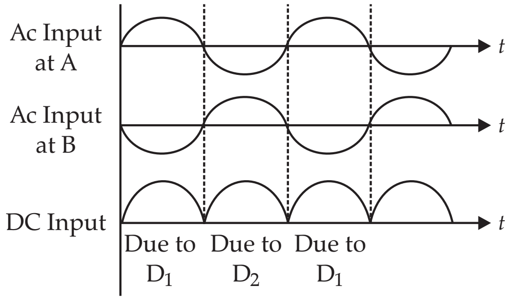
Input		Output
A	***B***	***Y***
0	0	1
0	1	1
1	0	1
1	1	0

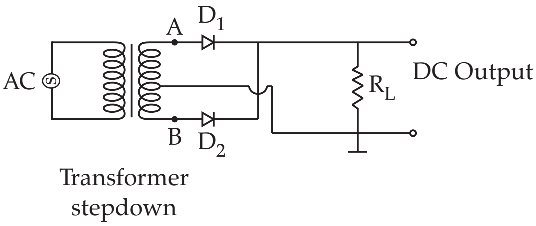
½+½

[CBSE Marking Scheme, 2018]

Detailed Answer :

(a) Full Wave Rectifier

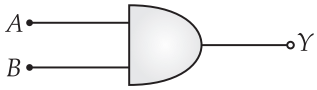




Circuit Diagrams

Working : For the half cycle of input ac, one of two diode gets forward biased and conducts and output current is obtained across R_L. For –ve half cycle of input ac, the other diode is forward biased and thus output current is obtained due to this diode in this way we get the output current across load R_L for complete cycle of input ac as shown in fig.

(b) Symbol of NAND gate



Truth Table of NAND Gate,

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

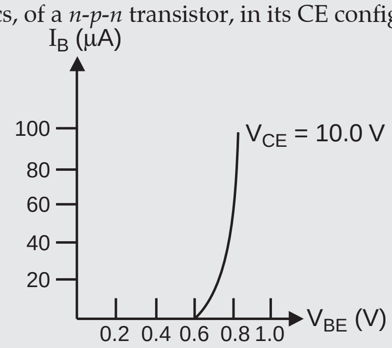
21. Input and Output characteristics **1+1**

Determination of

(a) Input resistance ½

(b) Current amplification factor ½

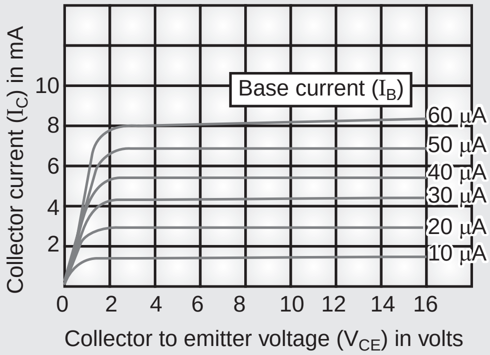
The input and output characteristics, of a *n-p-n* transistor, in its CE configuration, are as shown.



1

Input resistance

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



1

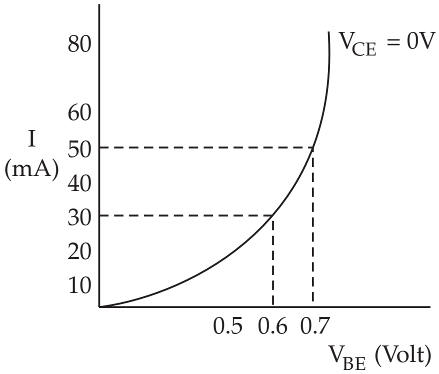
The relevant values can be read from the input characteristics.
Current amplification factor

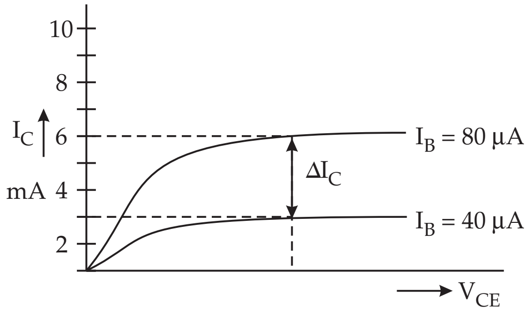
$$\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)$$

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

[CBSE Marking Scheme, 2018]

Detailed Answer :





(a) Input resistance (r_i)

From input characteristic curve we determine the input resistance as $r_i = \left.\frac{\Delta I_B}{\Delta V_{BE}}\right|_{V_{CE}=\text{cont}}$

For example, from graph, $\Delta I_B = 50 - 30 = 20\,\mu A$, $\Delta V_{BE} = 0{\cdot}7 - 0{\cdot}6 = 0{\cdot}1$ Volt.

So input resistance $ri = \frac{\Delta I_B}{\Delta V_{BE}} = \frac{20\,\mu A}{0.1 \text{ Volt}} = 200$ μΩ

(b) Current Amplification factor β is given by

$$\beta = \left.\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}=\text{const}}$$

For example,

From graph, $\Delta I_c = 6 - 3 = 3$ mA, $\Delta I_B = 80 - 40 = 40\,\mu$A

So $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{3 \text{ mA}}{40\,\mu\text{A}} = \frac{3000}{40} = 75$

22. (a) Stating the three reasons ½ + ½ + ½

(b) Graphical representation of the audio signal, carrier wave and the amplitude modulated wave ½ + ½ + ½

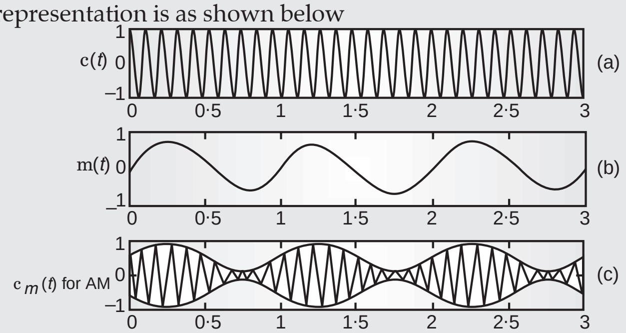
(a) The required three reasons are :

(i) A reasonable length of the transmission antenna. ½

(ii) Increase in effective power radiated by the antenna. ½

(iii) Reduction in the possibility of a 'mix-up' of different signals. ½

(b) The required graphical representation is as shown below



½

½

½

[CBSE Marking Scheme, 2018]

Detailed Answer :

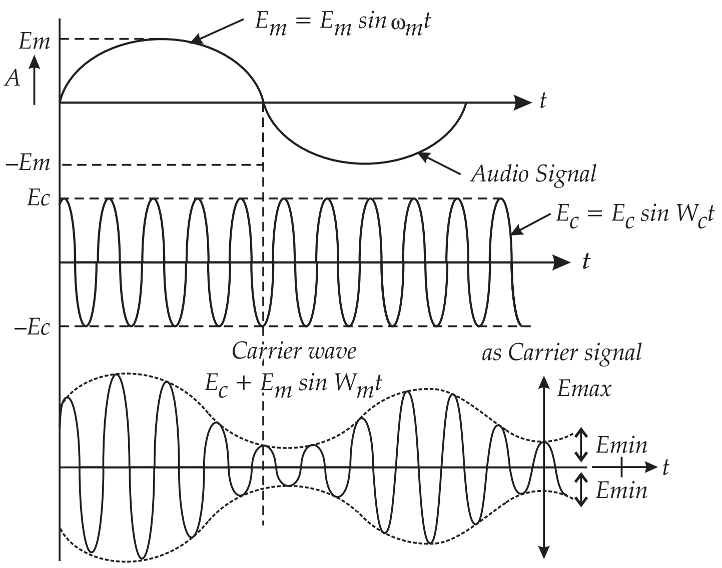
(a) For a long distance Transmission of message signal we need modulation because of following reasons.

(i) **Low energy:** The message signals when converted to e.m. waves, do not have the sufficient energy to travel up to long distance ,because of their low frequency. Hence these message signals are modulated with high frequency carrier signals before being send because carrier signals have high energy for long distance transmission.

(ii) **Size of Antenna:** For the effective Transmission by an antenna ,the size of antenna should be at least of the size $\lambda/4$, where λ is the wavelength of signal to be send. Thus for an em wave of audio signal of frequency is 20 kHz, we need an antenna of size $\lambda/4$ i.e. nearly 3.75 km high, which is practically impossible. Hence, these low frequency signals first modulated to high frequency signals before transmission to get the proper size of antenna.

(iii) **Mixing of signals :-** When number of signals are transmitted simultaneously, all these signals will get mixed up and at the end we get mixed signal, which is very difficult to separate. Therefore to remove this limitation, transmission is done at high frequency and a band of frequency is allotted to each user at the end , as done for radio and TV channels.

(b)



Amplitude modulated wave as signal

23. (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 x 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**

[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]

Detailed Answer :

(a) The device used to change the alternating voltage to a higher or lower value is step up and step down transformer. In a transformer we use two coils one is called primary coil and other is called secondary coil. We know the relation for transformer

$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

where E_1 and N_1 are voltage and number of turns in primary coil and E_2 and N_2 are voltage and number of turns in secondary coil.

The one cause of power dissipation in transformer is due to heat loss by eddy current.

(b) When electrical energy is transmitted over a long distance as an alternating current then power loss occurs due to the heat produced by the a.c. current.

Therefore, to reduce the power loss by heat, we reduced the current by increasing the ac voltage with the help of step up transformer and at the end again sufficient A.C. current is received by converting high voltage to low voltage current with step down transformer as

$$\frac{N_1}{N_2} = \frac{E_1}{E_2} = \frac{I_2}{I_2}$$

In this case A.C. power (P_{ac} = V.I. = const.)

But in direct current (dc) we cannot use the step up or step down transformer, therefore power loss cannot be reduced.

(c) Teacher : Concerned and ready to share knowledge .

Geeta : Good listener, keen learner.

24. **(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**

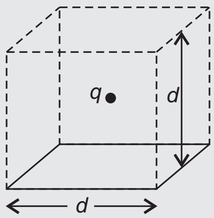
(a) Electric flux through a given surface is defined as the dot product of electric field and area vector over that surface. **1**

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

Also accept

Electric flux, through a surface equals the surface integral of the electric field over that surface. ½

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

$$= \frac{q}{\varepsilon_0}$$ ½

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

Hence electric flux through the square $\frac{1}{6} \times \frac{q}{\varepsilon_0} = \frac{q}{6\varepsilon_0}$ ½

(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**

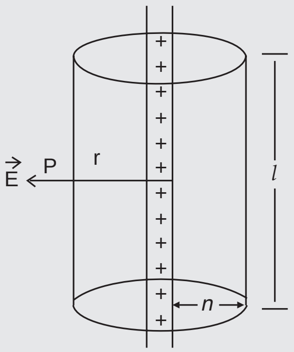
OR

(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.

$$= \text{Flux through the curved cylindrical part of the surface.}$$

$$= E \times 2\pi rl \qquad \text{...(i)} \ ½$$

Applying Gauss's Law

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

$$\text{Total charge enclosed} = \text{Linear charge density} \times l$$

$$= \lambda l$$

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

Using Equations (i) & ii

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

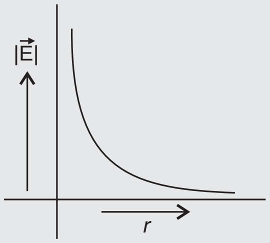
$$\Rightarrow \qquad E = \frac{\lambda}{2\pi\varepsilon_0 r} \qquad ½$$

In vector notation

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

(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'

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

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

$$= qEdr\cos 0$$

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

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

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

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

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

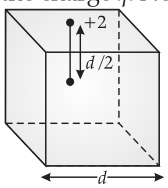
[CBSE Marking Scheme, 2018]

Detailed Answer :

(a) Electric flux : The electric flux linked with a surface is the number of electric lines of force passing through a surface normally and is measured as the surface integral of electric field over that surface, *i.e.*,

$$\phi = \int_S \vec{E}.\vec{ds}.$$

Electric flux ϕ is a scalar quantity. Now calculate the electric flux through the square of side d, we draw a cube of side d such that it completely enclosed the charge q. Now from Gauss's law



Total flux passing through the cube is given by

$$\phi_{\text{total}} = 6 \times \phi^1_{\text{square face}} = \frac{\text{total charge enclosed}}{\epsilon_0}$$

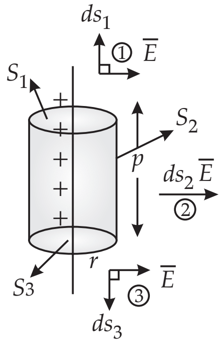
$$\Rightarrow 6\phi^1_{\text{square}} = \frac{q}{\epsilon_0}$$

$$\Rightarrow \boxed{\phi^1_{\text{square face}} = \frac{q}{6\epsilon_0}}$$

(b) If charge is now moved to distance d from centre of square and side of square is doubled, then electric flux is unchanged i.e. remains the same, because electric flux depends only on amount of charge and but not on side of square, OR position of charge.

OR

(a) Let us draw a gaussian cylinder of length l and radius r across the line of charge having density $\lambda\ ^{c}/_{m}$. Then from gauss's law we have



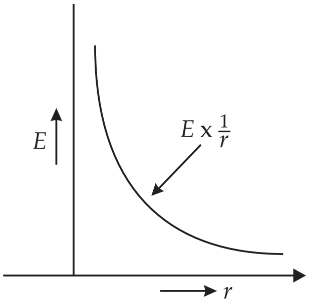
$$\phi = \oint \overline{E} \cdot \overline{ds} = \frac{q_{\text{enclosed}}}{\epsilon_0}$$

$$\Rightarrow \int_{S_1} E \cdot ds_1 \cos 90 + \int_{S_2} E \cdot ds_2 \cos 0 + \int_{S_3} E \cdot ds_3 \cos 90 = \frac{\lambda l}{\epsilon_0} \quad (\because q = \lambda l)$$

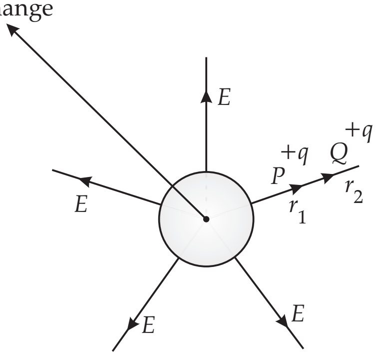
$$\Rightarrow 0 + E \cdot \int_{S_2} ds_2 + 0 = \frac{\lambda l}{\epsilon_0}$$

$$\Rightarrow E \cdot 2\pi r l = \frac{\lambda l}{\epsilon_0} \Rightarrow \boxed{E = \frac{\lambda}{2\pi \epsilon_0 r}}$$

(b) Graph to show the variation of E with perpendicular distance r from line change



(c) Work done in bringing charge q from perpendicular distance r_1 to r_2 $(r_2 > r_1)$



$$W = \overline{F} \cdot \overline{ds} = \int_{r_1}^{r_2} q\, E\, dr = \int_{r_1}^{r_2} q \frac{\lambda}{2\pi \epsilon_0 r} dr = \frac{2\lambda}{2\pi \epsilon_0} \int_{r_1}^{r_2} \frac{1}{r} dr$$

$$W = \frac{q\lambda}{2\pi \epsilon_0} (\log_e r_2 - \log_e r_1)$$

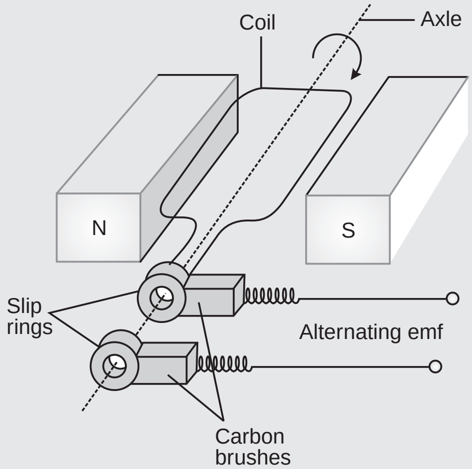
$$W_{q \atop r_1 \to r_2} = \frac{q\lambda}{2\pi \epsilon_0} \log_e \frac{r_2}{r_1}$$

25. (a) Principle of ac generator	½
working	½
mark Labeled diagram	**1**
Derivation of the expression for induced emf	**1 ½**
(b) Calculation of potential difference	**1 ½**

(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 cosθ) 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 ωt; (assuming $\theta = 0^\circ$ 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

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

∴ The induced emf $e = -N\dfrac{d\phi}{dt}$ 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

= 250m/s

Wing span (l) = 20 m

Vertical component of Earth's magnetic field

$$B_v = B_H\tan\delta$$

$$= 5\times10^{-4}(\tan 30^\circ)\text{ tesla}$$ ½

∴ Potential difference

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

$$= \frac{5\times 20\times 250\times 10^{-4}}{\sqrt{3}}$$

= 1.44 volt ½

Or

(a) Identification of the device X ½

Expression for reactance ½

OR

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

(c) Variation of reactance with frequency ½

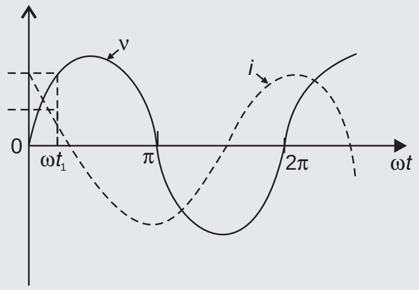
(Graphical variation) ½

(d) Phasor Diagram 1

(a) X : capacitor ½

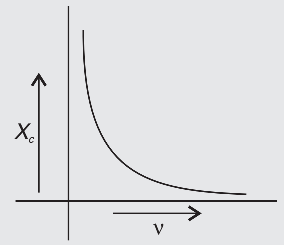
Reactance $X_c = \dfrac{1}{\omega C} = \dfrac{1}{2\pi\upsilon C}$ ½

(b)



½+½

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



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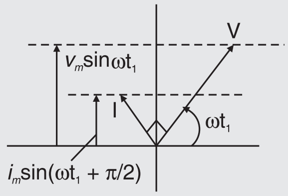


1

[CBSE Marking Scheme, 2018]

Detailed Answer :

(a) **AC generator**

A.C generator is a device which converts mechanical energy into electric energy.

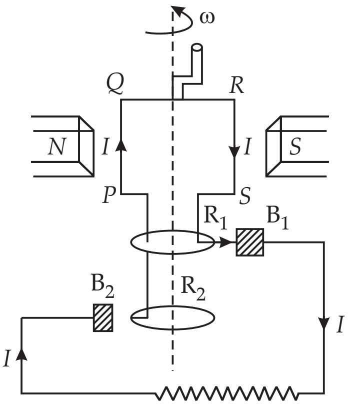
Principle: It works on the principle of electromagnetic induction. It consists of :

(i) Armature coil of large number of turns of copper wire wound over soft iron core, soft iron core is used to increase magnetic flux.

(ii) Field magnets are used to apply magnetic field in which armature coil is rotated with its axis perpendicular to field lines.

(iii) Slip rings used to provide movable contacts of armature coil with external circuit containing load.

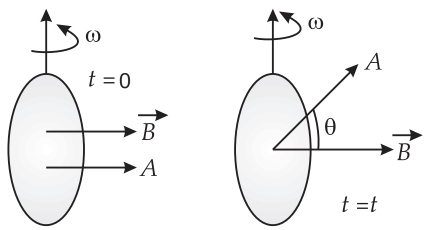
(iv) Brushes are the metallic pieces used to pass an electric current from armature coil to the external circuit containing load.



Theory :

Consider a coil PQRS free to rotate in a uniform magnetic field $\bar{B}$. The initial flux through the coil is maximum i.e., $\phi = BA$ but as the coil is rotating with angular velocity ω, at any instant 't' the flux is given by

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



As the coil rotates, the magnetic flux linked with it changes. An induced emf is set up in the coil which is given by,

$$\varepsilon = \frac{d\phi}{dt} = -\frac{d}{dt}(BA \cos\omega t) = BA \sin\omega t$$

If the coil has N turns, then the total induced emf will be

$$\varepsilon = NBA\ \omega \sin \omega t.$$

Thus, the induced emf varies sinusoidally with time 't'. The value of induced emf is maximum when $\sin \omega t = 1$ or $\omega t = 90^\circ$, i.e., when the plane of the coil parallel to the field $\overline{B}$. Denoting this maximum value by ε_0, we have

$\varepsilon_0 = NBA\omega$

$\varepsilon = \varepsilon_0 \sin \omega t = \sin 2\pi f t$ where f is the frequency of rotation of the coil.

We consider the following special cases :

(i) When $\omega t = 0^\circ$, the plane of the coil is perpendicular to B, $\sin \omega t = \sin 0^\circ$ so that $\varepsilon = 0$

(ii) When $\omega t = \pi / 2$, the plane of coil is parallel to field B, $\sin \omega t = \sin \pi / 2 = 1$, so that $\varepsilon = \varepsilon_0$

(iii) When $\omega t = \pi$, the plane of the coil is again perpendicular to B, $\sin \omega t = \sin \pi = 0$ so that $\varepsilon = 0$

(iv) When $\omega t = \dfrac{3\pi}{2}$, the plane of the coil is again parallel to B, $\sin \omega t - \sin \dfrac{3\pi}{2} = -1$ so that $\varepsilon = -\varepsilon_0$

(v) When $\omega = 2\pi$, the plane of the coil again becomes 1 to B after completing one rotation, $\sin \omega t = \sin 2\pi = 0$ so that $\varepsilon = 0$.

As the coil continues to rotate in the same sense the same cycle of changes repeats again and again. Such an emf is called sinusoidal or alternating emf. Both the magnitude and direction of this emf changes regularly with time.

- The fact that an induced emf is set up in a coil when rotated a magnetic field forms the basics principle of a dynamo or a generator.
- The electric current produced varies sinusoidally with time, so is known as 'alternating current' and hence the generator is known as 'A.C. generator'.

(b) As

$$\frac{B_V}{B_H} = \tan\theta$$

$$B_V = B_H \tan\theta$$

$$= 5 \times 10^{-4} \tan 10^o$$

$$= \frac{5 \times 10^{-4}}{\sqrt{3}}$$

$$e = B \cdot Iv$$

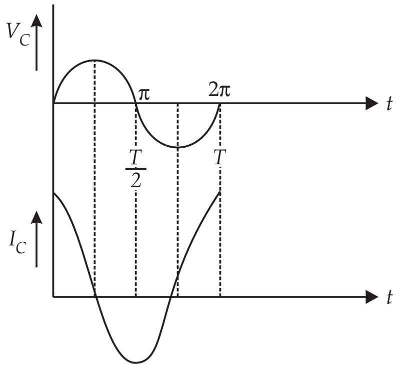
$$= \frac{5 \times 10^{-4}}{\sqrt{3}} \times 20 \times 250$$

$$\boxed{= 1.47 \text{ Volt}}$$

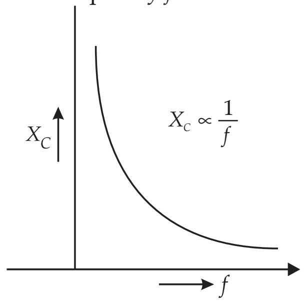
OR

(a) The device is capacitor. The reactance of capacitor is given by $X_c = \dfrac{1}{\omega_C} = \dfrac{1}{2\pi f_C}$

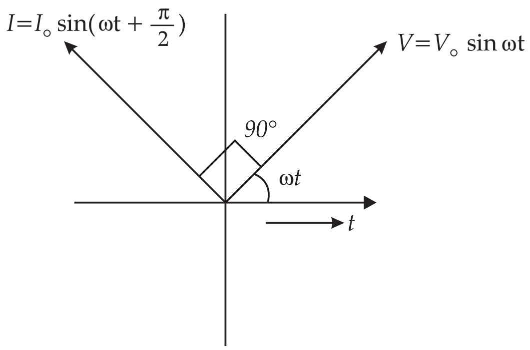
(b) Graph of voltage and current w.r. to time



(c) Graph showing the variation of X_C with frequency f

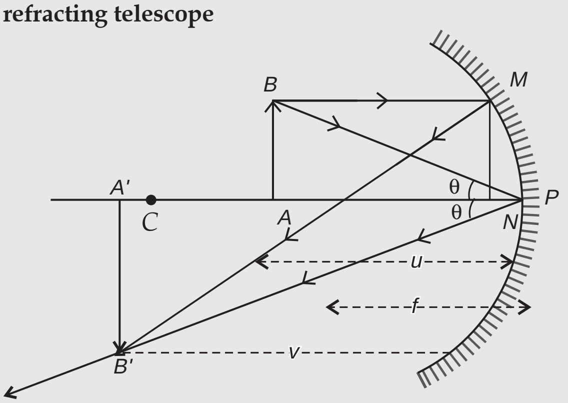


(d) Phase diagram for device X is shown in fig.



26. (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)



1

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

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

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)

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

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

$$PA' = -v$$
$$PF = -f$$

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

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

$$uv - uf = vf$$

Dividing each term by uvf, we get

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

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

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

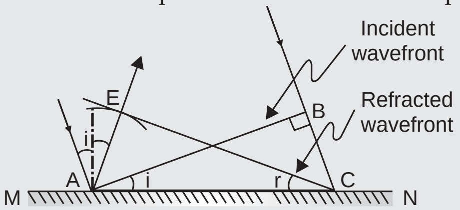
Verification of laws of reflection **2**

(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 locii of all points that are in the same phase)



1

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

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

Hence BC = $v\,\tau$

Let CE represent the reflected wave front

Distance AE = $v\,\tau = BC$

$\Delta\, AEC$ and $\Delta\, ABC$ are congruent

$$\angle BAC = \angle ECA$$ ½

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

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

($\therefore$ Size of central maxima = $2\dfrac{2\lambda D}{\alpha}$)

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.

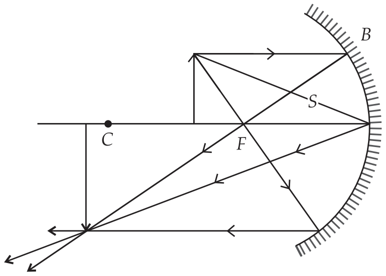
[Alternatively: Light gets diffracted by the tiny circular obstacle and reaches the centre of the shadow of the obstacle.] ½

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

[CBSE Marking Scheme, 2018]

Detailed Answer :

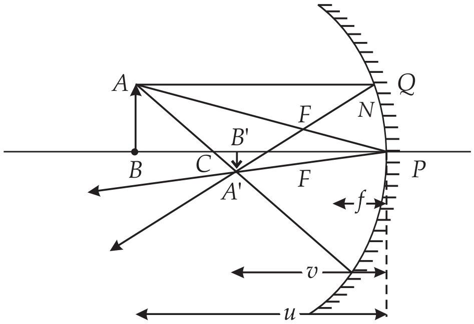
(a)



When object in placed in between F & C then we get Real, Inverted and Magnified image beyond C by the concave mirror.

(b) Mirror formula for concave mirror :-

When an object is placed beyond F, image formed is real, as $\Delta A^1B^1C \approx \Delta ABC$, So



$$\frac{A^1B^1}{AB} = \frac{B^1C}{BC} \qquad \textbf{(i)}$$

as $\Delta A^1B^1F \approx \Delta QNF$, So

$$\frac{A^1B^1}{QN} = \frac{FB^1}{NF}$$

But $QN = AB$, So $\dfrac{A^1B^1}{QN} = \dfrac{FB^1}{NF}$ **(ii)**

by **(i)** & **(ii)**

$$\frac{B^1C}{BC} = \frac{FB^1}{PF}$$

$$\text{OR} \quad \frac{PC - PB^1}{PB - PC} = \frac{PB^1 - PF}{PF} \qquad \textbf{(iii)}$$

using $PB = -u$, $PB^1 = -v$, $PC = -R = -2f$, $PF = -f$ from equation (iii), we have

$$\frac{-2f + v}{-u + 2f} = \frac{v + f}{-f}$$

OR

$$2f^2 - vf = uv + 2f^2 - uf - 2uf$$

OR

$$uv = uf + vf$$

Dividing both side by uvf, we get

$\boxed{\dfrac{1}{f} = \dfrac{1}{v} + \dfrac{1}{u}}$ (iv) is called mirror formula

Linear magnification produced by concave mirror is the ratio of the size of image I to the size of object 0 i.e.

$$\boxed{M = \frac{I}{0} = -\frac{v}{u}}$$

(c) Two advantages of reflecting Telescope over refracting Telescope are given as-

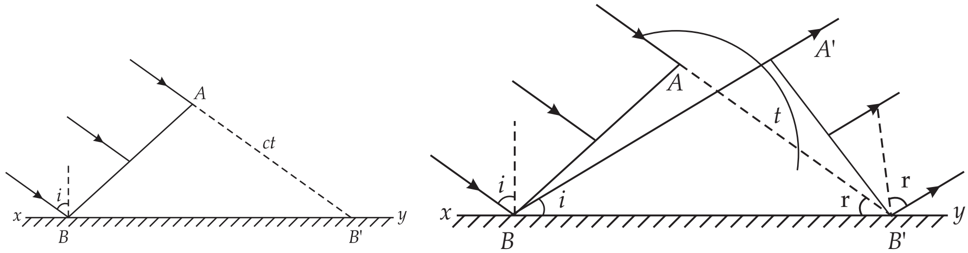
(i) No loss of intensity of incident light, therefore we get bright image in reflecting telescope.

(ii) In reflected telescope, spherical aberration is removed by using parabolic mirrors, so there is no spherical aberration in reflecting telescope.

OR

(a) **Wavefront:** The continuous locus of all the particles vibrating in same phase at any instant is called the wave front.

Laws of reflection by Hygen's Principle:



Let us consider a plane wave front AB incident on the place surface xy, incident rays are normal to the wavefront AB. Let in time t, the secondary wavelets reaches B$'$ covering distance ct. Similarly, from each point on primary wavefront AB, secondary wavelets starts growing with the speed c. To find reflected wave front after time t. Let us draw a sphere of radius ct taking B as centre and now a tangent is drawn from B$'$ on the sphere. The tangent B$'$A$'$ represents reflected wavefront after time t.

For every point on wavefront AB a corresponding point lie on the reflected wavefront A$'$B$'$. So comparing two triangle DBAB$'$ & DB$'$A$'$B we get AB$'$ = A$'$B = ct, BB$'$ = common

$\angle$ A = $\angle$ A$'$ = 90

Thus two triangles are congruent, hence $\angle i = \angle r$

This proves first law of reflection. Also incident rays, reflected rays and normal to them, all lies in the same plane. This gives the second raw of reflection.

OR

(b) In single slit diffraction experiment the fringe width is given by $\beta = \frac{2D\lambda}{d}$

where d $\Rightarrow$ slit width,

Now if slit width d is doubled $\Rightarrow d' = 2d$

$$\Rightarrow \beta^1 = \frac{2D\lambda}{d^1} = \frac{2D\lambda}{2d} = \frac{\beta}{2}$$

$\Rightarrow$ fringe size become half $\Rightarrow \beta' = \frac{\beta}{2}$

when slit width is doubled, the amplitude of light gets doubled, so intensity $I = ka^2$

$$\Rightarrow I^1 = ka^{12} = k \cdot (2a)^2 = 4ka^2 = 4I$$

OR

$\Rightarrow \boxed{I' = 4I} \Rightarrow$ Intensity becomes four times.

(c) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the center of the obstacle shadow because of the constructive interference of diffracted rays of light by the tiny circular obstacles.