Sample Question Paper-1

(Issued by Board dated 16th September 2022)

PHYSICS (042)

Class-XII

SOLVED

Maximum Marks: 70 **Time Allowed: 3 hours**

General Instructions:

(i) There are 35 questions in all. All questions are compulsory

(ii) This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.

(iii) Section A contains eighteen MCQs of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.

(iv) There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.

(v) Use of calculators is not allowed.

Section – A

1. According to Coulomb's law, which is the correct relation for the following figure?

(A) $q_1 q_2 > 0$ **(B)** $q_1 q_2 < 0$

(C) $q_1 q_2 = 0$ **(D)** $1 > \frac{q_1}{q_2} > 0$ **1**

2. The electric potential on the axis of an electric dipole at a distance 'r from it's centre is V. Then the potential at a point at the same distance on its equatorial line will be

(A) $2V$ **(B)** –V

(C) $\frac{V}{2}$ **(D)** Zero **1**

3. The temperature (T) dependence of resistivity of materials A and material B is represented by fig (i) and fig (ii) respectively. Identify material A and material B.

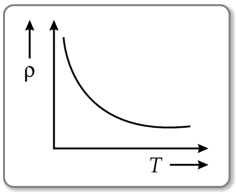


fig. (i)

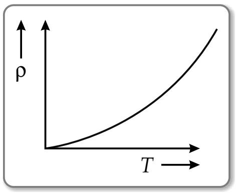


fig. (ii)

(A) material A is copper and material B is germanium

(B) material A is germanium and material B is copper

(C) material A is nichrome and material B is germanium

(D) material A is copper and material B is nichrome **1**

4. Two concentric and coplanar circular loops P and Q have their radii in the ratio 2:3. Loop Q carries a current 9 A in the anticlockwise direction. For the magnetic field to be zero at the common centre, loop P must carry

(A) 3 A in clockwise direction
(B) 9 A in clockwise direction
(C) 6 A in anti-clockwise direction
(D) 6 A in the clockwise direction. **1**

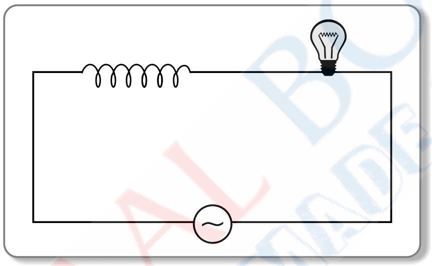
5. A long straight wire of circular cross section of radius a carries a steady current I. The current is uniformly distributed across its cross section. The ratio of the magnitudes of magnetic field at a point distant $\frac{a}{2}$ above the surface of wire to that at a point distant $\frac{a}{2}$ below its surface is

(A) 4 : 1 **(B)** 1 : 1
(C) 4 : 3 **(D)** 3 : 4 **1**

6. If the magnetizing field on a ferromagnetic material is increased, its permeability

(A) decreases **(B)** increases
(C) remains unchanged **(D)** first decreases and then increases **1**

7. An iron cored coil is connected in series with an electric bulb with an AC source as shown in figure. When iron piece is taken out of the coil, the brightness of the bulb will



(A) decrease **(B)** increase
(C) remain unaffected **(D)** fluctuate **1**

8. Which of the following statement is NOT true about the properties of electromagnetic waves?

(A) These waves do not require any material medium for their propagation
(B) Both electric and magnetic field vectors attain the maxima and minima at the same time
(C) The energy in electromagnetic wave is divided equally between electric and magnetic fields
(D) Both electric and magnetic field vectors are parallel to each other **1**

9. A rectangular, a square, a circular and an elliptical loop, all in the $(x - y)$ plane, are moving out of a uniform magnetic field with a constant velocity $\vec{v} = v\hat{i}$. The magnetic field is directed along the negative z-axis direction. The induced emf, during the passage of these loops, out of the field region, will not remain constant for

(A) any of the four loops
(B) the circular and elliptical loops
(C) the rectangular, circular and elliptical loops
(D) only the elliptical loops **1**

10. In a Young's double slit experiment, the path difference at a certain point on the screen between two interfering waves is $\frac{1}{8}$ th of the wavelength. The ratio of intensity at this point to that at the centre of a bright fringe is close to

(A) 0.80 **(B)** 0.74
(C) 0.94 **(D)** 0.85 **1**

11. The work function for a metal surface is 4.14 eV. The threshold wavelength for this metal surface is:

(A) 4125 Å **(B)** 2062.5 Å
(C) 3000 Å **(D)** 6000 Å **1**

12. The radius of the innermost electron orbit of a hydrogen atom is 5.3×10^{-11} m. The radius of the $n = 3$ orbit is

(A) 1.01×10^{-10} m **(B)** 1.59×10^{-10} m

(C) 2.12×10^{-10} m **(D)** 4.77×10^{-10} m 1

13. Which of the following statements about nuclear forces is not true?

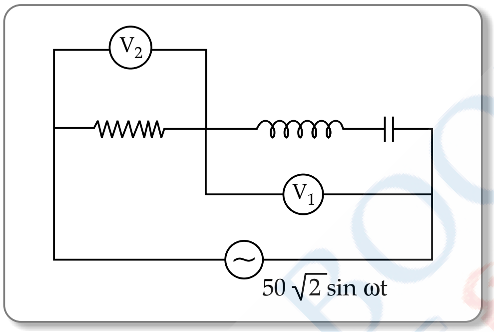
(A) The nuclear force between two nucleons falls rapidly to zero as their distance is more than a few femtometres.

(B) The nuclear force is much weaker than the Coulomb force.

(C) The force is attractive for distances larger than 0.8 fm and repulsive if they are separated by distances less than 0.8 fm.

(D) The nuclear force between neutron-neutron, proton-neutron and proton-proton is approximately the same. 1

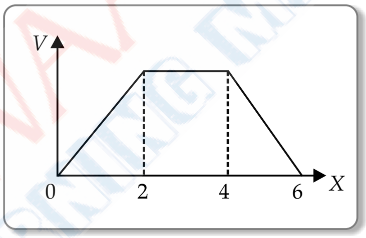
14. If the reading of the voltmeter V_1 is 40 V, then the reading of voltmeter V_2 is



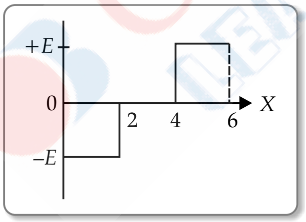
(A) 30 V **(B)** 58 V

(C) 29 V **(D)** 15 V 1

15. The electric potential V as a function of distance X is shown in the figure.



The graph of the magnitude of electric field intensity E as a function of X is

(A)


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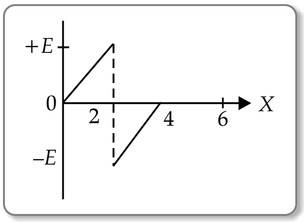
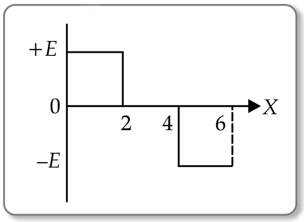


(C)


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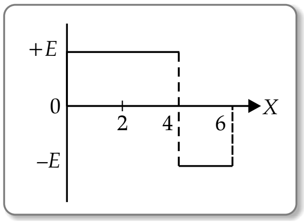


1

ASSERTION AND REASON

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

16. **Assertion (A):** The electrical conductivity of a semiconductor increases on doping.

Reason (R): Doping always increases the number of electrons in the semiconductor. 1

17. **Assertion (A):** In an interference pattern observed in Young's double slit experiment, if the separation (d) between coherent sources as well as the distance (D) of the screen from the coherent sources both are reduced to $\frac{1}{3}$ rd, then new fringe width remains the same.

Reason (R): Fringe width is proportional to $\left(\frac{d}{D}\right)$. **1**

18. **Assertion (A):** The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies.

Reason (R): The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal. **1**

Section – B

19. Electromagnetic waves with wavelength

(i) λ_1 is suitable for radar systems used in aircraft navigation.

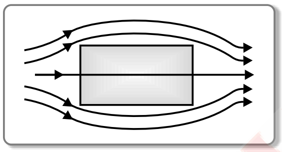
(ii) λ_2 is used to kill germs in water purifiers.

(iii) λ_3 is used to improve visibility in runways during fog and mist conditions.

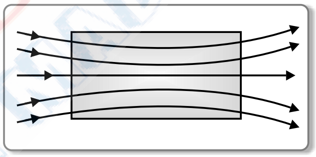
Identify and name the part of the electromagnetic spectrum to which these radiations belong. Also arrange these wavelengths in ascending order of their magnitude. **2**

20. A uniform magnetic field gets modified as shown in figure when two specimens A and B are placed in it.

(a)



(b)



(i) Identify the specimen A and B.

(ii) How is the magnetic susceptibility of specimen A different from that of specimen B? 2

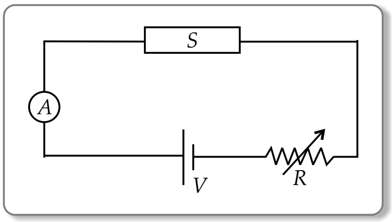
21. What is the nuclear radius of ^{125}Fe ,if that of ^{27}Al is 3.6 fermi?.

OR

The short wavelength limit for the Lyman series of the hydrogen spectrum is 913.4 A^0. Calculate the short wavelength limit for the Balmer series of the hydrogen spectrum. **2**

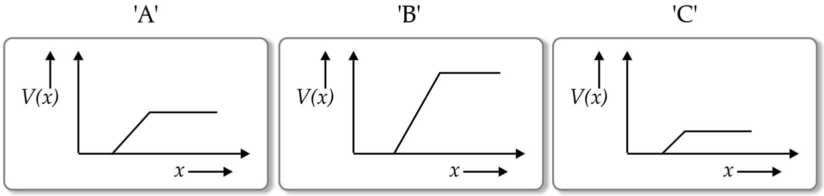
22. A biconvex lens made of a transparent material of refractive index 1.25 is immersed in water of refractive index 1.33. Will the lens behave as a converging or a diverging lens? Justify your answer. **2**

23. The figure shows a piece of pure semiconductor S in series with a variable resistor R and a source of constant voltage V. Should the value of R be increased or decreased to keep the reading of the ammeter constant, when semiconductor S is heated? Justify your answer



OR

The graph of potential barrier versus width of depletion region for an unbiased diode is shown in graph A. In comparison to A ,graphs B and C are obtained after biasing the diode in different ways .Identify the type of biasing in B and C and justify your answer.



2

24. A Narrow slit is illuminated by a parallel beam of monochromatic light of wavelength λ equal to 6000 Å and the angular width of the central maximum in the resulting diffraction pattern is measured. When the slit is next illuminated by light of wavelength λ', the angular width decreases by 30%. Calculate the value of the wavelength λ'. **2**

25. Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and of magnitude 17.7×10^{-22} C/m^2. What is electric field intensity E:

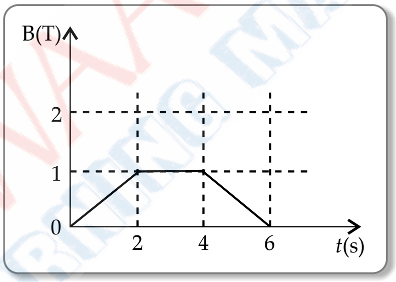
(a) in the outer region of the first plate, and

(b) between the plates? **2**

Section – C

26. Two long straight parallel conductors carrying currents I_1 and I_2 are separated by a distance *d*. If the currents are flowing in the same direction, show how the magnetic field produced by one exerts an attractive force on the other. Obtain the expression for this force and hence define 1 ampere. **3**

27. The magnetic field through a circular loop of wire, 12 cm in radius and 8.5 Ω resistance, changes with time as shown in the figure. The magnetic field is perpendicular to the plane of the loop. Calculate the current induced in the loop and plot a graph showing induced current as a function of time. **3**



28. An a.c. source generating a voltage $\varepsilon = \varepsilon_0 \sin \omega t$ is connected to a capacitor of capacitance C. Find the expression for the current I flowing through it. Plot a graph of ε and I versus ωt to show that the current is ahead of the voltage by $\frac{\pi}{2}$. **3**

OR

An ac voltage $V = V_0 \sin \omega t$ is applied across a pure inductor of inductance *L*. Find an expression for the current *i*, flowing in the circuit and show mathematically that the current flowing through it lags behind the applied voltage by a phase angle of $\frac{\pi}{2}$. Also draw graphs of *V* and *i* versus ωt for the circuit. **3**

29. Radiation of frequency 10^{15} Hz is incident on three photosensitive surfaces A, B and C. Following observations are recorded:

Surface A: no photoemission occurs

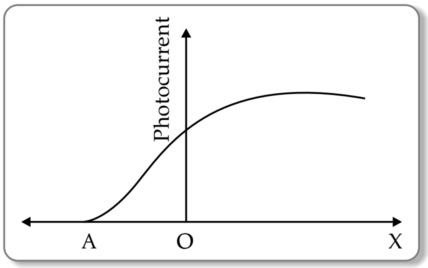
Surface B: photoemission occurs but the photoelectrons have zero kinetic energy.

Surface C: photo emission occurs and photoelectrons have some kinetic energy.

Using Einstein's photo-electric equation, explain the three observations. **3**

OR

The graph shows the variation of photocurrent for a photosensitive metal



(a) What does X and A on the horizontal axis represent?

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

(c) Draw this graph for three different values of intensities of incident radiation I_1, I_2 and I_3 ($I_3 > I_2 > I_1$) having the same frequency. **3**

30. The ground state energy of hydrogen atom is -13.6 eV. The photon emitted during the transition of electron from $n = 3$ to $n = 1$ state, is incident on a photosensitive material of unknown work function .The photoelectrons are emitted from the material with the maximum kinetic energy of 9 eV. Calculate the threshold wavelength of the material used. **3**

Section – D

31. **(a)** Draw equipotential surfaces for (i) an electric dipole and (ii) two identical positive charges placed near each other.

(b) In a parallel plate capacitor with air between the plates, each plate has an area of 6×10^{-3} m^2 and the separation between the plates is 3 mm.

(i) Calculate the capacitance of the capacitor.

(ii) If the capacitor is connected to 100V supply, what would be the the charge on each plate?

(iii) How would charge on the plate be affected if a 3 mm thick mica sheet of $k = 6$ is inserted between the plates while the voltage supply remains connected ? **5**

OR

(a) Three charges $-q$, Q and $-q$ are placed at equal distances on a straight line. If the potential energy of the system of these charges is zero, then what is the ratio $Q : q$?

(b) **(i)** Obtain the expression for the electric field intensity due to a uniformly charged spherical shell of radius R at a point distant r from the centre of the shell outside it.

(ii) Draw a graph showing the variation of electric field intensity E with r, for $r > R$ and $r < R$.

32. **(a)** Explain the term drift velocity of electrons in a conductor. Hence obtain the expression for the current through a conductor in terms of drift velocity.

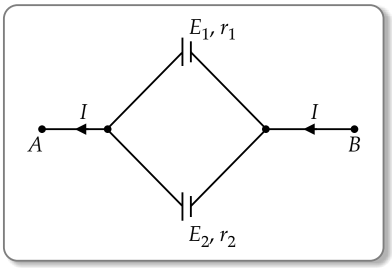
(b) Two cells of emfs E_1 and E_2 and internal resistances r_1 and r_2 respectively are connected in parallel as shown in the figure.

Deduce the expression for the

(i) equivalent emf of the combination

(ii) equivalent internal resistance of the combination

(iii) potential difference between the points A and B. 5



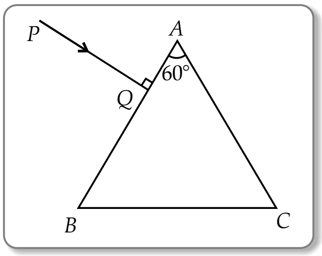
OR

(a) State the two Kirchhoff's rules used in the analysis of electric circuits and explain them.

(b) Derive the equation of the balanced state in a Wheats tone bridge using Kirchhoff's laws.

33. **(a)** Draw the graph showing intensity distribution of fringes with phase angle due to diffraction through a single slit. What is the width of the central maximum in comparison to that of a secondary maximum?

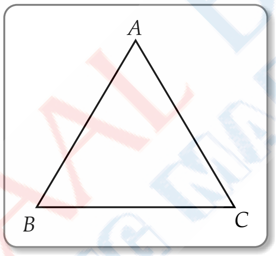
(b) A ray *PQ* is incident normally on the face *AB* of a 5 triangular prism of refracting angle 60° as shown in figure. The prism is made of a transparent material of refractive index $\frac{2}{\sqrt{3}}$. Trace the path of the ray as it passes through the prism. Calculate the angle of emergence and the angle of deviation. 5



OR

(a) Write two points of difference between an interference pattern and a diffraction pattern.

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



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

Section – E

34. **Read the following paragraph and answer the questions.**

A number of optical devices and instruments have been designed and developed such as periscope, binoculars, microscopes and telescopes utilising the reflecting and refracting properties of mirrors, lenses and prisms. Most of them are in common use. Our knowledge about the formation of images by the mirrors and lenses is the basic requirement for understanding the working of these devices.

(i) Why the image formed at infinity is often considered most suitable for viewing. Explain 1

(ii) In modern microscopes multi-component lenses are used for both the objective and the eyepiece. Why? 1

(iii) Write two points of difference between a compound microscope and an astronomical telescope 2

OR

Write two distinct advantages of a reflecting type telescope over a refracting type telescope. 2

35. **Case study: Light emitting diode.**

Read the following paragraph and answer the questions

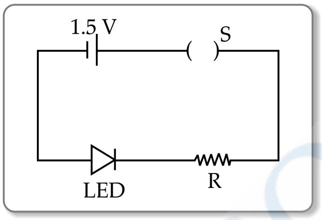
LED is a heavily doped *P-N* junction which under forward bias emits spontaneous radiation. When it is forward biased, due to recombination of holes and electrons at the junction, energy is released in the form of photons. In the case of Si and Ge diode, the energy released in recombination lies in the infrared region. LEDs that can emit red, yellow, orange, green and blue light are commercially available. The semiconductor used for fabrication of visible LEDs must at least have a band gap of 1.8 eV. The compound semiconductor Gallium Arsenide – Phosphide is used for making LEDs of different colours.

LEDs of different kinds

(i) Why are LEDs made of compound semiconductor and not of elemental semiconductors? **1**

(ii) What should be the order of band gap of an LED, if it is required to emit light in the visible range? **1**

(iii) A student connects the blue coloured LED as shown in the figure. The LED did not glow when switch *S* is closed. Explain why ? **2**



OR

Draw *V-I* characteristic of a *p-n* junction diode in

(a) forward bias and **(b)** reverse bias

❑❑❑

SOLUTIONS
Sample Question Paper-1
With CBSE Marking Scheme, 2022-23
PHYSICS

Section – A

1. Option (B) is correct.

Explanation: Since the force is attractive, the charges must be unlike.

So, $q_1 q_2 < 0$ **1**

2. Option (D) is correct.

Explanation: Potential at point (r, θ) is

$$V = \frac{Kp\cos\theta}{r^2} \quad [p = \text{dipole moment}]$$

On equatorial line $\theta = 90°$

$$\therefore V = \frac{Kp\cos 90°}{r^2}$$ **1**

3. Option (B) is correct.

Explanation: Resistivity of metal (copper) increases with increase of temperature. So, material B is copper.

Resistivity of semiconductor (Germanium) decreases with increase of temperature. So, material A is Germanium. **1**

4. Option (D) is correct.

Explanation: Magnetic field at the centre will be of same magnitude and opposite direction.

So, $$\frac{\mu_0 i_P}{2r_P} = \frac{\mu_0 i_Q}{2r_Q}$$

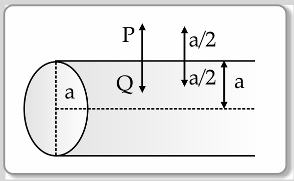
Or, $$\frac{i_P}{i_Q} = \frac{R_P}{R_Q}$$

Or, $$\frac{i_P}{9} = \frac{2}{3}$$

$\therefore$ $i_P = 6\text{A}$ **1**

5. Option (C) is correct.

Explanation:



Magnetic field, $$B = \frac{\mu_0}{2\pi} \times \frac{I}{r} \quad (\text{for } r > a)$$

And $$B = \frac{\mu_0}{2\pi} \times \frac{Ir}{a^2} \quad (\text{for } r < a)$$

For point P, $r > a$

So, $$B_P = \frac{\mu_0}{2\pi} \times \frac{I}{r_1} \quad \left[r_1 = \frac{3a}{2}\right]$$

For point Q, $r < a$

So, $$B_Q = \frac{\mu_0}{2\pi} \times \frac{Ir_2}{a^2} \quad \left[r_2 = \frac{a}{2}\right]$$

So, the ratio

$$\frac{B_P}{B_Q} = \frac{\frac{I}{r_1}}{\frac{Ir_2}{a^2}}$$

$$= \frac{I}{r_1} \times \frac{a^2}{Ir_2}$$

$$= \frac{a^2}{\frac{3a}{2} \times \frac{a}{2}}$$

$$= \frac{a^2}{\frac{3a^2}{4}}$$

$$= 4 : 3$$

6. Option (A) is correct.

Explanation: $\mu \propto 1/H$

So, as magnetizing field (H) increases, permeability (μ) decreases. **1**

7. Option (B) is correct.

Explanation: As the iron piece is taken out the self inductance of the coil decreases.

So, ωL i.e., X_L decreases.

So, the current in the circuit increases.

Hence, the brightness of the bulb increases. **1**

8. Option (D) is correct.

Explanation: For electromagnetic wave, electric and magnetic field vectors are perpendicular to each other. **1**

9. **Option (B) is correct.**

Explanation: When the circular and the elliptical loops come out of the field, equal areas will not be traced in equal intervals of time.
So, for these two loops induced emfs will not remain constant. **1**

10. **Option (D) is correct.**

Explanation: Path difference = $\frac{\lambda}{8}$

Phase difference = $\frac{2\pi}{\lambda}$ × path difference

$$\therefore \text{I} = I_0 \cos^2\left(\frac{\pi/4}{2}\right) = I_0 \cos^2\left(\frac{\pi}{8}\right)$$

$$\therefore \frac{I}{I_0} = \cos^2\left(\frac{\pi}{8}\right) = (0.92)^2 = 0.846 \approx 0.85$$ **1**

11. **Option (C) is correct.**

Explanation: Work function = 4.14 eV = $\frac{hc}{\lambda_0}$

$$\therefore \lambda_0 = \frac{6.6\times10^{-34}\times3\times10^8}{4.14\times1.6\times10^{-19}}$$

$$= 2.989 \times 10^{-7} \approx 3000\text{Å}$$ **1**

12. **Option (D) is correct.**

Explanation:

For $n = 3$

$$r_3 = n^2 r_1 = 3^2 \times 5.3 \times 10^{-11} \text{ m}$$

$$= 4.77 \times 10^{-10} \text{ m}$$ **1**

13. **Option (B) is correct.**

Explanation: The nuclear force is much stronger than the Coulomb force acting between charges. **1**

14. **Option (A) is correct.**

Explanation: In the given circuit,

$$V = 50\sqrt{2}\sin\omega t$$

$$\therefore \quad V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{50\sqrt{2}}{\sqrt{2}} = 50V$$

Now, $V_{rms} = \sqrt{V_2^2 + V_1^2}$

Or, $50 = \sqrt{V_2^2 + 40^2}$

Or, $V_2^2 = 2500 - 1600$

$\therefore$ $\text{V}_2 = 30V$ **1**

15. **Option (A) is correct.**

Explanation: $\text{E} = -\frac{dV}{dx}$

For $0 < x < 2$

The slope is positive, $\frac{dV}{dx} > 0$

So electric field intensity = $-E$

For $2 < x < 4$

The slope is positive, $\frac{dV}{dx} = 0$

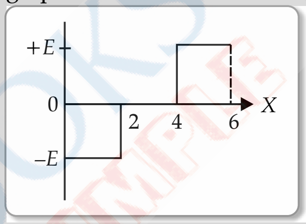
So electric field intensity = 0

For $4 < x < 6$

The slope is positive, $\frac{dV}{dx} < 0$

So electric field intensity = $+E$

So, E vs. x graph will be as below: **1**



16. **Option (C) is correct.**

Explanation: On doping number of free carriers increases, hence the electrical conductivity of a semiconductor increases on doping. So, the assertion is true.
Doping may increases the number of electrons or holes in the Semiconductor depending on the type of doping. If the dopant is donor type then number of electrons increases and if the dopant is acceptor type then the number of holes increases. So the reason is false. **1**

17. **Option (C) is correct.**

Explanation: Fringe width, $\beta = \frac{\lambda D}{d}$

When λ is fixed,1 then $\beta \propto \frac{D}{d}$.

Hence the reason is false.

Now if d and D both are reduced to $\frac{1}{3}$ rd, then

Initial fringe width = $\frac{\lambda D}{d}$

Final fringe width = $\frac{\lambda \frac{D}{3}}{\frac{d}{3}} = \frac{\lambda D}{d}$

So, the fringe width remains the same.
Hence, the assertion is true. **1**

18. **Option (A) is correct.**

Explanation: Photoelectrons produced by monochromatic light have different velocities and hence different energies.
Actually all the electrons do not occupy the same level of energy.

So, electrons coming out from different levels have different velocities and hence different energies. The electrons coming out from inside the metal surface, face collisions with the other atoms in the metal. So, energies become different. Hence the reason is true and it explains the assertion. **1**

Section – B

19. λ_1–Microwave ½
λ_2–Ultraviolet ½
λ_3–Infrared ½
Ascending order – $\lambda_2 < \lambda_3 < \lambda_1$ ½

Detailed Answer :
(i) The radiation of wavelength λ_1 is Microwave
(ii) The radiation of wavelength λ_2 is Ultraviolet
(iii) The radiation of wavelength λ_3 is Infrared
(iv) Arranging in ascending order:
$\lambda_2 < \lambda_3 < \lambda_1$ **2**

20. A-diamagnetic ½
B-paramagnetic ½
The magnetic susceptibility of A is small negative and that of B is small positive. **1**

Detailed Answer :
(i) Specimen A is diamagnetic and specimen B is paramagnetic. **1**
(ii) The magnetic susceptibility of A is small negative and that of B is small positive. **1**

21. From the relation $R = R_0A^{1/3}$, where R_0 is a constant and A is the mass number of a nucleus ½

$$\frac{R_{Fe}}{R_{Al}} = \left(\frac{A_{Fe}}{A_{Al}}\right)^{1/3}$$

$$= \left(\frac{125}{27}\right)^{1/3} \quad ½$$

$$R_{Fe} = \frac{5}{3}R_{Al} \quad ½$$

$$= \frac{5}{3}\times 3.6 \quad ½$$

$$= 6 \text{ fermi}$$

OR

Given short wavelength limit of Lyman series

$$\frac{1}{\lambda_L} = R\left(\frac{1}{1^2}-\frac{1}{\infty}\right) \quad ½$$

$$\frac{1}{913.4\text{Å}} = R\left(\frac{1}{1^2}-\frac{1}{\infty}\right) \quad ½$$

$$\lambda_L = \frac{1}{R} = 913.4\text{ Å}$$

For the short wavelength limit of Balmer series

$$n_1 = 2, n_2 = \infty$$

$$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2}-\frac{1}{\infty}\right) \quad ½$$

$$\lambda_B = \frac{4}{R} = 4\times 913.4\text{ Å} \quad ½$$

$$= 3653.6\text{ Å}$$

22.

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

$$\frac{1}{f} = \left(\frac{\mu_m}{\mu_w}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad ½$$

$$\frac{\mu_m}{\mu_w} = \frac{1.25}{1.33} \quad ½$$

$$\frac{\mu_m}{\mu_w} = 0.98 \quad ½$$

The value of (μ – 1) is negative and 'f' will be negative. So it will behave like diverging lens. ½

Detailed Answer :
The lens will behave like a diverging lens.
Justification:

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

Or, $$\frac{1}{f} = \left(\frac{\mu_m}{\mu_w}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

Or, $$\frac{1}{f} = \left(\frac{1.25}{1.33}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

Or, $$\frac{1}{f} = (0.98-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

Or, $$\frac{1}{f} = -0.02\times\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

So, f will be negative. Hence the lens will behave like a diverging lens.

23. To keep the reading of ammeter constant value of R should be increased as with the increase in temperature of a semiconductor, its resistance decreases and current tends to increase. **2**

OR

B-reverse biased ½

In the case of reverse biased diode the potential barrier becomes higher as the battery further raises the potential of the n side. ½

C-forward biased

Due to forward bias connection the potential of P side is raised and hence the height of the potential barrier decreases. **2**

24. Angular width $2\phi = 2\lambda/d$ ½

Given $\lambda = 6000$ Å

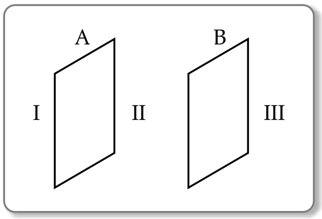
In Case of new λ (assumed λ' here), angular width decreases by 30% ½

New angular width $= 0.70\ (2\ \phi)$ ½

$$2\lambda'/d = 0.70 \times (2\lambda/d)$$

$\therefore$ $\lambda' = 4200$ Å ½

25.



Surface charge density of plate A = $+17.7 \times 10^{-22}$ C/m^2
Surface charge density of plate B = -17.7×10^{-22} C/m^2

(a) In the outer region of plate I, electric field intensity E is zero. ½

(b) Electric field intensity E in between the plates is given by relation ½

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

Where,
ε_0 = Permittivity of free space = 8.85×10^{-12} N^{-1} C^{2}m^{-2}

$$\therefore \quad E = \frac{17.7 \times 10^{-22}}{8.85 \times 10^{-12}}$$ ½

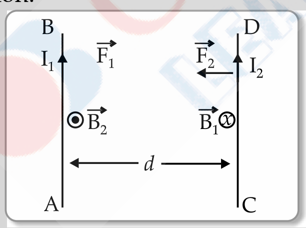
Therefore, electric field between the plates is 2.0×10^{-10} N/C ½

Section – C

26. Diagram ½
Derivation 1½
The ampere is the value of that steady current which, when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and placed one metre apart in vacuum, would exert on each of these conductors a force equal to 2 × 10^{-7} newtons per metre of length. 1

Detailed Answer :

Force between Two long straight parallel conductors carrying in the same Direction:



Two wires AB and CD carry currents I_1 and I_2 respectively in the same direction.
Distance between them is d.
Due to I_1 current in AB,

Magnetic field at any point on CD is $B_1 = \frac{\mu_0}{4\pi} \times \frac{2I_1}{d}$

Force on unit length of CD is $F_1 = \frac{BIL}{L} = B_1 \times I_2 \times 1 = \frac{\mu_0}{4\pi} \times \frac{2I_1 I_2}{d}$, acting towards AB (applying Fleming's left hand rule)

Similarly,
Due to I_2 current in CD,

Magnetic field at any point on AB is $B_2 = \frac{\mu_0}{4\pi} \times \frac{2I_2}{d}$

Force on unit length of AB is $F_2 = \frac{BIL}{L} = B_2 \times I_1 \times 1 = \frac{\mu_0}{4\pi} \times \frac{2I_1 I_2}{d}$, acting towards CD (applying Fleming's left hand rule)

So, the magnitudes of F_1 and F_2 are same and oppositely directed. So, the forces are attractive.

Definition of 1 ampere:
If $I_1 = I_2 = 1$ ampere and $d = 1$ m,

Then, $F = \frac{\mu_0}{4\pi} \times \frac{2I_1 I_2}{d} = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2 \times 1 \times 1}{1}$
$= 2 \times 10^{-7}$ N

So 1 A may be defined as,
The ampere is the value of that steady current which, when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and placed one metre apart in vacuum, would exert on each of these conductors a force equal to 2 × 10^{-7} newtons per metre of length.

27. Area of the circular loop = πr^2
$= 3.14 \times (0.12)^2$ m^2 $= 4.5 \times 10^{-2}$ m^2

$$E = -\frac{d\phi}{dt} = -\frac{d}{dt}(BA) = -A\frac{dB}{dt} = -A.\frac{B_2 - B_1}{t_2 - t_1}$$ ½

For $0 < t < 2s$

$$E_1 = -4.5 \times 10^{-2} \times \left\{\frac{1-0}{2-0}\right\} = -2.25 \times 10^{-2} V$$

$$\therefore I_1 = \frac{E_1}{R} = \frac{-2.25 \times 10^{-2}}{8.5} A = -2.6 \times 10^{-3} A = -2.6 \text{ m}A$$ ½

For $2s < t < 4s$,

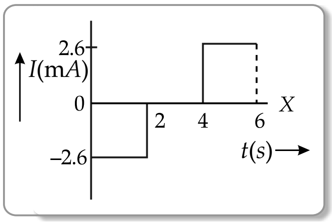
$$E_2 = -4.5 \times 10^{-2} \times \left\{\frac{1-1}{4-2}\right\} = 0$$ ½

$$\therefore I_2 = \frac{E_2}{R} = 0$$

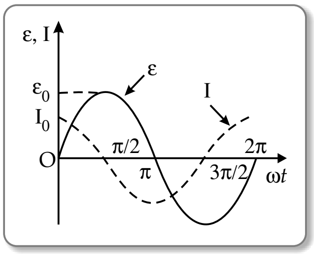
For $4s < t < 6s$,

$$I_3 = -\frac{4.5 \times 10^{-2}}{8.5} \times \left\{\frac{0-1}{6-4}\right\} A = 2.6 \text{ m}A$$ ½

	$0 < t < 2s$	$2 < t < 4s$	$4 < t < 6s$
$E(V)$	–0.023	0	+0.023
$I(mA)$	–2.6	0	+2.6



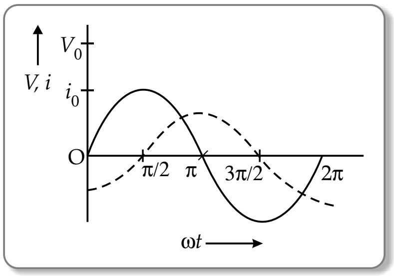
28. Derivation 2



1

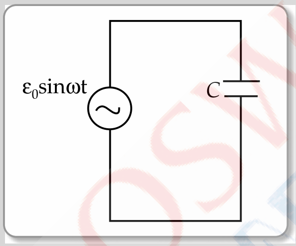
OR

Derivation 2



1

Detailed Answer :



At any moment charge on the capacitor is

$q = C\varepsilon = C\varepsilon_0 \sin\omega t$

Current in the circuit,

$$i = \frac{dq}{dt} = \frac{d}{dt}C\varepsilon_0 \sin\omega t$$

$$= \omega C\varepsilon_0 \cos\omega t$$

$$= \frac{\varepsilon_0}{\frac{1}{\omega C}}\sin\left(\omega t + \frac{\pi}{2}\right)$$

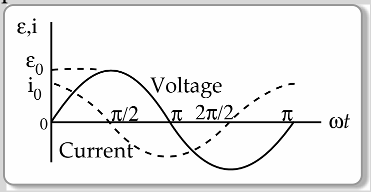
$$= \frac{\varepsilon_0}{X_C}\sin\left(\omega t + \frac{\pi}{2}\right)$$

$$= \frac{\varepsilon_0}{Z}\sin\left(\omega t + \frac{\pi}{2}\right)$$

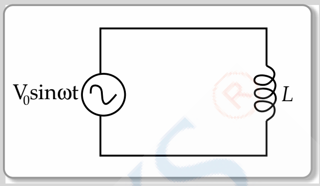
$$= i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

So, the current is ahead of the voltage by $\frac{\pi}{2}$.

Graph of ε and I versus ωt:



OR



Applying Kirchhhoff's rule,

$$V - L\frac{di}{dt} = 0$$

or, $$V_0 \sin\omega t = L\frac{di}{dt}$$

or, $$di = \frac{V_o}{L}\sin\omega t\, dt$$

On Integrating,

$$i = \frac{V_o}{L}\int \sin\omega t\, dt$$

or, $$i = -\frac{V_o}{\omega_L}\cos\omega t$$

or, $$i = -\frac{V_o}{\omega_L}\sin\left(\omega t - \frac{\pi}{2}\right)$$

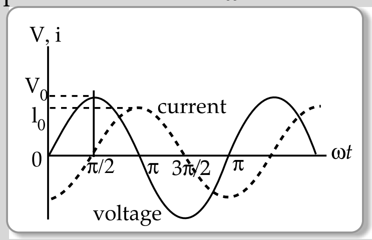
or, $$i = -\frac{V_o}{Z_L}\sin\left(\omega t - \frac{\pi}{2}\right)$$

or, $$i = -\frac{V_o}{Z}\sin\left(\omega t - \frac{\pi}{2}\right)$$

∴ $$i = -i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

So, the current flowing through it lags behind the applied voltage by a phase angle of $\frac{\pi}{2}$.

Graph of V and i versus ωt:



29. From the observations made (parts A and B) on the basis of Einstein's photoelectric equation, we can draw following conclusions:

1. For surface A, the threshold frequency is more than 10^{15} Hz, hence no photoemission is possible. **1**
2. For surface B the threshold frequency is equal to the frequency of given radiation. Thus, photo-emission

takes place but kinetic energy of photoelectrons is zero. **1**

3. For surface C, the threshold frequency is less than 10^{15} Hz. So photoemission occurs and photoelectrons have some kinetic energy **1**

OR

(a) A - cut off or stopping potential ½

X - anode potential ½

(b)

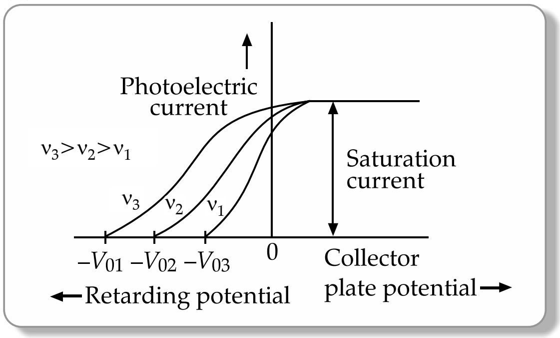


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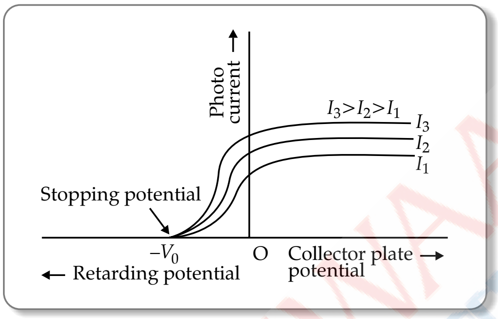
FIGURE: Variation of photocurrent with collector plate potential for different frequency of incident radiation.

(c)



1

FIGURE: Variation of photocurrent with collector plate potential for different intensity of incident radiation.

30. For a transition from $n = 3$ to $n = 1$ state, the energy of the emitted photon,

$$h\nu = E_2 - E_1 = 13.6\left[\frac{1}{1^2} - \frac{1}{3^2}\right]eV = 12.1 \text{ eV.}$$

From Einstein's photoelectric equation,

$$h\nu = K_{max} + W_0$$

$$\therefore \quad W_0 = h\nu - K_{max} = 12.1 - 9 = 3.1 \text{ eV}$$

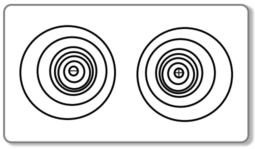
Threshold wavelength,

$$\lambda^{th} = \frac{hc}{W_0} = \frac{6.62\times10^{-34}\times3\times10^{8}}{3.1\times1.6\times10^{-19}}$$

$$= 4 \times 10^{-7} \text{ m}$$

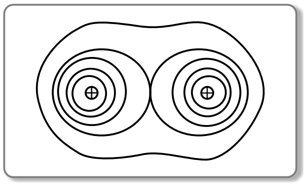
Section – D

31. (a)



(a)

(b)



(b)

FIGURE: Some equipotential surface for

(a) a dipole

(b) two identical positive charge.

Here, A = 6×10^{-3} m², d = 3 mm = 3×10^{-3} m

(b) (i) Capacitance, C = $\epsilon_0 A/d$

$= (8.85 \times 10^{-12} \times 6 \times 10^{-3}/3 \times 10^{-3})$

$= 17.7 \times 10^{-12}\ F$ **1**

(ii) Charge, $Q = CV$

$= 17.7 \times 10^{-12} \times 100$

$= 17.7 \times 10^{-10}\ C$ **1**

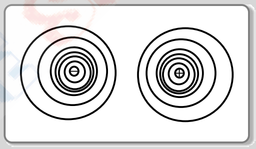
(iii) New charge $Q' = KQ$

$= 6 \times 17.7 \times 10^{-10}$

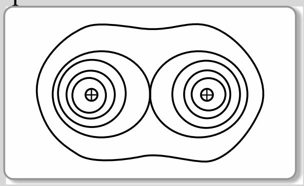
$= 1.062 \times 10^{-8}\ C$ **1**

Detailed Answer :

(a) (i) Equipotential surfaces for an electric dipole



(ii) Equipotential surfaces for two identical positive charges placed near each other



OR

(a) Diagram **1**

$$\frac{K(-q)Q}{x} + \frac{kQ(-q)}{x} + \frac{k(-q)(-q)}{2x} = 0 \quad \textbf{1}$$

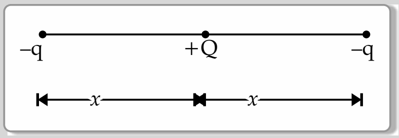
$$\frac{-2kqQ}{x} + \frac{kq^2}{2x} = 0$$

or $$\frac{kq^2}{2x} = \frac{2kqQ}{x}$$

$$q = 4Q \text{ or } \frac{Q}{q} = \frac{1}{4}$$

Detailed Answer :

(a)

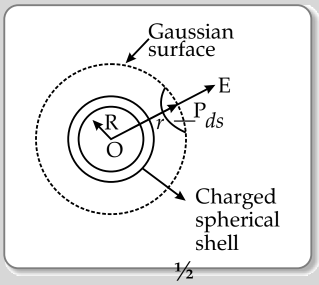


$$\frac{K(-q)Q}{x} + \frac{kQ(-q)}{x} + \frac{k(-q)(-q)}{2x} = 0$$

$$\frac{-2kqQ}{x} + \frac{kq^2}{2x} = 0 \text{ or } \frac{kq^2}{2x} = \frac{2kqQ}{x}$$

$$q = 4Q \text{ or } \frac{Q}{q} = \frac{1}{4}$$

(b) Electric field due to a uniformly charged thin spherical shell:



½

(i) When point P lies outside the spherical shell: Suppose that we have calculate field at the point P at a distance $r(r > R)$ from its centre. Draw Gaussian surface through point P so as to enclose the charged spherical shell. Gaussian surface is a spherical surface of radius r and centre O.

Let $\vec{E}$ be the electric field at point P, then the electric flux through area element of area $\vec{ds}$ is given by

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

Since $\vec{ds}$ is also along normal to the surface ½

$$d\phi = E\,dS$$

∴ Total electric flux through the Gaussian surface is given by

$$\phi = \oint Edx = E\oint ds$$

Now, $$\oint ds = 4\pi r^2 \quad \text{...(i)}$$

$$= E \times 4\pi r^2$$

Since the charge enclosed by the Gaussian surface is q, according to the Gauss's theorem,

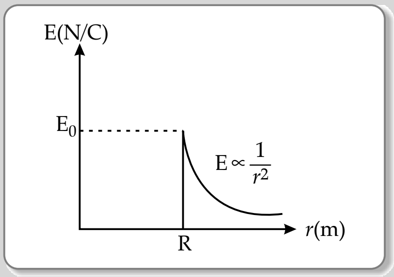
$$\phi = \frac{q}{\varepsilon_0} \quad \text{...(ii) ½}$$

From equation (i) and (ii) we obtain

$$E \times 4\pi r^2 = \frac{q}{\varepsilon_0}$$

$$E = \frac{1}{4\pi \in_0} \cdot \frac{q}{r^2} \text{ (for } r > R) \quad ½$$

(ii)



1

Graph showing the variation of electric field as a function of r is shown

32. (a) Drift velocity: It is the average velocity acquired by the free electrons superimposed over the random motion in the direction opposite to electric field and along the length of the metallic conductor.

Derivation $I = ne\,A\,Vd$ **2**

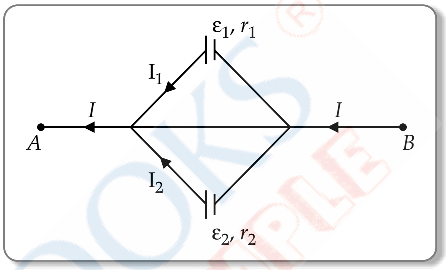
(b) Here, $I = I_1 + I_2$ ...(i)

Let V = Potential difference between A and B.

For cell ε_1

Then, $V = \varepsilon_1 - I_1 r_1$

$$\Rightarrow \quad I_1 = \frac{\varepsilon_1 - V}{V_1}$$



Similarly, for cell ω_2

$$I_2 = \frac{\varepsilon_2 - V}{r_2}$$

Putting these values in equation (i)

$$I = \frac{\varepsilon_1 - V}{r_1} + \frac{\varepsilon_2 - V}{r_2}$$

or $$I = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

or $$V = \left(\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}\right) - I\left(\frac{r_1 r_2}{r_1 + r_2}\right) \quad \text{...(ii)}$$

Comparing the above equation with the equivalent circuit of emf 'ε_{eq}' and internal resistance 'r_{eq}' then,

$$V = \varepsilon_{eq} - Ir_{eq} \quad \text{...(iii)}$$

Then

(i) $$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$$

(ii) $$r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

(iii) The potential difference between A and B **3**

$$V = \varepsilon_{eq} - Ir_{eq}$$

Detailed Answer :

(a) Derivation of expression for the current through a conductor in terms of drift velocity:

Length of a conductor = L

Area of cross section = A

Applied potential difference = V

Intensity of electric field, $E = \frac{V}{L}$

Number of free electrons per unit volume = n

Drift velocity achieved by each electron by the influence of E is vd

Distance traversed by each electron in dt time is $v_d dt$

So, number of electrons crossing the area of cross section A is equal to the number of electrons present in a cylinder of length vddt and area of cross section A i.e., $nAv_d dt$.

Charge crossing the area of cross section A in dt time, $dQ = enAv_d dt$

Current through conductor, $i = \frac{dQ}{dt} = enAv_d$

OR

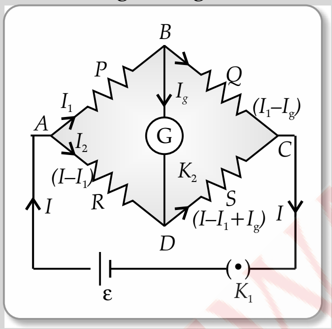
(a) Junction rule: At any junction, the sum of the currents entering the junction is equal to the sum of currents leaving the junction. **1**

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

(b) Derivation **3**

Detailed Answer :

(b) Derivation of equation of the balanced state in a Wheatstone bridge using Kirchhoff's rules:



Main circuit current = I

From A node, I_1 flows through P and $I - I_1$ flows through R.

From B node, I_g flows through galvanometer and $I_1 - I_g$ flows through Q.

At node D, currents $I - I_1$ and I_g meet and flows through S as $I - I_1 + I_g$.

At node C, currents $I - I_1 + I_g$ and $I_1 - I_g$ meet and returns to battery as I.

Applying Kirchhoff's rule in the loop ABDA,

$$I_1P + I_gG - (I - I_1)R = 0 \quad \text{...(i)}$$

Applying Kirchhoff's rule in BCDB loop,

$$(I_1 - I_g)Q - (I - I_1 + I_g)S - I_gG = 0 \quad \text{...(ii)}$$

In balanced condition,

$$I_g = 0$$

So, from equation (i)

$$I_1P = (I - I_1)R \quad \text{...(iii)}$$

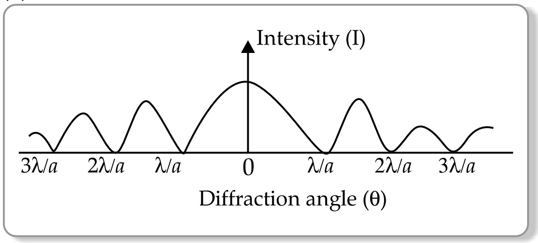
From equation (ii)

$$I_1Q = (I - I_1)S \quad \text{...(iv)}$$

Dividing (iii) and (iv)

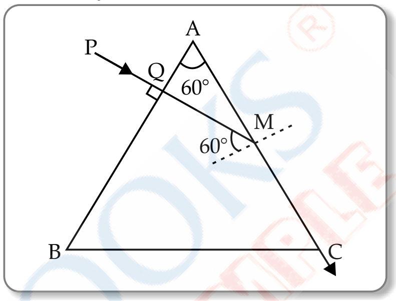
$$\frac{P}{Q} = \frac{R}{S}$$

33. (a) **1**



Width of central maximum is twice that of any secondary maximum **1**

(b) **1**



Given : $\angle A = 60°, \angle i = 0°$

At M : $\text{Sin } C = \frac{1}{\mu} = \frac{\sqrt{3}}{2} = \sin 60°$

$\therefore \quad C = 60°$ **1**

So the ray PM after refraction from the face AC grazes along AC.

$\therefore \quad \angle e = 90°$

From $\quad \angle i + \angle e = \angle A + \angle \delta$

Or $\quad 0° + 90° = 60° + \angle\delta$

$\therefore \quad \delta = 90° - 60° = 30°$ **1**

OR

(a) (i) The interference pattern has a number of equally spaced bright and dark bands. The diffraction pattern has a central bright maximum which is twice as wide as the other maxima. The intensity falls as we go to successive maxima away from the centre, on either side. **1**

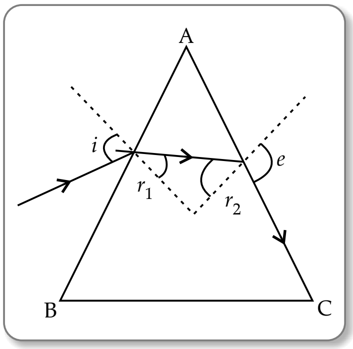
(ii) We calculate the interference pattern by superposing two waves originating from the two narrow slits. The diffraction pattern is a superposition of a continuous family of waves originating from each point on a single slit. **1**

(b) (i) $\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60°+30°}{2}\right)}{\sin\left(\frac{60°}{2}\right)} = \sqrt{2}$

Also $\mu = \frac{c}{v} \Rightarrow v = \frac{3\times 10^8}{\sqrt{2}}$ m/s **1½**

(ii) At face AC, let the angle of incidence be r_2. For grazing ray, $e = 90°$

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



1½

Let angle of refraction at face AB be r_1.

Now $r_1 + r_2 = A$

$\therefore$ $r_1 = A - r_2 = 60° - 45° = 15°$

Let angle of incidence at this face be i

$$\Rightarrow \quad \mu = \frac{\sin i}{\sin r_1} \Rightarrow \sqrt{2} = \frac{\sin i}{\sin 15°}$$

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

$$= 21.5°$$

Section – E

34. **(i)** When the image is formed at infinity, we can see it with minimum strain in the ciliary muscles of the eye. **1**

(ii) The multi-component lenses are used for both objective and the eyepiece to improve image quality by minimising various optical aberrations in lenses. **1**

(iii) (a) The compound microscope is used to observe minute nearby objects whereas the telescope is used to observe distant objects. **1**

(b) In compound microscope the focal length of the objective is lesser than that of the eyepiece whereas in telescope the focal length of the objective is larger than that of the eyepiece. **1**

OR

(a) The image formed by reflecting type telescope is brighter than that formed by refracting telescope. **1**

(b) The image formed by the reflecting type telescope is more magnified than that formed by the refracting type telescope. **1**

35. **(i)** LEDs are made up of compound semiconductors and not by the elemental conductor because the band gap in the elemental conductor has a value that can detect the light of a wavelength which lies in the infrared (IR) region. **1**

(ii) 1.8 eV to 3 eV **1**

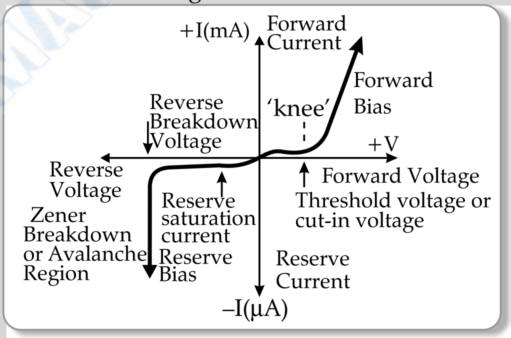
(iii) LED is reversed biased that is why it is not glowing. **2**

OR

V-I Characteristic curves of p-n junction diode in forward biasing and reverse biasing. **1+1**

Detailed Answer :

V-I Characteristic curves of p-n junction diode in forward biasing and reverse bias:



❑❑❑