Class: XII

SESSION : 2022-2023

SUBJECT: PHYSICS (THEORY)

SAMPLE QUESTION PAPER - 26

with SOLUTION

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

General Instructions:

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

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

(3) Section A contains eighteen MCQ 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.

(4) 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.

5. Use of calculators is not allowed.

Section A

1. In p-type semiconductor, **[1]**

A. major current carrier are electrons

B. major carrier are mobile negative ions

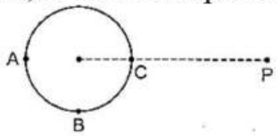
C. major carrier are mobile holes

D. the number of mobile holes exceeds the number of acceptor atoms

a) Option C b) Option A

c) Option D d) Option B

2. A hollow conducting sphere is placed in an electric field produced by a point charge placed at P as shown in figure. Let V_A, V_B, V_C be the potentials at points A, B and C respectively. Then: **[1]**



a) $V_A = V_C$ b) $V_A > V_B$

c) $V_B > V_C$ d) $V_C > V_B$

3. A concave lens of focal length 20 cm placed in contact with a plane mirror acts as a: **[1]**

a) concave mirror of focal length 10 cm

b) concave mirror of focal length 40 cm

c) concave mirror of focal length 60 cm

d) convex mirror of focal length 10 cm

4. Arrange the following electromagnetic radiations in the order of increasing energy. **[1]**

A. Blue light
B. Yellow light
C. X-ray
D. Radio wave

a) C, A, B, D

b) D, B, A, C

c) B, A, D, C

d) A, B, D, C

5. Which of the following, when added as an impurity, into the silicon, produces n-type semiconductor? **[1]**

a) phosphorous
b) aluminium
c) magnesium
d) both aluminium and magnesium

6. 6 eV of the energy of an electron striking a tungsten target is converted into X-rays. The maximum wavelength of X-rays emitted is nearly: **[1]**

a) 1×10^{-7} m
b) 2×10^{-7} m
c) 4×10^{-7} m
d) 3×10^{-7} m

7. The K_α line from molybdenum (atomic number = 42) has a wavelength of 0.7078 $\mathring{A}$. The wavelength of K_α line of zinc (atomic number = 30) will be **[1]**

a) 0.5 $\mathring{A}$
b) 1.3872 $\mathring{A}$
c) 0.3541 $\mathring{A}$
d) 1 $\mathring{A}$

8. An inductor is connected to a battery through a switch. Induced emf is e_1 when the switch is pressed and e_2 when the switch is opened. Then: **[1]**

a) $e_1 < e_2$
b) $e_1 = e_2$
c) $e_1 > e_2$
d) $e_1 >/< e_2$

9. The surface charge density of the earth is: **[1]**

a) -10^{-9} cm^{-2}
b) 10^{-9} cm^{-2}
c) -100 cm^{-2}
d) 10^{-6} cm^{-2}

10. Young's experiment is performed with light of wavelength 6000 $\mathring{A}$ wherein 16 fringes occupy a certain region on the screen. If 24 fringes occupy the same region with another light of wavelength λ, then λ is: **[1]**

a) 3000 $\mathring{A}$
b) 500 $\mathring{A}$
c) 400 $\mathring{A}$
d) 4000 $\mathring{A}$

11. At 0 K temperature, a p-type semiconductor: [1]

a) does not have any charge carriers

b) has few holes but no free electrons

c) has few holes and few free electrons

d) has equal number of holes and free electrons

12. An electron is accelerated from rest through a potential difference of V volt. If the de Broglie wavelength of the electron is 1.227×10^{-2} nm, the potential difference is: [1]

a) 10^4 V

b) 10 V

c) 10^2 V

d) 10^3 V

13. The torque acting on electric dipole of the dipole moment $\vec{p}$ placed in a uniform electric field $\vec{E}$ is [1]

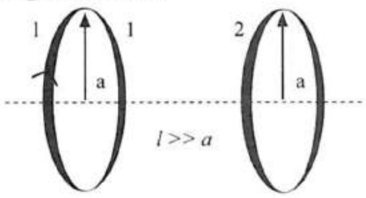
a) $\vec{p} \cdot \vec{E}$

b) $\vec{p} \times (\vec{E} \times \vec{p})$

c) $\frac{\vec{E} \cdot \vec{p}}{p^2}$

d) $\vec{p} \times \vec{E}$

14. What is the mutual inductance of a two-loop system as shown with centre separation l? [1]



[**Hint:** Magnetic field of the coil.]

a) $\frac{\mu_0 \pi a^4}{8l^3}$

b) $\frac{\mu_0 \pi a^4}{4l^3}$

c) $\frac{\mu_0 \pi a^4}{6l^3}$

d) $\frac{\mu_0 \pi a^4}{2l^3}$

15. **Assertion (A):** Kirchoff's junction rule follows from conservation of charge. [1]
Reason (R): Kirchoff's loop rule follows from conservation of momentum.

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 but R is true.

16. **Assertion:** Heavy water is used as moderator in nuclear reactor. [1]
Reason: When two bodies having approximately same mass undergo an elastic collision, energy transfer is maximum.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

17. The conduction current is same as the displacement current when source is: **[1]**

a) none of these

b) DC only

c) both AC and DC

d) AC only

18. **Assertion (A):** Induced emf will always occur whenever there is change in magnetic flux. **[1]**
Reason(R): Current always induces whenever there is change in magnetic flux.

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 but R is true.

Section B

19. The energy and momentum of an electron are related to the frequency and wavelength of the associated matter wave by the relations: **[2]**
$E = h\nu$, $p = \frac{h}{\lambda}$
while the value of λ is physically significant, the value of ν (and therefore, the value of the phase speed $\nu\lambda$) has no physical significance. Why?

20. Define mass number (A) of an atomic nucleus. Assuming the nucleus to be spherical, give the relation between mass number (A) and the radius (R) of the nucleus. Calculate the density of nuclear matter. Radius of nucleus of $^{1}_{1}\mathrm{H} = 1.1 \times 10^{-15} \overset{o}{A}$. What is the ratio of the order of magnitude of density of nuclear matter and density of ordinary matter? **[2]**

21. The energy of a hole is higher, the farther below it is from the top of the valence band. Give reason. **[2]**

22. A short bar magnet of magnetic moment 0.9 J/T is placed with its axis at 60° to a uniform magnetic field. It experience a torque of 0.063 Nm. **[2]**

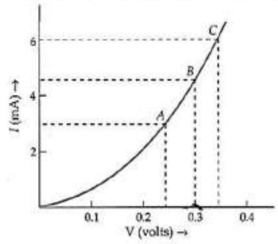
i. Calculate the strength of the magnetic field.

ii. What orientation of the bar magnet corresponds to the equilibrium position in the magnetic field?

OR

Is the permeability of a ferromagnetic material independent of the magnetic field? If not, is it more for lower or higher fields?

23. The figure shows the characteristic curve of a junction diode. Determine the d.c. and a.c. resistance of the diode, when it operates at 0.3 V. **[2]**



24. How will you convert 1 mA full scale deflection meter of resistance 100 ohms into an ammeter to read 1 A (full scale deflection) and into a voltmeter to read 1 volt (full scale deflection). **[2]**

OR

A positive charge of 1.5 μC is moving with a speed of 2×10^6 ms^{-1} along the positive X-axis. A magnetic field $\vec{B} = (0.2\hat{j} + 0.4\hat{k})$, tesla acts in space. Find the magnetic force acting on the charge.

25. What is the effect on the interference pattern observed in Young's double-slit experiment in the following cases: **[2]**

i. Screen is moved away from the plane of the slits.
ii. Separation between the slits is increased and
iii. Widths of the slits are doubled?

Section C

26. How will a dia-, para- and a ferromagnetic material behave when kept in a non-uniform external magnetic field? Give two examples of each of these materials. Name two main characteristics of a ferromagnetic material which help us to decide its suitability for making **[3]**

i. a permanent magnet
ii. an electromagnet. Which of these two characteristics should have high or low values for each of these two types of magnets?

27. Two narrow slits are illuminated by a single monochromatic source. Name the pattern obtained on the screen. One of the slits is now completely covered. What is the name of the pattern now obtained on the screen? Draw intensity pattern obtained in the two cases. Also, write two differences between the patterns obtained in the above two cases. **[3]**

OR

What is diffraction of light? Draw a graph showing the variation of intensity with angle in a single slit diffraction experiment. Write one feature which distinguish the observed pattern from the double slit interference pattern. How would the diffraction pattern of a single slit be affected when:

i. the width of the slit is decreased?

ii. the monochromatic source of light is replaced by a source of white light?

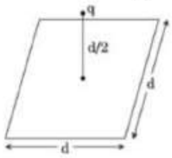
28. Name the type of EM waves having a wavelength range of 0.1 m to 1 mm. How are these waves generated? Write their two uses. **[3]**

OR

i. How are electromagnetic waves produced?

ii. How do you convince yourself that electromagnetic waves carry energy and momentum?

29. Define electric flux. Is it a scalar or a vector quantity? **[3]**
A point charge q is at a distance of $\frac{d}{2}$ directly above the centre of a square of side d, as shown in the figure. Use Gauss' law to obtain the expression for the electric flux through the square.



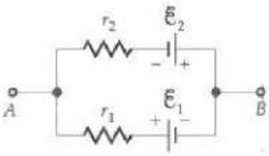
If the point charge is now moved to a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux will be affected.

30. State the underlying principle of working of a moving coil galvanometer. Write two reasons why a galvanometer cannot be used as such to measure the current in **[3]**

a given circuit. Name any two factors on which the current sensitivity of a galvanometer depends.

Section D

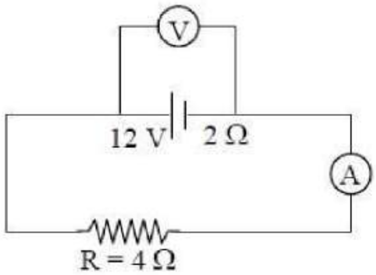
31. Find the emf (ε_0) and internal resistance (r_0) of a battery which is equivalent to a parallel combination of two batteries of emfs ε_1 and ε_2 and internal resistances r_1 and r_2 respectively, with polarities as shown in the figure. **[5]**



OR

i. The potential difference applied across a given resistor is altered, so that the heat produced per second increases by a factor of 9. By what factor does the applied potential difference change?

ii. In the figure shown, an ammeter A and a resistor of 4Ω are connected to the terminals of the source. The emf of the source is 12 V having an internal resistance of 2Ω. Calculate the voltmeter and ammeter readings



32. With the help of ray diagram, show the formation of image of a point object by refraction of light at a spherical surface separating two media of refractive indices n_1 and n_2 ($n_2 > n_1$) respectively. Using this diagram, derive the relation $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$. Write the sign conventions used. **[5]**
What happens to the focal length of convex lens when it is immersed in water?

OR

i. Draw a ray diagram to show the image formation by a combination of two thin convex lenses in contact. Obtain the expression for the power of this combination in terms of the focal lengths of the lenses.

ii. A ray of light passing from air through an equilateral glass prism undergoes minimum deviation when the angle of incidence is $\frac{3}{4}$th of the angle of prism. Calculate the speed of light in the prism.

33. State any two postulates of Bohr's theory of hydrogen atom. What is the maximum possible number of spectral lines observed when the hydrogen atom is in its second excited state? Justify your answer. **[5]**
Calculate the ratio of the maximum and minimum wavelengths of the radiations emitted in this process.

OR

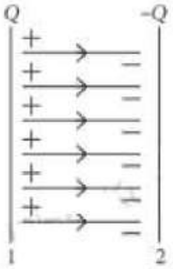
i. Using Bohr's postulates, derive the expression for the total energy of the electron in the stationary states of the hydrogen atom.

ii. Using Rydberg formula, calculate the wavelengths of the spectral lines of the first member of the Lyman series and of the Balmer series.

Section E

34. **Read the text carefully and answer the questions:** **[4]**

A capacitor is a device to store energy. The process of charging up a capacitor involves the transferring of electric charges from its one place to another. This work done in charging the capacitor is stored as its electrical potential energy.



If q is the charge and V is the potential difference across a capacitor at any instant during its charging, then small work done in storing an additional small charge dq against the repulsion of charge q already stored on it is dW = $V \cdot dq = (\frac{q}{C})dq$

(i) A system of 2 capacitors of capacitance 2 μF and 4 μF is connected in series across a potential difference of 6 V. Calculate the energy stored in the system.

(ii) A capacitor of the capacitance of 10 μF is charged to 10 V. Calculate the energy stored in it.

(iii) A parallel plate air capacitor has capacity C farad, potential V volt and energy E joule. What happens to the potential and electric field, When the gap between the plates is completely filled with dielectric.

OR

A capacitor with capacitance 5 μF is charged to 5 μC. If the plates are pulled apart to reduce the capacitance to 2 μF, how much work is done?

35. **Read the text carefully and answer the questions:** **[4]**

A transformer is essentially an a.c. device. It cannot work on d.c. It changes alternating voltages or currents. It does not affect the frequency of a.c. It is based on the phenomenon of mutual induction. A transformer essentially consists of two coils of insulated copper wire having a different number of turns and wound on the same soft iron core.
The number of turns in the primary and secondary coils of an ideal transformer are 2000 and 50 respectively. The primary coil is connected to the main supply of 120 V and secondary coil is connected to a bulb of resistance 0.6 Ω.

(i) What will be the value of voltage across the secondary coil?

(ii) Find the value of the current in the bulb.

(iii) What will be the value of current in the primary coil?

OR

Calculate the power in primary coil.

SOLUTION

Section A

1. **(a)** Option C

   Explanation: In p-type semiconductors, holes are the majority charge carriers.

2. **(a)** $V_A = V_C$

   Explanation: The conducting sphere becomes an equipotential surface.

3. **(a)** concave mirror of focal length 10 cm

   Explanation: $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_m} + \frac{1}{f_1}$

   $= \frac{2}{f_1} + \frac{1}{f_m} = \frac{2}{-20} + \frac{1}{\infty} = -\frac{1}{10}$

   F = -10cm

   This combination will behave like a convex mirror of a focal length of 10 cm.

4. **(b)** D, B, A, C

   Explanation: D, B, A, C

5. **(a)** phosphorous

   Explanation: As phosphorous is pentavalent, it produces n-type semiconductor when added to silicon.

6. **(b)** 2×10^{-7} m

   Explanation: $\frac{hc}{\lambda_{\max}} = 6$ eV

   $\therefore \lambda_{\max.} = \frac{hc}{6\text{eV}} = \frac{6.6\times10^{-34}\times3\times10^{8}}{6\times1.6\times10^{-19}} = 2.06 \times 10^{-7}$ m

7. **(c)** 0.3541 $\overset{\circ}{\text{A}}$

   Explanation: Wavelength of K_α line is given by K_α

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

   $\therefore \frac{K_\alpha(Zn)}{K_a(Mo)} = \frac{(30-1)^2}{(42-1)^2}$

   $\Rightarrow K_\alpha(\text{Zn}) = \frac{29\times29}{41\times41} \times 0.7078\overset{\circ}{\text{A}} = 0.3541\ \overset{\circ}{\text{A}}$

8. **(a)** $e_1 < e_2$

   Explanation: When the switch is pressed, the current grows in the circuit. On account of the self-inductance of the inductor, the growth is slow. When the switch is opened, the current suddenly decreases to zero on account of the infinite resistance of the circuit. Thus, the rate of decay is higher as compared to the rate of growth of the current.

   Therefore, $e_1 < e_2$

9. **(a)** -10^{-9} cm^{-2}

Explanation: -10^{-9} cm^{-2}

10. **(d)** 4000 $\mathring{A}$

Explanation: As we know that,

$n_1\lambda_1 = n_2\lambda_2$

$\lambda_2 = \frac{n_1}{n_2}\lambda_1$

$= \frac{16 \times 6000}{24}$

= 4000 $\mathring{A}$

11. **(b)** has few holes but no free electrons

Explanation: We know that at 0 K temperature, a pure semiconductor behaves as an insulator because it has a few holes in its valence band. But there is no free electron in this state.

12. **(a)** 10^4 V

Explanation: The de-Broglie wavelength of an electron is given as:

$\lambda = \frac{1.227}{\sqrt{V}}\text{nm}$

Substitute the wavelength in the above expression:

$V = \left(\frac{1.227}{1.227 \times 10^{-2}}\right)^2$

$V = 10^4$ V

13. **(d)** $\vec{p} \times \vec{E}$

Explanation: Torque on a dipole,

$\vec{\tau} = \vec{p} \times \vec{E}$

14. **(d)** $\frac{\mu_0 \pi a^4}{2l^3}$

Explanation: Magnetic field at the location of coil (2) produced due to coil (1),

$B_1 = \frac{\mu_0}{4\pi} \cdot \frac{2m}{l^3}$

where, m = magnetic dipole moment flux linked with coil (2),

$\phi_2 = B_1A_2$

$= \frac{\mu_0}{4\pi}\frac{2I(\pi a^2)}{l^3} \times \left(\pi a^2\right)$ ...($\because$ m = NIA)

Also, ϕ_2 = MI

$\Rightarrow M = \frac{\mu_0 \pi a^4}{2l^3}$

15. **(c)** A is true but R is false.

Explanation: A is true but R is false.

16. **(a)** Assertion and reason both are correct statements and reason is correct explanation for assertion.

Explanation: Assertion and reason both are correct statements and reason is correct explanation for assertion.

17. **(c)** both AC and DC

Explanation: both AC and DC

18. **(c)** A is true but R is false.

Explanation: Emf will always induces whenever, there is change in magnetic flux.

The current will induced only in closed loop.

Section B

19. For a moving particle, the energy and momentum of an electron are related to the frequency and wavelength of the associated matter wave by the relations:
De-broglie wavelength is given by $\lambda = \frac{h}{p}$ or, $p = \frac{h}{\lambda}$
p is momentum.
The energy of photon is, E = h$\nu = h\frac{c}{\lambda}$
Therefore,
The energy of a moving particle $= \frac{p^2}{2m} = \frac{(h/\lambda)^2}{2m} = \frac{h^2}{2\lambda^2 m}$
From the above relation, we can see that, ν has no direct significance on the relation of E and p

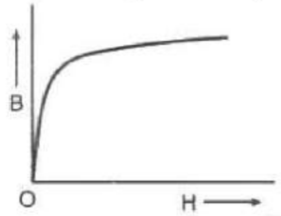
20. The total number of protons and neutrons present inside a nucleus is called its mass number (A).
The relation between the mass number (A) and radius (R) of the nucleus is
$R = R_0 A^{1/3}$ where $R_0 = 1.1 \times 10^{-15}$ m
Density of nuclear matter,
$\rho = \frac{\text{Mass of } {}_1^1\text{H}}{\text{Volume}} = \frac{1.66 \times 10^{-27} \text{ kg}}{\frac{4}{3}\pi\left(1.1 \times 10^{-15} \text{ m}\right)^3}$
$= 3 \times 10^{17}$ kgm^{-3}
$\frac{\text{Density of nuclear matter}}{\text{Density of ordinary matter}} = \frac{10^{17}}{10^3} = 10^{14}$

21. Imagine an electron being removed from the filled valence band to the bottom of the conduction band. This removal creates a vacancy or a hole in the valence band. Clearly, it requires more energy to remove an electron that is farther from the top of the valence band. Thus a valence hole state, farther from the top of the valence band, has higher energy just as a conduction electron farther from the bottom of the conduction band has higher energy.

22. i. Torque, $\tau = mB\sin\theta$ where m is the magnetic moment of the magnet, B is the external magnetic field and θ is the angle with which a short bar magnet placed with its axis.
Here, $\theta = 60^\circ$
$\tau = 0.063Nm$
$m = 0.9J/T$
$\Rightarrow B = \frac{\tau}{m \sin\theta} = \frac{0.063}{0.9 \times \sin 60^\circ}$
$\Rightarrow B = 0.081\ T$
ii. The magnet will be in stable equilibrium in the magnetic field if torque, $\tau = 0$
$\Rightarrow mB\sin\theta = 0 \Rightarrow \theta = 0^\circ$
i.e when bar magnet aligns itself parallel to the field.

OR

No, the permeability of a ferromagnetic material depends upon the applied magnetic field. Its value is large for the small values of the applied field. The graph between B and H is of the shape as shown in Figure. It follows that the value of B is quite large for a comparitively small value of H.



23. The d.c. resistance is just equal to the voltage divided by current.

$\therefore r_{dc} = \frac{V_B}{I_B} = \frac{0.3\text{ V}}{4.5\times10^{-3}A} = 66.67\ \Omega$

Consider two points A and C around the point of operation B. Then,

$r_{ac} = \frac{\Delta V}{\Delta I} = \frac{V_C - V_A}{I_C - I_A} = \frac{0.35-0.25}{(6-3)\times10^{-3}} = 33.33\ \Omega$

24. i. For conversion into ammeter : $R_g = 100\ \Omega$, $I_g = 1$ mA = 0.001 A, I = 1 A

$R_s = \frac{I_g}{I-I_g} \times R_g = \frac{0.001\times100}{1-0.001} = \frac{0.001\times100}{0.999}$

$=0.1\ \Omega$

ii. For conversion into voltmeter:

R_g=100 Ω, I_g = 0.001 A, V = 1 V

$R = \frac{V}{I_g} - R_g = \frac{1}{0.001} - 100 = 900\Omega$

OR

Here q = 1.5 μC = 1.5 × 10^{-6} C,

$\vec{v} = 2\times10^6\hat{i}\ ms^{-1}$, $\vec{B} = (0.2\hat{j} + 0.4\hat{k})T$

Magnetic force on the positive charge is

$\vec{F} = q(\vec{v}\times\vec{B})$

$= 1.5\times10^{-6}\left[2\times10^6\hat{i}\times(0.2\hat{j}+0.4\hat{k})\right]$

$= 3.0[0.2\hat{i}\times\hat{j} + 0.4\hat{i}\times\hat{k}]$

$= (0.6\hat{k} - 1.2\hat{j})$ N ...$[\because i\times\hat{j} = \hat{k}, \hat{i}\times\hat{k} = -\hat{j}]$

25. The fringe width is given by the expression

$\beta = \frac{D\lambda}{d}$

i. When D is increased, the fringes width increases.
ii. When d is increased, the fringe width increases.
iii. If the width w of the slits is changed, then interference occurs only, if $\frac{1}{w} > \frac{1}{d}$ remains satisfied, where d is the distance between the slits.

Section C

26. In a non-uniform magnetic field,
  a. a diamagnetic substance tends to move very slowly from stronger to weaker parts of the field.
  b. a paramagnetic substance tends to move slowly from weaker to stronger parts of the field.

c. a ferromagnetic substance tends to move quickly from weaker to stronger parts of the field.

Diamagnetic materials. Bismuth, copper.

Paramagnetic materials. Aluminium, sodium.

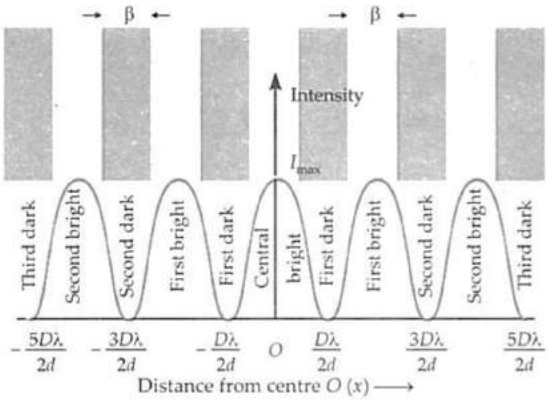
Ferromagnetic materials. Iron, cobalt.

i. For a permanent magnet, the ferromagnetic material should have high retentivity, high coercivity and high permeability.

ii. For an electromagnet, the material should have low retentivity and low coercivity.

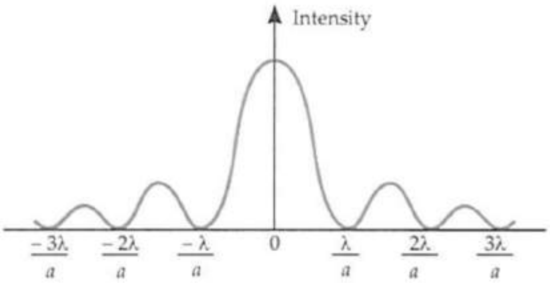
27. With two narrow slits, an interference pattern is obtained.
When one slit is completely covered, the diffraction pattern is obtained.

For intensity distribution curve for interference, see Fig.



Intensity distribution curve.

For intensity distribution curve for diffraction, see Fig.

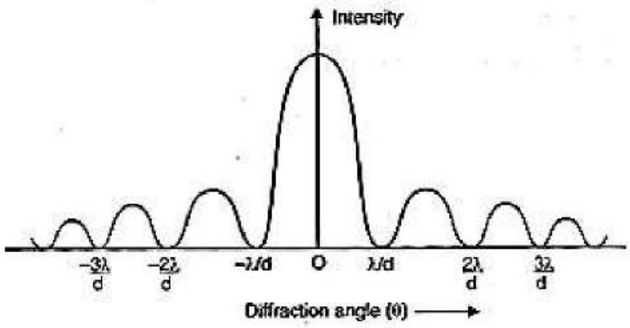


Interference	Diffraction
1. All the bright fringes are of same intensity.	Intensity of bright fringes decreases with the increasing order.
2. All the bright fringes are of equal width.	Central bright fringe is twice as wide as any secondary bright fringe.
3. Regions of dark fringes are perfectly dark.	Regions of dark fringes are not perfectly dark.
4. Maxima occur at $\theta = n\frac{\lambda}{d}$	Minima occur at $\theta = n\frac{\lambda}{a}$

OR

Diffraction of light: Phenomenon of bending of light around the corners of an obstacle or aperture is called diffraction.

The intensity distribution wave for diffraction is shown in the diagram below:



In interference, by 2 slits all bright fringes are of same intensity. In diffraction, the intensity of bright fringes decreases with the increase in distance from the central bright fringe.

i. The diffraction pattern becomes narrower if the width of the slit is decreased.

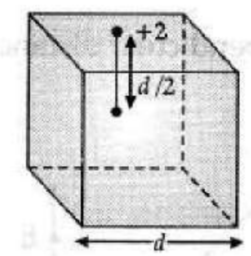
ii. When the monochromatic source is replaced by a white light source, we get a coloured diffraction pattern. The central band is white, but the other bands are coloured. As bandwidth is proportional to λ, the red band of higher wavelength is wider than the violet band with smaller wavelength.

28. i. Microwaves: Wavelength 10^{-4}m - 10^{-1}m, frequency 10^{13} Hz - 10^{9} Hz
  ii. Generation: Microwaves are produced by valves like magnetron, using a maser or Klystron valve. They are detected with crystal detectors, Point contact diodes or solid-state diodes.
  iii. Uses:
    a. Used in radar
    b. Used in telemetry
    c. Used in electron spin resonance studies
    d. Used in microwave ovens for heating food

OR

  i. The oscillating charge produces an oscillating or time-varying electric field and an oscillating electric field produces a time-varying magnetic field which then produces an oscillating emf. An oscillating voltage (emf) produces an oscillating magnetic field and so on. This, in turn, produces an oscillating electric field and so on. Thus oscillating electric and magnetic fields regenerate each other and as a result, an electromagnetic wave is produced and the wave propagates through space. In this way, the oscillating charges produce an electromagnetic wave. Vibrations of electric and magnetic fields are mutually perpendicular to each other and also perpendicular to the direction of propagation of the wave
  ii. According to quantum theory, electromagnetic radiation is made up of massless particles called photons. The momentum of the photon is expressed as
  $p = \frac{E}{c}$
  Where p and E are momentum and energy carried by the electromagnetic radiation or photons respectively and c = speed of light.
  Thus, electromagnetic waves carry energy and momentum.

29. Electric flux: The electric flux may be defined as the number of electric lines of force crossing through a surface normal to the surface. It can be measured as the surface integral of the electric field over that surface, i.e.
$\phi = \int_s \overline{E} \cdot d\overline{s}$
Electric flux ϕ is a scalar quantity.
Now to calculate the electric flux passing through the square of side d, draw a cube of side d such that it completely encloses the charge q. Now by using Gauss's law.



Total flux through the all the six surfaces of a cube is given as
$\phi_{\text{total}} = 6 \times \phi_{\text{square face}} = \frac{\text{total charge enclosed}}{\epsilon_0}$

$\Rightarrow 6\phi_{\text{square}} = \frac{q}{\epsilon_0}$

$\Rightarrow \phi_{\text{square face}} = \frac{q}{6\epsilon_0}$

Hence the flux through the square of side d with charge q at a distance d/2 directly above the head is $q/6\epsilon_0$.

If a charge is now moved to the distance d from the center of square and side of the square is doubled, then electric flux remains unchanged because electric flux in a closed surface depends only on the amount of charge contained inside the closed surface and is independent of the distance of charge.

30. Principle **:** The current carrying coil placed in normal magnetic field experiences a torque when current passes through it, which is given by

$\tau = NI(\vec{A} \times \vec{B})$

where, N =number of turns of the coil, I = current in the coil, A = area of coil and B = magnetic field applied

The galvanometer cannot be used to measure the current because

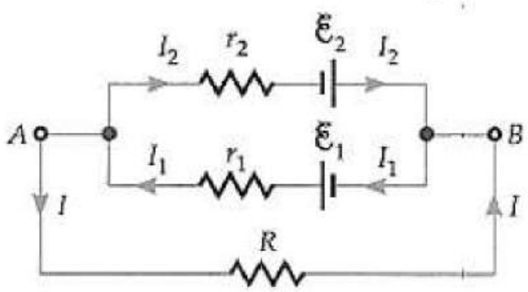
i. all the currents to be measured has to be passed through coil which would get damaged due to heating effect of electric current or
ii. its coil has considerable resistance because of length and it may affect original current.

Current sensitivity is defined as the angular deflection of a moving coil galvanometer when unit current pass through it and expressed as $\frac{\theta}{I} = \frac{NAB}{K}$. It can be increased by

i. increasing the magnetic field intensity, B and
ii. decreasing the value of torsional constant, K.

Section D

31. Suppose we connect a resistance R between points A and B. Then the circuit will be of the form as shown in the figure.



Applying Kirchhoff's first law at junction A,

$I = I_1 - I_2$ ...(i)

Applying Kirchhoff's second law,

$\varepsilon_1 = I_1 r_1 + IR$

or $IR = \varepsilon_1 - I_1 r_1$ ...(ii)

and $\varepsilon_2 = Ir_2 - IR$

or $IR = -\varepsilon_2 + I_2 r_2$ ...(iii)

From (i) and (iii),

$IR = -\varepsilon_2 + (I_1 - I)I_2$

or $I(R + r_2) = -\varepsilon_2 + I_1 r_2$

Multiplying (ii) by r_2 and (iv) by r_1, and on adding, we get

$IRr_2 + I(R + r_2)r_1 = \varepsilon_1 r_2 - \varepsilon_2 r_1$

or $I = \frac{\varepsilon_1 r_2 - \varepsilon_2 r_1}{R(r_1 + r_2) + r_1 r_2}$

$= \frac{(\varepsilon_1 r_2 - \varepsilon_2 r_1)/(r_1 + r_2)}{R + \frac{r_1 r_2}{r_1 + r_2}} = \frac{\varepsilon_0}{R + r_0}$

Clearly,

$\varepsilon_0 = \frac{\varepsilon_1 r_2 - \varepsilon_2 r_1}{r_1 + r_2}$ = emf of the battery required and $r_0 = \frac{r_1 r_2}{r_1 + r_2}$

= internal resistance of the battery required.

OR

i. $H = \frac{V^2 t}{R}$ is the formula of the produced heat across the resistor R when applied potential difference is V.

New potential difference is V' and Heat Produced after change is H'.

Then , $H' = \frac{V'^2 t}{R}$

According to question,

H' = 9H

$\frac{V'^2 t}{R} = 9\frac{V^2 t}{R}$

$\Rightarrow V'^2 = 9V^2$

$\Rightarrow V' = 3V$

ii. Current is calculated by using Ammeter. Ammeter is connected in series with the resistor.

Current 'I' in the circuit is given by

$I = \frac{E}{R+r} = \frac{12}{4+2} = 2A$

Voltage is calculated by using voltmeter. Voltmeter is connected in parallel with the battery.

Also, terminal voltage across the cell is given by

V = E - Ir

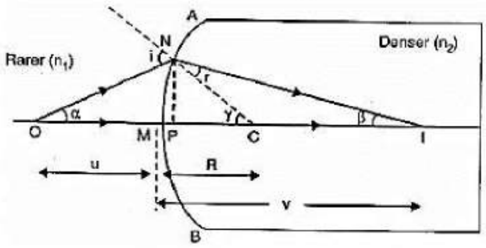
12 2 2

= 8 V

So, ammeter reading = 2A

and voltmeter reading = 8 V

32. AMB is a convex surface separating two media of refractive indices n_1 and n_2 ($n_2 > n_1$). Consider a point object O placed on the principal axis. A ray ON is incident at N and refracts along NI. The ray along ON goes straight and meets the previous ray at I. Thus I is the real image of O.



From Snell's law,

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

$n_1 \sin i = n_2 \sin r$

or $n_1 i = n_2 r$ [$\because \sin\theta \cong \theta$ as θ is very small]

From $\Delta NOC, i = \alpha + \gamma$

From $\Delta NIC, \gamma = r - \beta$

or $r = \gamma - \beta$

$\therefore n_1(\alpha + \gamma) = n_2(\gamma - \beta)$

or $n_1\alpha + n_2\beta = (n_2 - n_1)\gamma$

But $\alpha \cong \tan\alpha = \frac{NP}{OP} = \frac{NP}{OM}$ [P is close to M]

$\beta \cong \tan\beta = \frac{NP}{PI} = \frac{NP}{MI}$

$\gamma \cong \tan\gamma = \frac{NP}{PC} = \frac{NP}{MC}$

$\therefore n_1 \cdot \frac{NP}{OM} + n_2 \cdot \frac{NP}{MI} = (n_2 - n_1)\frac{NP}{MC}$

or $\frac{n_1}{OM} + \frac{n_2}{MI} = \frac{n_2 - n_1}{MC}$

Using Cartesian sign convention,

OM = -u, MI = +v, MC = +R

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

or $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

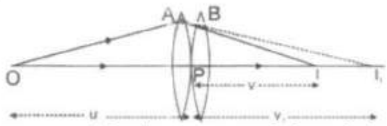
The lens maker formula gives us the relationship,

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

i.e. focal length, f and refractive index, μ have inverse dependence.
Now, as refractive index of water is greater than the air, the focal length of the lens will reduce when immersed in water.

OR

i.



Two thin lenses, of focal length f_1 and f_2 are kept in contact. Let O be the position of the object and let u be the object distance. The distance of the image (which is at I_1), for the first lens is v_1

This image serves as object for the second lens. Let the final image be at I. We then have

$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$

$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$

Adding, we get

$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

$\therefore P = P_1 + P_2$

ii. A ray of light passing from the air through an equilateral glass prism undergoes minimum deviation. Thus, At a minimum deviation

$r = \frac{A}{2} = 30^\circ$

We are given that, $i = \frac{3}{4}A = 45^\circ$

$\therefore \mu = \frac{\sin 45^\circ}{\sin 30^\circ} = \sqrt{2}$

$\therefore$ Speed of light in the prism $v = \frac{c}{\mu} = \frac{c}{\sqrt{2}}$

$= (2.1 \times 10^8 \text{ ms}^{-1})$

33. Two postulates of Bohr's theory of hydrogen atom are
   i. Every atom consists of small and massive central core, known as nucleus around which electron revolve. The necessary centripetal force is provided by electrostatic

force of attraction between positively charged nucleus and negatively charged electrons.

ii. The electrons revolved around the nucleus in only those circular orbits which satisfy the quantum condition, that the angular momentum of electrons is equal to integral multiple of $\frac{h}{2\pi}$ where, h is Planck's constant. Thus, for any stationary orbit,
$mvr = \frac{nh}{2\pi}$
where, n = 1, 2, 3,...

In second excited state i.e., n = 3, two spectral lines namely Lyman series and Balmer series can be obtained corresponding to transition of electron from n = 3 to n = 1 and n = 3 to n = 2, respectively.

For Lyman series, n = 3 to n = 1, for minimum wavelength

$\frac{1}{\lambda_{\text{min}}} = R\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = \frac{8R}{9}$ ....(i)

For Balmer series (maximum wavelength),

$\frac{1}{\lambda_{\text{max}}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

$= \left(\frac{9-4}{36}\right) R = \frac{5R}{36}$ ....(ii)

On dividing Eq. (i) by Eq. (ii), we get

$\frac{\lambda_{\text{max}}}{\lambda_{\text{min}}} = \frac{8R/9}{5R/36} = \frac{8R}{9} \times \frac{36}{5R} = \frac{32}{5}$

$\Rightarrow \lambda_{\text{max}} : \lambda_{\text{min}} = 32 : 5$

OR

i. $mvr = \frac{nh}{2\pi}$

$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$

$r = \frac{4\pi\varepsilon_0 mv^2}{e^2}$

$r = \frac{4\pi\varepsilon_0 m\left(\frac{nh}{2\pi mr}\right)^2}{e^2}$

$\Rightarrow \quad r = \frac{\varepsilon_0 n^2 h^2}{\pi me^2}$

Potential energy, U = $-\frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r}$

$= -\frac{me^4}{4\varepsilon_0 n^2 h^2}$

$K.E. = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{nh}{2\pi mr}\right)^2$

$= \frac{n^2h^2\pi^2m^2e^4}{8\pi^2 me_0^2 n^4 h^4}$

K.E. = $\frac{me^4}{8\varepsilon_0^2 n^2 h^2}$

total energy = Kinetic energy + Potential energy

$= -\frac{me^4}{8\varepsilon_0^2 n^2 h^2}$

ii. **Rydberg formula:** For first member of Lyman series

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

$\lambda = \frac{4}{3R} = \frac{4}{3} \times 912\overset{o}{A}$

= 1216 $\overset{o}{A}$

For first member of Balmer Series

$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$\lambda = \frac{36}{5R}$

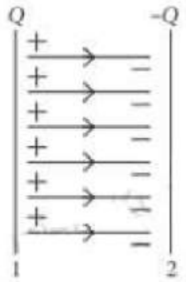
$= \frac{36}{5} \times 912\overset{o}{A}$

$= 6566.4\ \overset{o}{A}$

Section E

34. **Read the text carefully and answer the questions:**

A capacitor is a device to store energy. The process of charging up a capacitor involves the transferring of electric charges from its one place to another. This work done in charging the capacitor is stored as its electrical potential energy.



If q is the charge and V is the potential difference across a capacitor at any instant during its charging, then small work done in storing an additional small charge dq against the repulsion of charge q already stored on it is dW = $V \cdot dq = (\frac{q}{C})dq$

(i) As, $C_1 = 2\ \mu F$, $C_2 = 4\ \mu F$

In series combination, the equivalent capacitance will be, C = $\frac{C_1C_2}{C_1+C_2} = \left(\frac{2\times4}{2+4}\right)\mu F = \frac{4}{3}\mu F$

Potential difference applied, V = 6V

Energy stored in the system, U = $\frac{1}{2}CV^2$

$= \frac{1}{2} \times \frac{4}{3} \times 10^{-6} \times (6)^2\ J = 24\mu J$

(ii) The energy stored in a capacitor is U = $\frac{1}{2}CV^2 = \frac{1}{2} \times \left(10 \times 10^{-6}\right)(10)^2 = 500\mu J$

(iii) The potential difference and electric field both decrease.

When the gap between the plates is completely filled with dielectric of dielectric constant K, then potential is V = $\frac{Qd}{A\varepsilon_0 K}$ ...(i)

and electric field is

E = $\frac{Q}{A\varepsilon_0 K}$ ...(ii)

From equations (i) and (ii), both electric field and potential decrease.

OR

Work done = $U_f - U_i = \frac{1}{2}\frac{q^2}{C_f} - \frac{1}{2}\frac{q^2}{C_i}$

$= \frac{q^2}{2}\left[\frac{1}{C_f} - \frac{1}{C_i}\right] = \frac{(5\times10^{-6})^2}{2}\left[\frac{1}{2\times10^{-6}} - \frac{1}{5\times10^{-6}}\right]$

$= 3.75 \times 10^{-6}$ J

35. **Read the text carefully and answer the questions:**

A transformer is essentially an a.c. device. It cannot work on d.c. It changes alternating voltages or currents. It does not affect the frequency of a.c. It is based on the phenomenon of mutual induction. A transformer essentially consists of two coils of insulated copper wire having a different number of turns and wound on the same soft iron core.

The number of turns in the primary and secondary coils of an ideal transformer are 2000 and 50 respectively. The primary coil is connected to the main supply of 120 V and secondary coil is connected to a bulb of resistance 0.6 Ω.

(i) As $\frac{E_s}{E_p} = \frac{n_s}{n_p} \Rightarrow E_S = E_P \cdot \frac{n_s}{n_p}$

$= \frac{120 \times 50}{2000} = 3V$

(ii) $I_S = \frac{E_s}{R} \Rightarrow I_S = \frac{3}{0.6} = 5A$

(iii) As $\frac{I_p}{I_s} = \frac{E_s}{E_p}$

$\Rightarrow I_p = \frac{E_s}{E_p} \times I_s = \frac{3}{120} \times 5 = 0.125\ A$

OR

Power in primary, $P_p = E_P \times I_p = 120 \times 0.125 = 15W$