PHYSICS
CBSE
Sample Question Paper 2020-21

(Issued by Board on 9th Oct. 2020)

1

Sample Question Paper

Solved _____

General Instructions :

(1) *All questions are compulsory. There are 33 questions in all.*

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

(3) *Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.*

(4) *There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.*

Section 'A'

All questions are compulsory. In case of internal choices, attempt any one of them.

1. Name the physical quantity having unit J/T. **1**

2. Mention one use of part of electromagnetic spectrum to which a wavelength of 21 cm (emitted by hydrogen in interstellar space) belongs.

OR

Give the ratio of velocity of the two light waves of wavelengths 4000Å and 8000Å travelling in vacuum.

3. An electron with charge -e and mass m travels at a speed v in a plane perpendicular to a magnetic field of magnitude B. The electron follows a circular path of radius R. In a time, t, the electron travels halfway around the circle. What is the amount of work done by the magnetic field? **1**

4. A solenoid with N loops of wire tightly wrapped around an iron-core is carrying an electric current I. If the current through this solenoid is reduced to half, then what change would you expect in inductance L of the solenoid.

OR

An alternating current from a source is given by $i=10\sin314t$. What is the effective value of current and frequency of source? **1**

5. What is the value of angular momentum of electron in the second orbit of Bohr's model of hydrogen atom? **1**

6. In a photoelectric experiment, the potential required to stop the ejection of electrons from cathode is 4V. What is the value of maximum kinetic energy of emitted Photoelectrons? **1**

7. In decay of free neutron, name the elementary particle emitted along with proton and electron in nuclear reaction.

OR

In the following nuclear reaction, Identify unknown labelled X. **1**

$$^{22}_{11}Na + X \rightarrow ^{22}_{10}Na + v_e$$
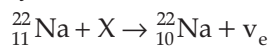
8. How does the width of a depletion region of a pn junction vary if doping concentration is increased?

OR

In half wave rectification, what is the output frequency if input frequency is 25 Hz. **1**

9. When a voltage drop across a pn junction diode is increased from 0.70 V to 0.71 V, the change in the diode current is 10 mA .What is the dynamic resistance of diode? **1**

10. Which specially fabricated pn junction diode is used for detecting light intensity? **1**

For question numbers 11, 12, 13 and 14, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false and R is also false

11. **Assertion (A) :** In a non uniform electric field, a dipole will have translatory as well as rotatory motion.

Reason (R) : In a non uniform electric field, a dipole experiences a force as well as torque. **1**

12. **Assertion (A) :** Electric field is always normal to equipotential surfaces and along the direction of decreasing order of potential.

Reason(R) : Negative gradient of electric potential is electric field. **1**

13. **Assertion (A) :** A convex mirror cannot form real images.

Reason (R) : Convex mirror converges the parallel rays that are incident on it. **1**

14. **Assertion (A) :** A convex lens of focal length 30 cm can't be used as a simple microscope in normal setting.

Reason (R) : For normal setting, the angular magnification of simple microscope is M = $\dfrac{D}{f}$. **1**
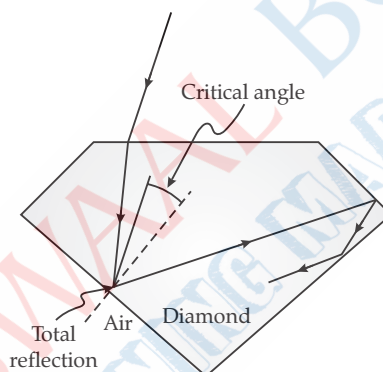
Section 'B'

Questions 15 and 16 are Case Study based questions and are compulsory. Attempt any 4 sub parts from each question. Each question carries 1 mark.

15. **Faraday Cage:** A Faraday cage or Faraday shield is an enclosure made of a conducting material. The fields within a conductor cancel out with any external fields, so the electric field within the enclosure is zero. These Faraday cages act as big hollow conductors you can put things in to shield them from electrical fields. Any electrical shocks the cage receives, pass harmlessly around the outside of the cage. **4**
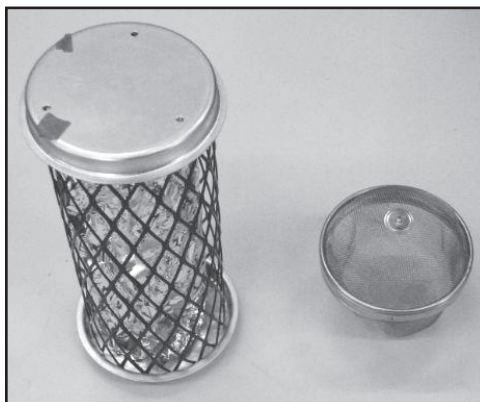
1. Which of the following material can be used to make a Faraday cage?
   (a) Plastic   (b) Glass
   (c) Copper   (d) Wood
2. Example of a real-world Faraday cage is
   (a) car   (b) plastic box
   (c) lightning rod   (d) metal rod
3. What is the electrical force inside a Faraday cage when it is struck by lightning?
   (a) The same as the lightning
   (b) Half that of the lightning
   (c) Zero
   (d) A quarter of the lightning
4. An isolated point charge $+q$ is placed inside the Faraday cage. Its surface must have charge equal to-
   (a) Zero   (b) $+q$
   (c) $-q$ (d) $+2q$
5. A point charge of 2C is placed at centre of Faraday cage in the shape of cube with surface of 9 cm edge. The number of electric field lines passing through the cube normally will be-
   (a) 1.9×10^5 Nm^2/C entering the surface (b) 1.9×10^5 Nm^2/C leaving the surface
   (c) 2.0×10^5 Nm^2/C leaving the surface (d) 2.0×10^5 Nm^2/C entering the surface

16. **Sparking Brilliance of Diamond:**   4

The total internal reflection of the light is used in polishing diamonds to create a sparking brilliance. By polishing the diamond with specific cuts, it is adjusted the most of the light rays approaching the surface are incident with an angle of incidence more than critical angle. Hence, they suffer multiple reflections and ultimately come out of diamond from the top. This gives the diamond a sparking brilliance.

1. Light cannot easily escape a diamond without multiple internal reflections. This is because:
   (a) Its critical angle with reference to air is too large
   (b) Its critical angle with reference to air is too small
   (c) The diamond is transparent
   (d) Rays always enter at angle greater than critical angle
2. The critical angle for a diamond is 24.4°. Then its refractive index is-
   (a) 2.42   (b) 0.413
   (c) 1   (d) 1.413
3. The basic reason for the extraordinary sparkle of suitably cut diamond is that
   (a) It has low refractive index   (b) It has high transparency
   (c) It has high refractive index   (d) It is very hard
4. A diamond is immersed in a liquid with a refractive index greater than water. Then the critical angle for total internal reflection will
   (a) will depend on the nature of the liquid
   (b) decrease
   (c) remains the same
   (d) increase

5. The following diagram shows same diamond cut in two different shapes.
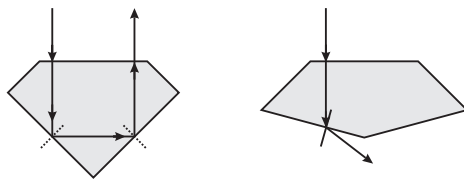

The brilliance of diamond in the second diamond will be:

(a) less than the first   (b) greater than first

(c) same as first   (d) will depend on the intensity of light

Section 'C'

All questions are compulsory. In case of internal choices, attempt anyone.

17. Two straight infinitely long wires are fixed in space so that the current in the left wire is 2 A and directed out of the plane of the page and the current in the right wire is 3 A and directed into the plane of the page. In which region(s) is/are there a point on the *x*-axis, at which the magnetic field is equal to zero due to these currents carrying wires? Justify your answer.   **2**
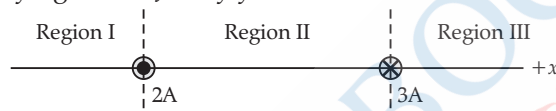
18. Draw the graph showing intensity distribution of fringes with phase angle due to diffraction through single slit.

OR

What should be the width of each slit to obtain n maxima of double slit pattern within the central maxima of single slit pattern?   **2**

19. Deduce an expression for the potential energy of a system of two point charges q_1 and q_2 located at positions r_1 and r_2 respectively in an external field $(\vec{E})$

OR

Establish the relation between electric field and electric potential at a point.

Draw the equipotential surface for an electric field pointing in $+Z$ direction with its magnitude increasing at constant rate along $-Z$ direction   **2**

20. Explain with help of circuit diagram, the action of a forward biased *p-n* junction diode which emits spontaneous radiation. State the least band gap energy of this diode to have emission in visible region. **2**

21. A coil of wire enclosing an area 100 cm^2 is placed with its plane making an angle 60° with the magnetic field of strength 10^{-1}T.

What is the flux through the coil? If magnetic field is reduced to zero in 10^{-3} s, then find the induced emf ?   **2**

22. Two waves from two coherent sources S and S' superimpose at X as shown in the figure. If X is a point on the second minima and SX – S'X is 4.5 cm. Calculate the wavelength of the waves.   **2**
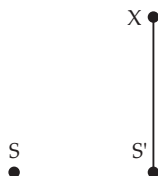
23. Draw the energy band diagram when intrinsic semiconductor (Ge) is doped with impurity atoms of Antimony (Sb). Name the extrinsic semiconductor so obtained and majority charge carriers in it.   **2**

24. Define the terms magnetic inclination and horizontal component of earth's magnetic field at a place. Establish the relationship between the two with help of a diagram.

OR

Horizontal component of earth's magnetic field at a place is √3 times the vertical component. What is the value of inclination at that place?   **2**

25. Write two characteristics of image formed when an object is placed between the optical centre and focus of a thin convex lens. Draw the graph showing variation of image distance v with object distance u in this case. **2**

Section 'D'

All questions are compulsory. In case of internal choices, attempt any one.

26. A rectangular loop which was initially inside the region of uniform and time - independent magnetic field, is pulled out with constant velocity v as shown in the figure. **3**
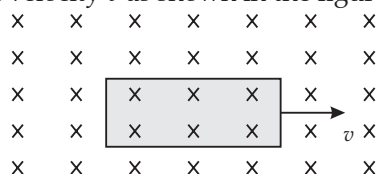
(a)

(a) Sketch the variation of magnetic flux, the induced current, and power dissipated as Joule heat as function of time.

(b) If instead of rectangular loop, circular loop is pulled out; do you expect the same value of induced current? Justify your answer. Sketch the variation of flux in this case with time.

27. A variable resistor R is connected across a cell of emf E and internal resistance r.

(a) Draw the circuit diagram.

(b) Plot the graph showing variation of potential drop across R as function of R.

(c) At what value of R current in circuit will be maximum.

OR

A storage battery is of emf 8 V and internal resistance 0.5 ohm is being charged by d.c. supply of 120 V using a resistor of 15.5 ohm

(a) Draw the circuit diagram.

(b) Calculate the potential difference across the battery.

(c) What is the purpose of having series resistance in this circuit? **3**

28. (a) Explain de-Broglie argument to propose his hypothesis. Show that de-Broglie wavelength of photon equals electromagnetic radiation.

(b) If, deuterons and alpha particle are accelerated through same potential, find the ratio of the associated de-Broglie wavelengths of two.

OR

State the main implications of observations obtained from various photoelectric experiments. Can these implications be explained by wave nature of light? Justify your answer. **3**

29. Derive an expression for the frequency of radiation emitted when a hydrogen atom de-excites from level n to level $(n-1)$. Also show that for large values of n, this frequency equals to classical frequency of revolution of an electron. **3**

30. (a) Give one point of difference between nuclear fission and nuclear fusion.

(b) Suppose we consider fission of a $^{56}_{26}Fe$ into two equal fragments of $^{28}_{13}Al$ nucleus. Is the fission energetically possible? Justify your answer by working out Q value of the process.

Given $(m)^{56}_{26}Fe = 55.93494$ u and $(m)^{28}_{13}Al = 27.98191$ **3**

Section 'E'

All questions are compulsory. In case of internal choices, attempt any one.

31. (a) State Gauss's law in electrostatics. Show that with help of suitable figure that outward flux due to a point charge Q, in vacuum within gaussian surface, is independent of its size and shape.

(b) In the figure there are three infinite long thin sheets having surface charge density $+2\sigma$, -2σ and $+\sigma$ respectively. Give the magnitude and direction of electric field at a point to the left of sheet of charge density $+2\sigma$ and to the right of sheet of charge density $+\sigma$. **5**

$$2\sigma \qquad -2\sigma \qquad \sigma$$

A | B | C | D
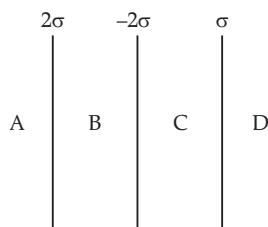
OR

(a) Define an ideal electric dipole. Give an example.

(b) Derive an expression for the torque experienced by an electric dipole in a uniform electric field. What is net force acting on this dipole.

(c) An electric dipole of length 2 cm is placed with its axis making an angle of 60° with respect to uniform electric field of 10^5 N/C. If it experiences a torque of $8\sqrt{3}$ Nm, calculate the magnitude of charge on the dipole, and its potential energy.

32. (a) Derive the expression for the current flowing in an ideal capacitor and its reactance when connected to an *ac* source of voltage $V = V_0 \sin\omega t$.

(b) Draw its phasor diagram.

(c) If resistance is added in series to capacitor what changes will occur in the current flowing in the circuit and phase angle between voltage and current.

OR

(a) State the principle of *ac* generator.

(b) Explain with the help of a well labelled diagram, its working and obtain the expression for the emf generated in the coil.

(c) Is it possible to generate emf without rotating the coil? Explain   **5**

33. (a) Define a wave front.

(b) Draw the diagram to show the shape of plane wave front as they pass through (i) a thin prism and (ii) a thin convex lens. State the nature of refracted wave front.

(c) Verify Snell's law of refraction using Huygen's principle.

OR

(a) State two main considerations taken into account while choosing the objective of astronomical telescope.

(b) Draw a ray diagram of reflecting type telescope. State its magnifying power.

(c) State the advantages of reflecting type telescope over the refracting type?

■■■

Solutions of Question Paper 1

Section 'A'

1. Magnetic dipole moment   **1**
2. Any one use of micro waves   **1**

Detailed Answer :

The wavelength is of Microwave range.

Use of microwave:

(i) Satellite communication

(ii) Medical treatment

(iii) Food preparation

(mention any one)

OR

1 : 1

Detailed Answer :

Velocity of light wave is independent of frequency.

So, both the light wave have same velocity.

So, the ratio will be 1:1.

3. Zero   **1**

Detailed Answer :

Since the magnetic field is perpendicular to the velocity, so there will be no work on the charged particle.

4. Remains same   **1**

Detailed Answer :

$$L = \mu \frac{N^2 A}{l}$$

So, inductance is independent of the current through the solenoid.

So, the inductance remains unchanged even if the current changes.

OR

7.07A, 50Hz   **½ + ½**

Detailed Answer :

$$I_{eff} = I_0/\sqrt{2}$$

$$= 10/\sqrt{2}$$

$$= 7.07A$$

Angular frequency $= \omega = 314$

$$2\pi f = 314$$

$$f = 314/2\pi$$

$$\therefore \quad f = 50Hz$$

5. $\dfrac{h}{2\pi}$ **1**

Detailed Answer :

The moment of linear momentum $L = nh / 2\pi$

For $n = 2$, angular momentum $= 2 \times h/2\pi$

$= h/\pi$

6. 4 eV   **1**

Detailed Answer :

Since the stopping potential is 4V, the maximum kinetic energy of photo electrons

$=$ Charge $\times$ stopping potential

$= 4$ eV

7. Antinutrino   **1**

OR

Electron   **1**

Detailed Answer :

$^{22}_{11}$Na in beta decay (electron) emitting a positron into $^{22}_{11}$Ne

8. Decreases   **1**

OR

25 Hz   **1**

9. Dynamic resistance $= \dfrac{\text{Change in voltage}}{\text{Change in current}}$ **1**

Detailed Answer :

Dynamic resistance $= \dfrac{\text{Change in voltage}}{\text{Change in current}}$

$$= \frac{0.71 - 0.70}{10 \times 10^{-3}}$$

$$= 1 \, \Omega$$

10. Photodiode   1
Detailed Answer :

Photodiode is a specially fabricated pn junction diode which is used for detecting light intensity.

11. (a) Both A and R are true and R is the correct explanation of A   1
Detailed Answer :

When an electric dipole placed in a uniform electric field at an angle θ with the field, The dipole experiences a torque.

The torque produced by two parallel forces qE acting as couple $= \tau$

$$\tau = q\text{E}2\,l\,\sin\theta$$

In case of non-uniform field, force acting on both the ends of the dipole will not be equal. So, there will be a combination of couple and a net force. In this way, dipole will have both rotational as well as linear motion.

So, both assertion and reason are true. Reason also explains the assertion.

12. (a) Both A and R are true and R is the correct explanation of A   1
Detailed Answer :

$$\vec{E} = -\vec{\nabla} V$$

So, The electric field is always perpendicular to equipotential surface.

Negative gradient of electric potential is electric field. So, direction of electric field must have in the direction of the decreasing order of electric potential.

13. (c) A is true but R is false   1
Detailed Answer :

Convex mirror always form virtual image. So, the assertion is true.

Parallel rays incident on convex mirror do not actually meet. They get reflected in such a manner that their extension meet at a point. So, the reason is false.

14. (b) Both A and R are true but R is NOT the correct explanation of A.   1
Detailed Answer :

For normal adjustment, a 30 cm lens final image cannot form image at the near point (25 cm from the eye). So the statement is true.

For image at infinity, angular magnification of simple microscope is given by
M = D/f.

So, the reason is also true. But reason does not explain the assertion.

15. (1) (c) Copper

Detailed Answer :

A Faraday cage or Faraday shield is an enclosure made of a conducting material.

Since copper is the only metal given in the list of options, copper is the correct answer.

(2) (a) car
Detailed Answer :

Cars are examples of Faraday Cages in the real world. Cars can help keep ourselves safe from lightning. Its metal body acts as a Faraday Cage.

(3) (c) zero
Detailed Answer :

The fields within a conductor cancel out with any external fields, so the electric field within the enclosure is zero.

(4) (a) $-q$
Detailed Answer :

If a charge is placed inside an ungrounded Faraday shield without touching the walls of the internal face of the shield becomes charged with $-q$, and $+q$ accumulates on the outer face of the shield. If the cage is grounded, the excess charges will be neutralized by the ground connection.

(5) (c) 2.0×10^5 Nm²/C leaving the surface
                    (any 4 parts to be attempted)
Detailed Answer :

The number of electric field lines passing through the cube normally and leaving the surface = Q/ε_0
$$Q = 2\mu C = 2 \times 10^{-6} C$$
$$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$$
$$\therefore \quad Q/\varepsilon_0 = 2.2 \times 10^5 \text{ C}^2/\text{Nm}^2$$

16. (1) (b) Its critical angle with reference to air is too small.
Detailed Answer :

Light cannot easily escape a diamond, because its critical angle with air is too small. Most of the reflections are total, and it is cut so that light can exit only in particular direction —thus light is concentrated inside and making the diamond sparkle.

(2) (a) 2.42
Detailed Answer :

Refractive index = 1/ sinC
C = critical angle = 24.4
$\therefore \mu$ = 1/sin 24.4 = 1/0.4131 = 2.42

(3) (c) high refractive index
Detailed Answer :

The brilliance of diamond is due to its too small critical angle with air. As the critical angle

become smaller, value of sine of critical angle also become small and hence refractive index increases (since $\mu = 1/\sin C$). So, the basic reason for the extraordinary sparkle of suitably cut diamond is its high refractive index.

(4) (d) increase

Detailed Answer :

A diamond is immersed in a liquid with a refractive index greater than water. Then the critical angle for total internal reflection will increase.

This is because, as the refractive index of outer medium increases, the refracted ray will bend less away from normal. So, for angle of incidence should increase more to achieve 90° angle of refraction.

(5) (a) less than first   (any 4 parts to be attempted)

Detailed Answer :

The brilliance of diamond in the second diamond will be less than the first since in the second case no total internal reflection has taken place.

17. Explanation by showing magnetic field directions in all three regions   **1**

Concluding left of region 1.   **1**

Detailed Answer :

Magnetic field strength at a point P (where the resultant magnetic field is zero), at a distance r due to

left wire $= B_1 = \dfrac{\mu_0 I_1}{2\pi r}$

right wire $= B_2 = \dfrac{\mu_0 I_2}{2\pi r}$

The fields are oppositely directed.

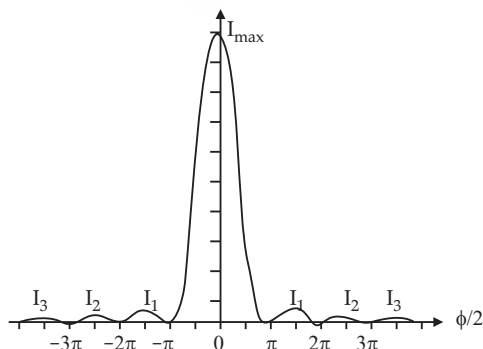Region I   Region II   Region III

$+x$
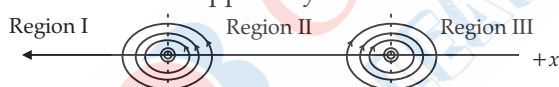
Since $I_2 > I_1$, the point P cannot be in region II or III.

It will be in the region I.

18. Plot of Intensity distribution of diffraction with proper labelling.   **2**

Detailed Answer :

OR

$$\dfrac{n\lambda}{d} = \dfrac{2\lambda}{a}$$

$n = \dfrac{2d}{a}$,where d is separation between slit and a width of slit

Detailed Answer :

Let the width of each slit $= a$

The separation between m maxima in a double slit experiment $= y_m$

$$y_m = m\dfrac{\lambda D}{d}$$

D = distance between screen and slit

d = separation between slits.

Angular separation between m maxima $= \theta_m$

$$\theta_m = y_m/D = \dfrac{\lambda m}{d}$$

Now,

Angular separation between n bright fringes $= \theta_n$

$$\theta_n = \dfrac{\lambda m}{d} \qquad \ldots (1)$$

The angular width of central maximum in the diffraction pattern due to single slit $= \theta_n$

$$2\theta_1 = 2\dfrac{\lambda}{a} \qquad \ldots(2)$$

a = width of single slit

Equating (1) and (2)

$$\dfrac{n\lambda}{d} = 2\dfrac{\lambda}{a}$$

$\therefore \qquad\qquad a = 2d/n$

19. Derivation including both terms electrostatic energy in system and in external field   **1 + 1**

Detailed Answer :

V_1 = electric potential at the point having position vectors r_1

V_2 = electric potentials at the point having position vectors r_2.

$q_1 V_1$ = Work done in bringing q_1 from infinity to r_1 against the external field

$q_2 V_2$ = Work done in bringing q_2 from infinity to r_2 against the external field

$\dfrac{1}{4\pi\varepsilon_0} \times \dfrac{q_1 q_2}{r^2}$ = Work done on q_2 against the force exerted by q_1

(r_{12} is the distance between q_1 and q_2.)

So, the total potential energy of the system

$$= q_1 V_1 + q_2 V_2 + \dfrac{1}{4\pi\varepsilon_0} \times \dfrac{q_1 q_2}{r^2}$$

OR

Derivation of relation $E = \dfrac{-dV}{dr}$

Diagram of equipotential surfaces   **1 + 1**

Detailed Answer :

A and B are two points separated by a small distance dr in an electric field E.

dr being small, the electric field E may be assumed uniform along AB. By definition, the force acting on a unit positive charge at A is equal to E.

The work done to move a unit positive charge from A to B against the electric field is $dW = -Edr$.

The negative sign indicates that the work is done against the direction of the field.

Again the work done = potential difference dV between A and B

i.e. $dV = -Edr$

$\therefore$ $E = -dV/dr$

Magnitude of electric field increasing at constant rate along –Z direction means it is decreasing along +Z direction. So, along +Z direction the distance between the equipotential surfaces increases for same potential difference.

$d_1 < d_2$
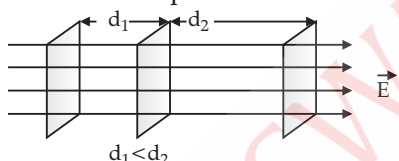
20. Circuit diagram showing biasing of LED in F.B
                                                    ½

Action of LED   **1**

For emission in visible range least band energy required is 1.8 eV   ½

Detailed Answer :
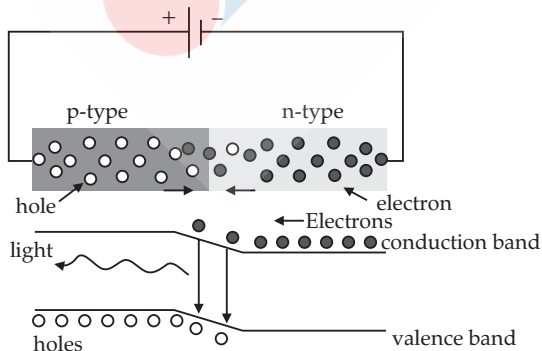
When Light Emitting Diode (LED) is forward biased, free electrons in the conduction band recombines with the holes in the valence band and releases energy in the form of light.

The wavelength of electromagnetic radiation

for it to lie in the visible region should lie in the range of 4000Å−7000Å.

Band gap energy = hc/λ

$$= \dfrac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{7000 \times 10^{-10} \times 1.6 \times 10^{-19}}$$

$$= 1.8 \text{ eV}$$

21. Calculation of magnetic flux $\phi = BA\cos\theta$,

where $\theta = 30° = \sqrt{\dfrac{3}{2}} \times 10^{-3}$ Wb   **1**

Calculation of induced emf $E = A.\cos\theta \dfrac{dB}{dt}$

$= 0.5$V.   **1**

Detailed Answer :

$$\phi = BA \cos\theta$$
$$B = 10^{-1}\text{T}$$
$$A = 100 \text{ cm}^2 = 10^{-2}\text{ m}^2$$
$$\cos\theta = \cos 300 = \dfrac{\sqrt{3}}{2}$$

$\therefore$ $\phi = 10^{-1} \times 10^{-2} \times \dfrac{\sqrt{3}}{2}$

$\therefore$ $\phi = \dfrac{\sqrt{3}}{2} \times 10^{-3}$ Wb

Induced emf $= |e| = d\phi/dt$

$$= \dfrac{\dfrac{\sqrt{3}}{2} \times 10^{-3}}{10^{-3}}$$

$$= \dfrac{\sqrt{3}}{2} \text{ V}$$

22. Path difference $= \dfrac{3\lambda}{2}$ **1**
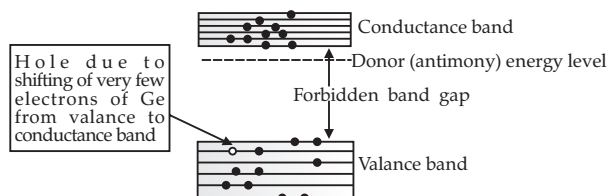
Putting value we will get $\lambda = 3$ cm   **1**

23. Well labelled energy band diagram of *n*-type semiconductor   **1**

n-type semiconductor   ½

electrons-majority charge carriers   ½

Detailed Answer :

This is an *n*-type extrinsic semiconductor.

Majority carriers are electrons.
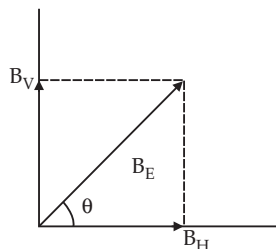
24. Definition of each term   ½ + ½

Diagram showing relation   **1**

Detailed Answer :

MAGNETIC INCLINATION : It is the angle between resultant magnetic field of earth and the horizontal.

HORIZONTAL COMPONENT of EARTH's MAGNETIC FIELD: It is the component of earth's magnetic field in the horizontal direction.

B_E = Earth's net magnetic field.

B_V = vertical component

B_H = Horizontal component

θ = Magnetic inclination

∴ $\qquad B_H = B_E \cos \theta$

OR

$$\frac{B_V}{B_H} = \tan \theta \qquad \textbf{1}$$

Putting values, $\quad \theta = 30°$ **1**

Detailed Answer :

$$B_V / B_H = \tan \theta$$

or, $\qquad \dfrac{B_V}{\sqrt{3}B_V} = \tan \theta$

or, $\qquad 1/\sqrt{3} = \tan \theta$

∴ $\qquad \theta = 30°$

25. Two characteristics- virtual and enlarged image and same side of object. **1**

As u and v both negative, we get $\dfrac{1}{v} = \dfrac{1}{u} - \dfrac{1}{f}$

Interpret $y = mx + c$, plot of the graph **1**

Detailed Answer :

Characteristics of the image formed (any two)

(i) Virtual

(ii) Enlarged

(iii) On the same side of the object

The lens formula:

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

For virtual image

u is –ve

v is –ve

f is +ve

So, the equation becomes,

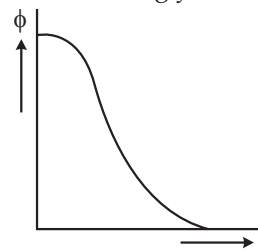$$\frac{1}{v} = \frac{1}{u} - \frac{1}{f}$$

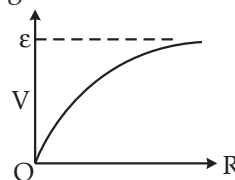which is a straight line in the form y = $mx - c$

26.

½
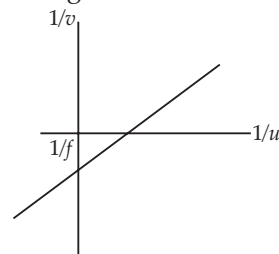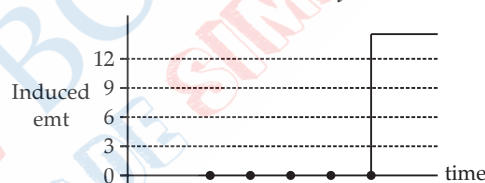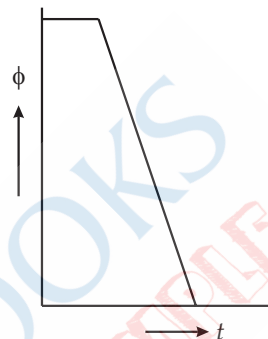
Induced current and power, sketch is same as shown above. In case of circular coil, rate of change of area of the loop during its passage out of field is not constant, hence induced current varies accordingly. **1**
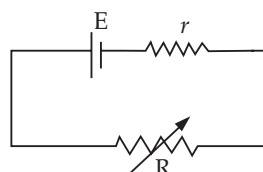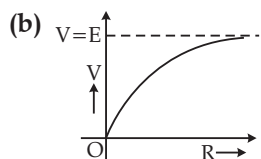

27. Circuit diagram **1**
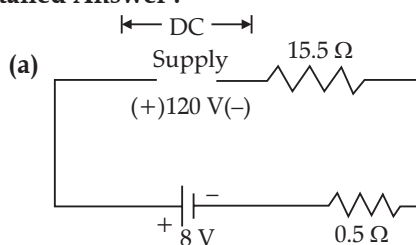

1

Maximum current drawn will be at R = 0 **1**

Detailed Answer :

(a)

(b)

(c) Current in the circuit = I = E/(R + r)

So, the current will be maximum when R = 0.

OR

Circuit diagram	**1**
Applying correct formula	½
And caluation of p.d = 11.5 V	½

Series resistor limits the current drawn from source **1**

Detailed Answer :

(a)

(b) emf of storage battery = E = 8 V

Internal resistance = r = 0.5 Ω

DC supply voltage = V_a = 120 V

Charging through R = 15.5 Ω

Current on the circuit = I = $(V_a – E)/(R + r)$

Or,   I = (120 – 8)/(15.5 + 0.5)

∴   I = 7A

Potential across the storage battery = V = E + Ir

Or,   V = 8 + 7 x 0.5

∴   V = 11.5 V

(c) The purpose of series resistor in the circuit is to limit the current drawn from DC source.

28. de-Broglie reasoned out that nature was symmetrical and two basic physical entities –mass and radiation must be symmetrical. If radiation shows shows dual aspect than matter should do so. **1**

de-Broglie equation :

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

For photon :

$$p = \frac{h\nu}{c}$$

Therefore, $\frac{h}{p} = \frac{c}{\nu} = \lambda$

As $\lambda = \frac{h}{\sqrt{2mk}}$

So, alpha particle will be having shortest de-Broglie wavelength compared to deutrons.

Detailed Answer :

(a) de-Broglie argument : To explain some phenomenon, like photoelectric effect, light is considered to be particle in nature. To explain some phenomenon, like interference, diffraction and polarization, light is considered to be wave in nature.

de-Broglie argued that nature is symmetrical and two basic physical entities–mass and radiation must be symmetrical. If radiation shows dual aspect than matter should do so. if light can behave as wave in some situations and as particle in other situations then we may expect that those entities which ordinarily behave like a particle will exhibit wave properties under suitable circumstance. Electron and other material particle can therefore show wave properties

de- Broglie wavelength of photon = λ = h/p

Momentum of photon = p = $h\lambda/c$

Hence $\lambda = \dfrac{h}{\frac{h\nu}{c}}$

$$= c/\lambda$$

This shows that de-Broglie wavelength of photon equals electromagnetic radiation.

(b) de-broglie wavelength = λ= h/p

$$p = mv = \sqrt{2mqv}$$

∴ $\lambda = h/\sqrt{2mqv}$

For deuteron,

∴ $\lambda_d = h/\sqrt{2m_a q_a v}$

For alpha particle,

$$\lambda_a = h/\sqrt{2m_a q_a v}$$

∴ $\dfrac{\lambda_d}{\lambda_a} = \sqrt{\dfrac{m_a q_q}{m_a q_d}}$

$$= \sqrt{\dfrac{4 \times 2}{2 \times 1}}$$

$$= 2{:}1$$

OR

Main implications :

1. Kinetic energy of emitted electrons depends upon frequency, but not on intensity of radiation. **1**

2. There exist a frequency of radiation below which no photoemission takes place, how high intensity of radiation may be. **1**

Explanation wave nature of radiation fails to explain photoelectric effect. **1**

29. Derivation of frequency of radiation emitted when a hydrogen atom de-excites from level n to level $(n-1)$. **2**

$$\nu = \frac{me^4(2n-1)}{(4\pi)^2\left(\frac{h}{2\pi}\right)^3 n^2(n-1)^2}$$

Comparing for large values of n, with classical frequency $\nu = \dfrac{v}{2\pi r}$ **1**

Detailed Answer :

The frequency of emitted radiation when a hydrogen atom de-excites from level n to level $(n-1) = \nu$

$$\nu = \frac{me^2}{(4\pi)^2\varepsilon_0^2(h/2\pi)^2}\left[\frac{1}{(n-1)^2}-\frac{1}{n^2}\right]$$

$$\nu = \frac{me^2}{(4\pi)^2\varepsilon_0^2(h/2\pi)^2}\left[\frac{n^2-(n-1)^2}{(n-1)^2 n^2}\right]$$

$$\therefore \quad \nu = \frac{(2n-1)me^4}{(4\pi)^2 e_0^2(h/2\pi)^2(n-1)^2} \quad \text{...(i)}$$

For large n,

$$2n-1 \simeq 2n$$
$$n-1 \simeq n$$

Putting in eqn (i)

$$\therefore \quad \nu = \frac{2\pi me^4}{(4\pi)^3\varepsilon_0^2(h/2\pi)^3 n^2 n^2}$$

$$\therefore \quad \nu = \frac{me^4}{32\pi^3\varepsilon_0^2(h/2\pi)^3 n^3}$$

classical frequency of revolution of an electron $= \nu_c$

$$\nu_c = \frac{v}{2\pi r} \quad \text{...(ii)}$$

where, $$v = \frac{n\left(\frac{h}{2\pi}\right)}{mr}$$

and $$r = \frac{4\pi\varepsilon_0\left(\frac{h}{2\pi}\right)^2 n^2}{me^2}$$

Replacing v in equion (ii)

$$\nu_c = \frac{n\left(\frac{h}{2\pi}\right)}{2\pi m\left[\frac{4\pi\varepsilon_0\left(\frac{h}{2\pi}\right)^2 n^2}{me^2}\right]}$$

or $$\nu_c = \frac{n\left(\frac{h}{2\pi}\right)}{2\pi m\left[\frac{16\pi\varepsilon_0^2\left(\frac{h}{2\pi}\right)^4 n^4}{m^2 e^2}\right]}$$

$$\therefore \quad \nu_c = \frac{me^4}{32\pi^2\varepsilon_0^2(h/2\pi)^3 n^3}$$

So, $\nu = \nu_c$ for large value of n.

30. One difference between nuclear fission and nuclear fusion

Calculating $Q = ((m)\text{Fe} - 2(m)\text{A}l)\,C^2$
$= -26.90$ MeV **1**

Justification not possible **1**

Detailed Answer :

(a) Difference between nuclear fission and nuclear fusion: (any one)

(i) Fission is the splitting of a large atom into two or more smaller ones.

Fusion is the fusing of two or more lighter atoms into a larger one.

(ii) Fission reaction does not normally occur in nature.

Fusion occurs in stars, such as the sun.

(iii) For fission, little energy is required.

For fusion, Extremely high energy is required.

(iv) For fission, Uranium is the primary fuel used in power plants.

Deuterium and Tritium are the primary fuel used in experimental fusion power plants.

(b) Let us consider the fission of a $^{56}_{26}$Fe into two equal fragments of $^{28}_{13}$Al nucleus.

Q value $= (55.93494 - 2 \times 27.98191) \times 931.5$
$= -26.9$ MeV

Q is negative. Hence fission is not possible.

31. (a) Statement of Gauss law

Proof of outward flux due to a point charge Q, in vacuum within gaussian surface, is independent of its size and shape **2**

(b) Net electric field towards left $= \dfrac{\sigma}{\varepsilon}$ left **1**

Net electric field towards right $= \dfrac{\sigma}{\varepsilon}$ right **1**
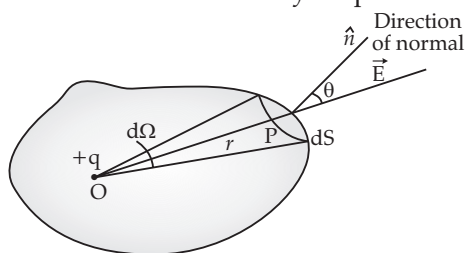
Detailed Answer :

(a) Gauss Law : Gauss's law states that the electric flux φE emerging out from any closed surface is equal to the net charge Σq enclosed by the surface divided by ε_0 i.e.

$$\phi_E = \Sigma q/\varepsilon_0$$

or, $$\oint \vec{E}.\vec{ds} = \Sigma q/\varepsilon_0$$

A point charge Q is enclosed within a closed gaussian surface of arbitary shape in vacuum.

Let us consider an elementary area ds about point P whose position vector is $\vec{r}$.

$\hat{n}$ is the unit vector along the normal to the surface ds.

$\hat{n}$ makes and angle θ with the radius vector $\vec{r}$.

$\vec{E}$ is directed along $\vec{r}$.

$\vec{ds}$ is directed along $\hat{n}$.

$$d\phi_E = \vec{E} \cdot \vec{ds} = E ds \cos\theta$$

As $$E = \frac{Q}{4\pi\varepsilon_0 r^2}, \text{ where } r = OP$$

∴ $$d\phi_E = \frac{Q}{4\pi\varepsilon_0 r^2} ds \cos\theta$$

or, $$\phi_E = \frac{Q}{4\pi\varepsilon_0} \int \frac{ds \cos\theta}{r^2}$$

Since $\frac{ds \cos\theta}{r^2}$ is a small solid angle $d\Omega$ subtended by the elementary area ds at the point Q, so

$$d\phi_E = \frac{Q}{4\pi\varepsilon_0} \int d\Omega$$

or, $$d\phi_E = \frac{Q}{4\pi\varepsilon_0} 4\pi$$

∴ $$d\phi_E = \frac{Q}{\varepsilon_0}$$

So, the outward flux due to a point charge Q, in vacuum within gaussian surface, is independent of its size and shape.

(b) Electric field at a point to the left of sheet of charge density $+2\sigma$:

Electric field due to 1st plate having charge density 2σ is $\frac{2\sigma}{\varepsilon_0}$ towards left

Electric field due to 2nd plate having charge density - 2σ is $\frac{2\sigma}{\varepsilon_0}$ towards right

Electric field due to 3rd plate having charge density σ is $\frac{\sigma}{\varepsilon_0}$ towards left

So, net electric field $= \frac{2\sigma}{\varepsilon_0} - \left(\frac{2\sigma}{\varepsilon_0} + \frac{\sigma}{\varepsilon_0}\right) = -\frac{\sigma}{\varepsilon_0}$

So, the net electric field is $\frac{\sigma}{\varepsilon_0}$ towards left.

Similarly, electric field at a point to the left of sheet of charge density σ is $\frac{\sigma}{\varepsilon_0}$ towards right.

OR

Definition of ideal dipole + example   ½ + ½
Derivation of torque   **2**
Putting values in correct formula and solving, value of charge and potential energy **1**

$$Q = 8 \times 10^{-3} \text{ C}$$
$$U = -8 \text{ J}$$ **1**

Detailed Answer :

(a) An ideal electric dipole is one in which the two equal and opposite point charges whose magnitudes tend to infinity are separated by a distance which tends to zero.

Example: molecules of water , ammonia etc.

(b) A dipole AB having charges $\pm q$ separated by a distance $2l$ is placed in a uniform electric field so that the; line joining the two charges makes an angle θ with the field lines.
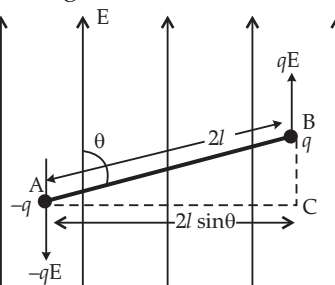
The two charges equal but opposite forces of magnitude F = QE and thus form a couple.
The torque due to these forces is given by

$$\tau = F \times AC = QE \times 2l \sin\theta$$

Force on positive charge = QE
Force on negative charge = – QE
So, net charge on the dipole = 0
(b) $\tau = QE \times 2l \sin\theta$
Given :

$$\tau = 8\sqrt{3} \text{ Nm}$$

$E = 10^5$ N/C

$2l = 2$ cm $= 2/100$ m

$\theta = 60°$

(i) Putting the values :

$$8\sqrt{3} = Q \times 10^5 \times \frac{2}{100} \times \sin 60°$$

Or, $\qquad 8\sqrt{3} = Q \times 10^5 \times \frac{2}{100} \times \frac{\sqrt{3}}{2}$

$\qquad Q = 8 \times 10^{-3}$ C

(ii) Potential energy $= U = -$ PEcos θ

$\qquad = -q \times 2l \times \cos 60°$

$\qquad = -8 \times \frac{2}{100} \times 10^5 \times \frac{1}{2}$

$\qquad = -8$ J

32. (a) Derivation of instantaneous current

$$i = i_o \sin\left(\omega t + \frac{\pi}{2}\right) \qquad \text{1}$$

Reactance, $\quad X_C = \frac{1}{\omega C} \qquad$ 1

Phasor diagram showing v and i relation in pure C $\qquad$ 1
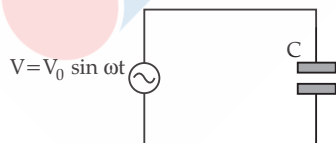
(b) Explanation that adding R it will behave RC series *ac* circuit.

Calculation of current and phase angle. $\quad$ **1 + 1**

Detailed Answer :

(a) An alternating voltage $V = V_0 \sin \omega t$ is supplied across the two ends of a capacitor of capacitance C.

At any instant the charge on capacitor $= q$

$$q = CV = C V_0 \sin \omega t$$

Current $= I = dq/dt$

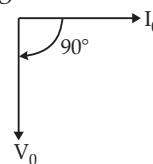$\qquad = \dfrac{d}{dt}$ (C $V_0 \sin \omega t$)

$\qquad = \omega C V_0 \cos \omega t$

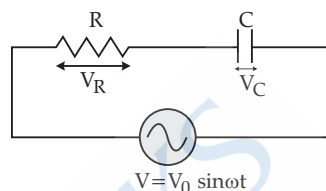$\qquad = \dfrac{V_0}{1/\omega C} \sin\left(\omega t + \dfrac{\pi}{2}\right)$

$\qquad = I_0 \sin\left(\omega t + \dfrac{\pi}{2}\right) \quad \left[I_0 = \dfrac{V_0}{1/\omega C}\right]$

Reactance $= X_C = 1/\omega C$

(b) Phasor diagram :

(c) A resistor is now connected with the capacitor in series :

Peak voltage drop across R is $I_0 R$

Peak voltage drop across C is $I_0 X_C$.
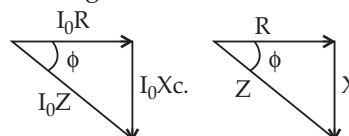
Voltage cross R is in phase with the current.

Voltage across C lags the current by 90°.

So, the voltage drops across R and across C are also not in phase. They are also out of phase by 90°.

So, $V_0 = \sqrt{(I_0 R)^2 + (I_m X_C)^2}$

$\therefore \quad I_0 = \dfrac{V_0}{\sqrt{R^2 + X_C^2}}$

The phase angle by which the current leads the applied voltage is

Phase Angle $= \phi = \tan^{-1} \dfrac{X_C}{R}$

OR

(a) Principle of *ac* generator $\qquad$ 1

(b) Well labelled diagram $\qquad$ 1

$\qquad$ Brief working and emf expression $\qquad$ 2

(c) reason $\qquad$ 1

Detailed Answer :

(a) AC generator :

AC generator converts mechanical energy into electrical energy.

Principle : It works on the principle of electromagnetic induction.

(b) Working : It consists of

(i) Armature : A large number of turns of copper wire wound on a soft iron core.

(ii) Field magnets : Permanent magnet. Provides strong magnetic fields. Armature coil rotates perpendicular to the magnetic field lines.

(iii) Slip rings : Used to provide mobile contacts with external circuit.

(iv) Brushes : Carbon pieces, used to pass the electric current generated in armature to the external circuit.

N S
Field magnet
Armature
slip rings
carbon brush
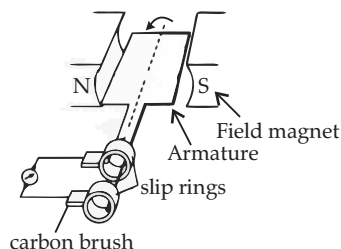
Theory : PQRS is the armature coil rotates freely in a uniform magnetic field B.

When the coil rotates with an angular velocity ω, at any instant the flux is given

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

The induced emf set up in the coil is given by

$$\varepsilon = -d\phi/dt = -(BA \cos \omega t) = \omega BA \sin \omega t$$

If the coil has N turns, then the total induced emf is

$$\varepsilon = NBA\omega \sin \omega t$$
$$= \varepsilon_0 \sin \omega t \qquad [\text{where } \varepsilon_0 = NBA\omega]$$
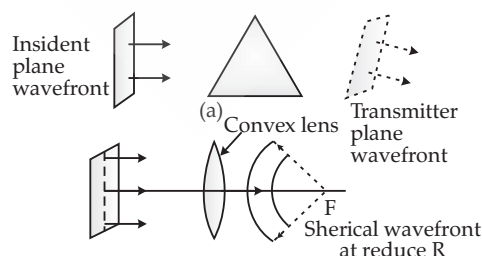$$= \varepsilon_0 \sin 2\pi ft$$

[f = frequency of rotation of armature]

(c) No. To develop an induced emf, there should be relative motion between the coil and the magnetic field.

33. (a) Definition of wave front   1
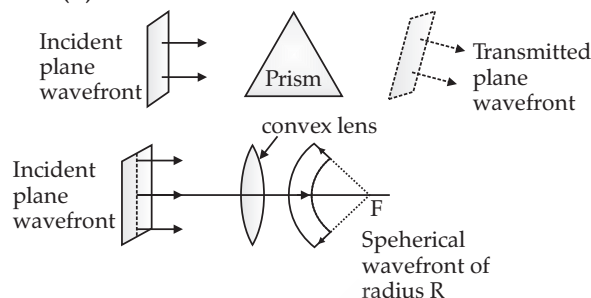
(b) Ray diagram showing shapes of wave front

Insident plane wavefront
(a) Convex lens
Transmitter plane wavefront
F
Sherical wavefront at reduce R

1 + 1

(c) Proof of Snell's law   2

Detailed Answer :

(a) Wavefront : A wavefront is defined as the locus of points vibrating in the same phase.

(b)

Incident plane wavefront
Prism
Transmitted plane wavefront
convex lens
Incident plane wavefront
F
Speherical wavefront of radius R

(c) Proof of Snell's law:

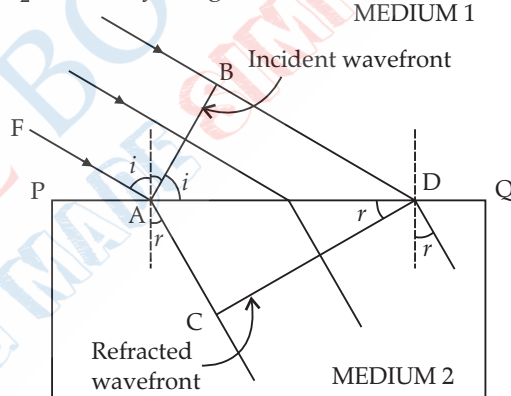A plane wavefront is incident on a surface PQ separating two media 1 and 2.

n_1 = refractive index of medium 1 (rarer medium)

n_2 = refractive index of medium 2 (denser medium)

c_1 = velocity of light in medium 1

c_2 = velocity of light in medium 2

MEDIUM 1
B Incident wavefront
F
P i i D Q
A r r
C
Refracted wavefront   MEDIUM 2

i = The angle between the incident ray FA and the normal at the point of incidence.

= angle between the incident plane wavefront AB and the surface of separation PQ.

Similarly,

r = angle between the refracted wavefront CD and the surface of separation PQ

$\sin i = \sin \angle BAD = BD/AD = c_1 t/AD$

$\sin r = \sin \angle ADC = AC/AD = c_2 t/AD$

$\sin i / \sin r = c_1/c_2$ = constant

Thus Snell's law is proved.

OR

(a) choice of objective   1

(b) ray diagram of reflecting type telescope   **2 + 1**
Formula of magnifying power

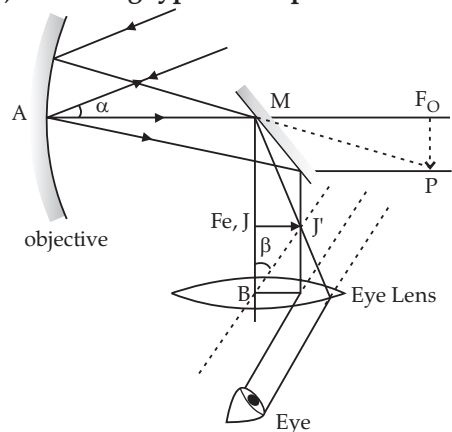**(c)** stating two advantages   **2**

Detailed Answer :

(a) The main considerations with an astronomical telescope:

(i) The diameter of the objective on which the brightness of the image, resolving power depend.

(ii) The focal length of the objective on which the magnification ($M = f_O/f_E$) depends.

(b) Reflecting type telescope :

Magnifying power = M = f_O/f_E

(c) Advantages of reflecting type telescope over refracting type telescope:

(i) Mirrors do not cause chromatic aberration.

(ii) Mirrors are easier and cheaper to build.

(iii) Mirrors are easier to mount because the back of the mirror can be used to attach to the mount.

(iv) Image is brighter compared to the image formed in refracting type telescope

■■■