Class XII Session 2023-24
Subject - Physics
Sample Question Paper - 9

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

General Instructions:

1. There are 33 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.
3. All the sections are compulsory.
4. **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.
5. There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
6. Use of calculators is not allowed.

Section A

1. Rectification is the process of conversion of **[1]**

a) low d.c. into high d.c. b) low a.c. into high a.c.

c) a.c. into d.c. d) d.c. into a.c.

2. Which can be the unit of Resistivity from the following? **[1]**

a) $V.m$ b) $\Omega.cm^2$

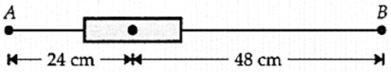
c) $\Omega.m$ d) $\Omega.cm^3$

3. An equi-convex crown glass lens has a focal length 20 cm for violet rays. Here $\mu_v = 1.5$ & $\mu_r = 1.47$. Its focal length for red rays is **[1]**

a) 24.85 cm b) 20.82 cm

c) 21.28 cm d) 22.85 cm

4. A bar magnet of length 3 cm has points A and B along its axis at distances of 24 cm and 48 cm on the opposite sides. Ratio of magnetic fields at these points will be **[1]**



a) $\frac{1}{2\sqrt{2}}$ b) 4

c) 3 d) 8

5. If the potential of a capacitor having capacity 8 pF is increased from 10 V to 20 V, then increase in its energy will be: **[1]**

a) 12×10^{-4} J

b) 4×10^{-6} J

c) 12×10^{-6} J

d) 4×10^{-4} J

6. The ratio of magnetic induction on the axis of a straight long current carrying solenoid at a point on end to that at the centre of solenoid is **[1]**

a) 1 : 1

b) $\sqrt{2} : 1$

c) 2 : 1

d) 1 : 2

7. If the speed of rotation of a dynamo is doubled, then the induced e.m.f. will **[1]**

a) become four times

b) become half

c) become double

d) remain unchanged

8. The magnetic moment has dimensions of **[1]**

a) $[L^2A]$

b) $[L^2T^{-1}A]$

c) $[LT^{-1}A]$

d) [LA]

9. In double-slit experiment using light of wavelength 600 nm, the angular width of a fringe formed on a distant screen is 0.1^o. What is the spacing between the two slits? **[1]**

a) 6.7×10^{-4}m

b) 4.5×10^{-4}m

c) 3.4×10^{-4}m

d) 5.6×10^{-4}m

10. The force per unit charge is known as ________. **[1]**

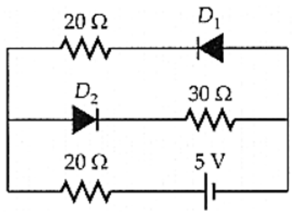
a) electric potential

b) electric field

c) electric current

d) electric flux

11. The current in the circuit will be **[1]**



a) $\frac{5}{10}A$

b) $\frac{5}{50}A$

c) $\frac{5}{20}A$

d) $\frac{5}{40}A$

12. The frequency of light in a material is 2×10^{14} Hz and wavelength is 5,000 $\overset{\circ}{A}$. The refractive index of the material will be **[1]**

a) $1 \cdot 40$

b) $3 \cdot 00$

c) $1 \cdot 50$

d) $1 \cdot 33$

13. **Assertion (A):** The kinetic energy of photoelectrons emitted from metal surface does not depend on the intensity of incident photon. **[1]**

Reason (R): The ejection of electrons from metallic surface is not possible with the frequency of incident photons below the threshold frequency.

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.

14. **Assertion:** Dielectric polarisation means the formation of positive and negative charges inside the dielectric. **[1]**

Reason: Free electrons are not formed in this process.

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.

15. **Assertion (A):** Colours are seen in thin layers of oil on the surface of the water. **[1]**

Reason (R): White light is composed of several colours.

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 (A):** In series LCR-circuit, the resonance occurs at one frequency only. **[1]**

Reason (R): At resonance, the inductive reactance is equal and opposite to the capacitive reactance.

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

17. How does Ampere-Maxwell law explain the flow of current through a capacitor when it is being charged by a battery? Write the expression for the displacement current in terms of the rate of change of electric flux. **[2]**

18. Use the Ampere's law for $\vec{H}$ and continuity of lines of $\vec{B}$, to conclude that inside a bar magnet, **[2]**

a. lines of run from the N-pole to S-pole, while
b. lines of must run from the S-pole to N-pole.

19. Explain the terms depletion layer and potential barrier in a p-n junction diode. How are the **[2]**

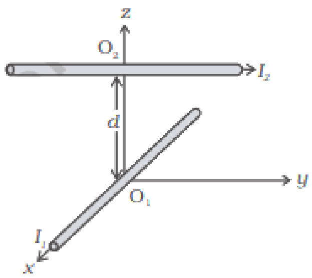
i. width of depletion layer, and
ii. value of potential barrier affected when the p-n junction is forward biased?

20. **[2]**

i. The radius of the innermost electron orbit of a hydrogen atom is 5.3×10^{-11} m. Calculate its radius in n = 3 orbit.
ii. The total energy of an electron in the first excited state of the hydrogen atom is -3.4 e V. Find out its (a) kinetic energy and (b) potential energy in this state.

21. Two long wires carrying current I_1 and I_2 are arranged as shown in Fig. The one carrying current I_1 is along the x-axis. The other carrying current I_2 is along a line parallel to the y-axis given by x = 0 and z = d. Find the force **[2]**

exerted at O_2 because of the wire along the x-axis.

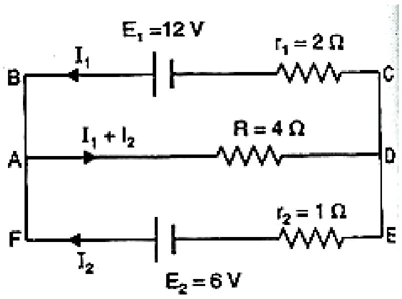


OR

A semicircular arc of radius 20 cm carries a current of 10 A. Calculate the magnitude of the magnetic field at the centre of the arc.

Section C

22. Find the potential difference across each cell and the rate of energy dissipation in R. **[3]**



23. Draw a circuit diagram of a full-wave rectifier. Explain its working principle. Draw the input/output, wave-forms indicating clearly the functions of the two diodes used. **[3]**

24. Write the basic features of the photon picture of electromagnetic radiation on which Einstein's photoelectric equation is based. **[3]**

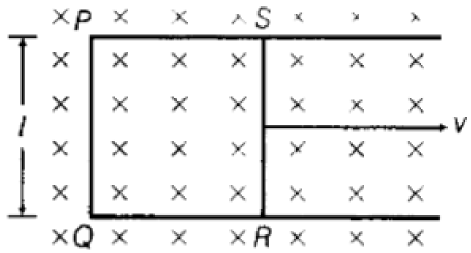
25. What is a moderator? Explain its action in slowing down the neutrons. **[3]**

26. State Bohr's postulate to explain stable orbits in a hydrogen atom. Prove that the speed with which the electron revolves in n^{th} orbit is proportional to (1/n) **[3]**

27. Two sources S_1 and S_2 emitting light of wavelength 600 nm placed 0.1 mm apart. A detector is moved on the line S_1P which is perpendicular to S_1S_2. **[3]**

 i. What would be the minimum and maximum path difference at the detector as it is moved along the line S_1P.
 ii. Locate the position of farthest minimum detected.

28. Figure shows a rectangular conducting loop PQRS in which arm RS of length I is movable. The loop is kept in a uniform magnetic field B directed downward perpendicular to the plane of the loop. The arm RS is moved with a uniform speed v. **[3]**



Deduce an expression for

 i. the emf induced across the arm RS
 ii. the external force required to move the arm and
 iii. the power dissipated as heat.

OR

i. A metallic rod of length l is moved perpendicular to its length with velocity v in a magnetic field B acting perpendicular to the plane in which rod moves. Derive the expression for the induced emf.

ii. A wheel with 15 metallic spokes each 60 cm long, is rotated at 360 rev/min in a plane normal to the horizontal component of the earth's magnetic field. The angle of dip at that place is 60^o. If the emf induced between the rim of the wheel and the axle is 400 mV, calculate the horizontal component of the earth's magnetic field at the place. How will the induced emf change, if the number of spokes is increased?

Section D

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

Maxwell showed that the speed of an electromagnetic wave depends on the permeability and permittivity of the medium through which it travels. The speed of an electromagnetic wave in free space is given by c = $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$. The fact led Maxwell to predict that light is an electromagnetic wave. The emergence of the speed of light from purely electromagnetic considerations is the crowning achievement of Maxwell's electromagnetic theory. The speed of an electromagnetic wave in any medium of permeability μ and permittivity ε will be $\frac{c}{\sqrt{K\mu_r}}$ where K is the dielectric constant of the medium and μ_r is the relative permeability.

(i) The dimensions of $\frac{1}{2}\varepsilon_0 E^2$ (ε_0 : permittivity of free space; E = electric field) is

a) MLT^{-1}

b) $ML^{-1}T^{-2}$

c) ML^2T^{-2}

d) ML^2T^{-1}

(ii) Let $[\varepsilon_0]$ denote the dimensional formula of the permittivity of the vacuum. If M = mass, L = length, T = time and A = electric current, then

a) $[\varepsilon_0] = ML^2T^{-1}$

b) $[\varepsilon_0] = MLT^{-2}A^{-2}$

c) $[\varepsilon_0] = M^{-1}L^{-3}T^4A^2$

d) $[\varepsilon_0] = M^{-1}L^{-3}T^2A$

(iii) An electromagnetic wave of frequency 3 MHz passes from vacuum into a dielectric medium with permittivity ε = 4. Then

a) wavelength is halved and the frequency remains unchanged.

b) wavelength and frequency both remain unchanged

c) wavelength is doubled and the frequency remains unchanged

d) wavelength is doubled and the frequency becomes half

OR

Which of the following are not electromagnetic waves?
cosmic rays, γ-rays, β-rays, X-rays

a) β-rays

b) X-rays

c) γ-rays

d) cosmic rays

(iv) The electromagnetic waves travel with

a) the speed of light c = 3×10^8 m s^{-1} in fluid medium.

b) the speed of light c = 3×10 m s^{-1} in solid medium

c) the speed of light c = 3×10^8 m s^{-1} in

d) the same speed in all media

free space

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

The smallest charge that can exist in nature is the charge of an electron. During friction, it is only the transfer of electrons that makes the body charged. Hence net charge on anybody is an integral multiple of the charge of an electron [1.6×10^{-19} C] i.e.

$q = \pm ne$

where n = 1, 2, 3, 4,...

Hence nobody can have a charge represented as 1.1e, 2.7e, $\frac{3}{5}$e, etc.

Recently, it has been discovered that elementary particles such as protons or neutrons are composed of more elemental units called quarks.

(i) Which of the following properties is not satisfied by an electric charge?

a) Total charge conservation
b) Quantization of charge
c) Two types of charge
d) Circular line of force

(ii) Which one of the following charges is possible?

a) 4.5×10^{-19} C
b) 8.6×10^{-19} C
c) 5.8×10^{-18} C
d) 3.2×10^{-18} C

(iii) If a charge on a body is 1 nC, then how many electrons are present on the body?

a) 6.25×10^{9}
b) 6.25×10^{28}
c) 6.25×10^{27}
d) 1.6×10^{19}

(iv) If a body gives out 10^9 electrons every second, how much time is required to get a total charge of 1 C from it?

a) 188.21 years
b) 198.19 years
c) 190.19 years
d) 150.12 years

OR

A polythene piece rubbed with wool is found to have a negative charge of 3.2×10^{-7} C. Calculate the number of electrons transferred.

a) 3×10^{12}
b) 3×10^{14}
c) 2×10^{14}
d) 2×10^{12}

Section E

31. i. Draw a labelled schematic ray diagram of the astronomical telescope in normal adjustment. **[5]**

ii. Which two aberrations do objectives of refracting telescope suffer from? How are these overcome in reflecting telescope?

OR

i. There are two sets of apparatus of Young's double-slit experiment. Inset A, the phase difference between the two waves emanating from the slits does not change with time, whereas in set B, the phase difference between the two waves from the slits changes rapidly with time. What difference will be observed in the pattern obtained on the screen in the two setups?

ii. Deduce the expression for the resultant intensity in both the above-mentioned setups (A and B), assuming that the waves emanating from the two slits have the same amplitude a and same wavelength λ.

32. i. Describe briefly the process of transferring the charge between the two plates of a parallel plate capacitor when connected to a battery. Derive an expression for the energy stored in a capacitor. **[5]**

ii. A parallel plate capacitor is charged by a battery to a potential difference V. It is disconnected from the battery and then connected to another uncharged capacitor of the same capacitance. Calculate the ratio of the energy stored in the combination to the initial energy on the single capacitor.

OR

Calculate potential on the axis of a disc of radius R due to a charge Q uniformly distributed on its surface.

33. In an ac circuit, is then applied instantaneous voltage equal to the algebraic sum of the instantaneous voltages across the series elements of the circuit? Is the same true for rms voltage? **[5]**

OR

A circuit containing a 80 mH inductor and a 60 μF capacitor in series is connected to a 230 V, 50 Hz supply. The resistance of the circuit is negligible.

a. Obtain the current amplitude and rms values.
b. Obtain the rms values of potential drops across each element.
c. What is the average power transferred to the inductor?
d. What is the average power transferred to the capacitor?
e. What is the total average power absorbed by the circuit? [‘Average’ implies ‘averaged over one cycle’.]

Solution

Section A

1.

(c) a.c. into d.c.

Explanation: Rectification is the process of conversion of a.c. into d.c.

2.

(c) $\Omega . m$

Explanation: Electrical resistivity of the material of a conductor is the resistance offered by the conductor of length 1 m and area of cross-section $1 m^2$. A low resistivity indicates a material that readily allows the movement of electric charge.

$\because$ Resistance, $R = \rho \frac{L}{A}$

Where ρ is resistivity, L is the length and A is area.

$\Rightarrow \rho = R\frac{A}{L}$

Since unit of R = Ohm, A = $(\text{meter})^2$, l = (meter)

Unit of resistivity , $\rho = \frac{((ohm \times (metre)^2)}{(metre)}$

$\rho = ohm - metre(or\, \Omega - m)$

3.

(c) 21.28 cm

Explanation: $\frac{1}{f} = (\frac{\mu_2}{\mu_1} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$

For violet light,

$\frac{1}{f_v} = (1.5 - 1)(\frac{1}{R_1} - \frac{1}{R_2}) = 0.5(\frac{1}{R_1} - \frac{1}{R_2})$

For red light,

$\frac{1}{f_r} = (1.47 - 1)(\frac{1}{R_1} - \frac{1}{R_2}) = 0.47(\frac{1}{R_1} - \frac{1}{R_2})$

Hence, $f_r = \frac{0.5}{0.47} f_v = 1.064 \times 20 = 21.28 cm$

4.

(d) 8

Explanation: For a short magnet,

$B_{\text{axial}} \propto \frac{1}{d^3}$

$\therefore \frac{B_A}{B_B} = \left(\frac{48}{24}\right)^3$ = 8

5. **(a)** 12×10^{-4} J

Explanation: $\Delta U = U_2 - U_1 = \frac{1}{2}C\left(V_2^2 - V_1^2\right)$

$= \frac{1}{2} \times 8 \times 10^{-6}\left(20^2 - 10^2\right)$

= $4 \times 10^{-6} \times 300$ J = 12×10^{-4} J

6.

(c) 2 : 1

Explanation: A solenoid is equivalent to a bar magnet.

For points at distances greater than the length of the solenoid, the field along the axis of the solenoid is $B_{axial} = \frac{\mu_0}{4\pi}\frac{2m}{x^3}$ and along the perpendicular bisector or equatorial line is

$B_{equatorial} = \frac{\mu_0}{4\pi}\frac{m}{x^3}$

Therefore, $\frac{B_{axial}}{B_{equatorial}} = \frac{2}{1}$

7.

(c) become double

Explanation: $\varepsilon_{ind} = \frac{-d(NAB\cos\theta)}{dt} = NAB\sin\theta\frac{d\theta}{dt} = NAB\omega\sin\theta$

8. **(a)** $[L^2A]$

Explanation: Magnetic moment = Current × area

$[M] = [L^2A]$

9.

(c) 3.4×10^{-4}m

Explanation: Given, $\lambda = 600nm = 600 \times 10^{-9}m$

Now convert degrees to radian i.e.,

$\theta = 0.1^\circ = \frac{0.1\pi}{180}\ rad$

Now, $\theta = \frac{\lambda}{d} \Rightarrow d = \frac{\lambda}{\theta} = \frac{600\times10^{-9}}{0.1\pi} \times 180 = 3.44 \times 10^{-4}\ m$

10.

(b) electric field

Explanation: Force per unit charge is the electric field.

11.

(b) $\frac{5}{50}A$

Explanation: Diode D_1 does not conduct as it is reverse biased. D_2 conducts as it is forward biased.

$I = \frac{5}{30+20} = \frac{5}{50}$ A

12.

(b) $3 \cdot 00$

Explanation: Here, λ = 5,000 $\mathring{A}$ = 5×10^{-7} m and $\nu = 2 \times 10^{14}$ Hz

Therefore, speed of light in the material,

$v = \nu\lambda = 2 \times 10^{14} \times 5 \times 10^{-7} = 10^8\ ms^{-1}$

Hence, the refractive index of the material,

$\mu = \frac{c}{v} = \frac{3\times10^8}{10^8} = 3$

13.

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

Explanation: Both A and R are true but R is not the correct explanation of A.

14.

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

Explanation: Polarisation induces +ve and -ve charges on the two opposite faces of the dielectric. No free electrons are formed in the process.

15.

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

Explanation: Both assertion and reason true but the reason is not the correct explanation of assertion. Colours are seen due to interference between light waves reflected by the upper and lower surfaces of the thin oil film.

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

Explanation: At resonance,

$X_L = X_C$

or $2\pi f_r L = \frac{1}{2\pi f_r C}$

or $f_r = \frac{1}{2\pi\sqrt{LC}}$

$\therefore$ Both A and R are true and R is the correct explanation of A.

Section B

17. When we charge a capacitor with the help of a cell, current flows all through the circuit except the part of a circuit which lies between two plates of the capacitor. There is no current found in that gap. But it was found that an electric field exists inside the plates, therefore, indicating the existence of a magnetic field which leads to inconsistency in the Ampere's circuital law.

When a battery is attached to a capacitor, conduction current flow in wire outside the capacitor, then through the capacitor the Electric flux ϕ_E = EA.

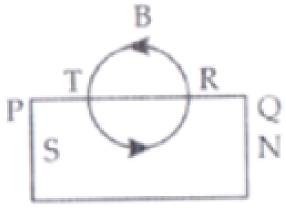
when $E = \frac{Q}{\epsilon_0 A}$ and $Q = \epsilon_0 EA$

so $I = \frac{dQ}{dt} = \frac{\epsilon_0 d\phi}{dt}$

This maintains the current in the capacitor.

During charging, the electric flux between the plates of the capacitor keeps on changing, this results in the production of a displacement current between the plates.

$I_d = \varepsilon_0 \frac{d\phi_E}{dt} \left(I_d = \varepsilon_0 A \frac{dE}{dt}\right)$

18. 

Consider an Ampere loop C inside and outside the magnet NS on side PQ of magnet then

$\int_P^Q \vec{H} \cdot \overrightarrow{dl} = \int_Q^P \frac{\vec{B}}{\mu_0} \overrightarrow{dl}$

Where B is magnetic field and m_0 is dipole moment. As angle between B and dl varies from 90^o, So

$\int_P^Q \vec{H} \cdot \overrightarrow{dl} = \int_Q^P \frac{\vec{B}}{\mu_0} \cdot \overrightarrow{dl} > 0$ i.e. positive.

Hence, the value of B must be varied from south pole to north pole inside the magnet.

According to Ampere's law, we get $\oint_{PDP} \vec{H} \cdot \overrightarrow{dl} = 0$

$\oint_{PQP} \vec{H} \cdot \overrightarrow{dl} = \int_P^Q \vec{H} \cdot \vec{dl} + \int_Q^P \vec{H} \cdot \overrightarrow{dl} = 0$

As $\int_p^Q H \cdot dl > 0$ (outside the magnet) and $\int_0^P H \cdot dl < 0$ (inside the magnet). It is due to the angle between H and dl is more than 90^o inside the magnet so cos θ is negative. It means the lines of H must run from north pole to south pole inside the bar magnet.

19. **Potential barrier:** The accumulation of negative charges in the p-region and positive charges in the n-region sets up a potential difference across the junction. This acts as a barrier and is called barrier potential.

Depletion layer: It is a layer of the immobile ion formed near the p-n junction by diffusion of majority charge carriers and electron-hole recombination.

i. Width of the depletion layer decreases in forward bias.
ii. The value of the potential barrier reduces in forward bias.

20. Given, Bohr's radius (r_0) = 5.3 $\times$ 10^{-11} m, n = 3

i. Radius of orbit is given by, $r_n = n^2 r_0$

For n = 3, $r_3 = (3)^2 \times 5.3 \times 10^{-11}$

$r_3 = 4.7 \times 10^{-10}$

$r_3 = 4.7$ A^0

ii. Given Total energy of an electron in the first excited state of the hydrogen atom is -3.4 eV

a. Kinetic energy = -Total energy = -(-3.4 eV) = 3.4 eV
b. Potential energy = - 2 $\times$ Kinetic energy = -2 $\times$ 3.4 = -6.8 eV

21. We know that force on current (I) carrying conductor placed in magnetic field B is

F = I(L $\times$ B) = ILB sin θ

The direction of the magnetic field at O_2 due to the current I_1 is parallel to Y-axis and in -Y direction.

As wire of current I_2 is parallel to Y-axis, current in I_2 is also along Y-axis. So I_2 and B_1 (magnetic field due to current I_1) are along Y-axis i.e., the angle between I_2 and B_1 is zero.

So, magnetic force F_2 on wire of current I_2 is $F_2 = B_2 I_2 L_1 \sin \theta° = 0$, thus resultant force = 0

OR

The magnetic field due to a semi-circular arc of radius 'r' carrying current (I) at centre is given by

$\Delta B = \frac{\mu_0}{4\pi} \frac{I \triangle l \sin 90°}{r^2} = \frac{\mu_0}{4\pi} \frac{I \Delta l}{r^2}$

The net magnetic field due to the whole length of arc l will be

B = $= \frac{\mu_0}{4\pi} \frac{I}{r^2} \sum \Delta l$

For semi-circular arc $\sum \Delta l = \pi r$

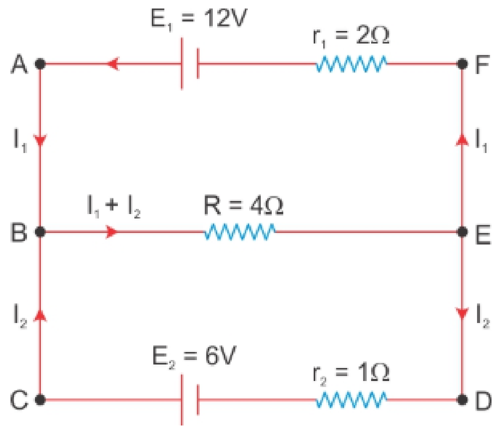
$\therefore$ B = $\frac{\mu_0}{4\pi}\frac{I}{r^2} = \frac{\mu_0 I}{4r}$

Given I = 10 A, r = 20m = 0.20 m

$\therefore$ B = $\frac{4\pi\times10^{-7}\times10}{4\times0.20}$ = $\frac{4\times3.14\times10^{-7}\times10}{4\times0.20}$ = 1.57 $\times$ 10^{-5} T

Section C

22.



Applying Kirchoff's Voltage Law (KVL) at loop ABCDEFA,

$E_1 - E_2 + I_2r_2 - I_1r_1 = 0$

$12 - 6 + I_2r_2 - I_1r_1 = 0$

$\Rightarrow 6 + I_2 - 2I_1 = 0$

$\Rightarrow 2I_1 - I_2 = 6$ ..... (i)

Applying KVL at loop ABEFA,

$E_1 - (I_1 + I_2)R - I_1r_1 = 0$

$12 - (I_1 + I_2)R - I_1r_1 = 0$

$\Rightarrow 12 - 4(I_1 + I_2) - 2I_1 = 0$

$\Rightarrow 12 - 4I_2 - 6I_1 = 0$

$\Rightarrow 4I_2 + 6I_1 = 12$ ...... (ii)

Solving (i) and (ii) we get,

$I_1 = \frac{18}{7}A$ and $I_2 = \frac{-6}{7}A$

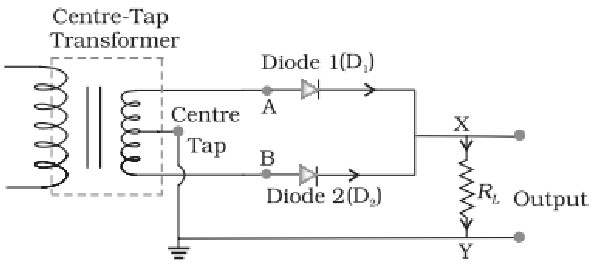
Potential difference across $cell_1 = V_1 = E_1 - I_1r_1 = 12 - \frac{18}{7} \times 2 = \frac{48}{7}V$

Potential difference across $cell_2 = V_2 = E_1 - I_1r_1 = = 6 - \frac{-6}{7} = \frac{48}{7}$ V

Rate of energy dissipation in R = power consumed = $(I_1 + I_2)^2$ R $= \left(\frac{18}{7} - \frac{6}{7}\right)^2 \times 4 = \frac{576}{7}$ watt

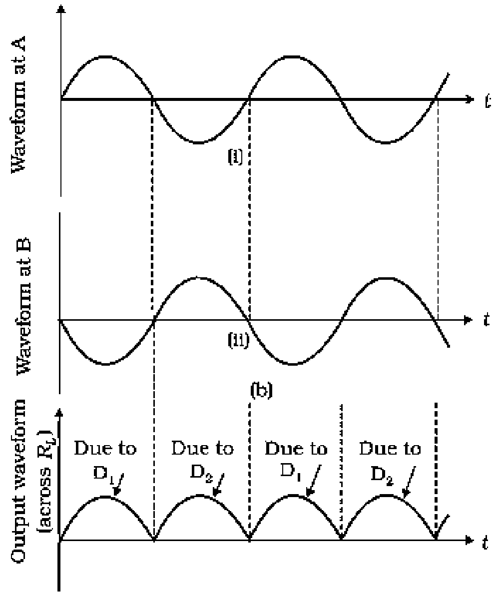
23. A rectifier which rectifies both halves of each a.c. input cycle is called a full wave rectifier. To make use of both the halves of input cycle, two junction diodes are used.

The **circuit diagram** of full-wave rectifier is shown below:



Principle: It also works on the principle that a junction diode offers low resistance during forward bias and high resistance, when reverse biased. Here, two junction diodes are connected in such a manner that if one diode gets forward biased during the first half cycle of a.c. input, the other gets reverse biased but when the next opposite half cycle comes, the first diode gets reverse biased and the second forward biased. Thus, output is obtained during both the half cycles of the a.c. input.

The **input and output waveforms** have been given below:



24. The basic features of the photon picture of e.m. radiation are as follows:
    i. Light is composed of discrete packets of energy called quanta or photons.
    ii. Each photon carries an energy E $(= h\nu)$ and momentum p (= h / λ), which depend on the frequency ν of the incident radiation and not on its intensity.
    iii. During the collision of a photon with an electron, the total energy of the photon gets absorbed by the electron.
    iv. Photoelectric emission from the metal surface occurs due to the absorption of a photon by an electron.
25. **Moderator:** Any substance which is used to slow down fast-moving neutrons to thermal energies ($\approx$ 0.0235 eV) is called a moderator. The commonly used moderators are water, heavy water (D_2O), graphite, and beryllium.

    The action of the moderator. Fast neutrons are passed through substances like paraffin, deuterium, or water, which contain a large number of hydrogen nuclei or protons. Neutrons and protons have nearly the same mass. When fast-moving neutrons are passed through paraffin, they make elastic collisions with protons, which have comparatively much smaller velocities. In few interactions, the velocities of the neutrons get interchanged with those of protons. The final velocities of the neutrons correspond to the random velocities of the atoms or molecules of the moderator at room temperature. Such neutrons are called thermal neutrons.

    About 25 collisions with deuterons (present in heavy water) or 100 collisions with carbon or beryllium are sufficient to slow down a neutron from 2 MeV to thermal energies.

    A good moderator has two properties:
    i. It slows down neutrons by elastic collisions.
    ii. It does remove neutrons from the system by absorbing them.
26. According to Bohr's second postulate only those orbits around the nucleus are allowed for electron to revolve for which the angular momentum of the electron is an integral multiple of $\frac{h}{2\pi}$ where h is Planck's constant

    So the electron revolves as

    Centripetal force = Coulombs force between proton electrons

    $\frac{mv^2}{r} = \frac{ke^2}{r^2}$

    $v^2 = \frac{ke^2}{mr}$

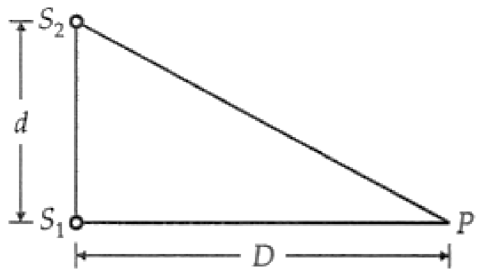
    also for hydrogen atom

    $r = \frac{\varepsilon_0 h^2 n^2}{e^2 \pi m}$

    $v^2 = \frac{ke^2 \times e^2 \pi m}{m \times \varepsilon_0 h^2 n^2} = \frac{k\pi e4}{\varepsilon_0 h^2 n^2}$

    $v^2 \propto \frac{1}{n^2}$

    $v \propto \frac{1}{n}$
27. i. The situation is shown in Fig. The path difference is minimum when the detector is at a large distance from S_1. Then the path difference is near to zero.



The path difference is maximum when the detector lies at point S_1.

$\therefore$ Maximum path difference = S_1S_2 = 0.1 mm

ii. The farthest minimum will occur at a point P for which the path difference is $\frac{\lambda}{2}$

Let S_1P = D. Then

p = $S_2P - S_1P = \frac{\lambda}{2}$

or $\sqrt{D^2+d^2}$ - D = $\frac{\lambda}{2}$

or $D^2 + d^2 = \left(D+\frac{\lambda}{2}\right)^2$

or $d^2 = D\lambda + \frac{\lambda^2}{4}$

or D = $\frac{d^2}{\lambda} - \frac{\lambda}{4} = \frac{(0.1\times10^{-3})^2}{600\times10^{-9}} - \frac{600\times10^{-9}}{4}$

$= \frac{1}{60}$ - 150 $\times$ 10^{-9} = $\simeq \frac{1}{60}$ m = 1.7 cm

28. i. Let RS moves with speed v rightward and also RS is at distances x_1 and x_2 from PQ at instants t_1 and t_2, respectively.

Change in flux, $d\phi = \phi_2 - \phi_1 = Bl\,(x_2 - x_1)$ [$\because$ magnetic flux, $\phi = \vec{B}.\vec{A} = BAcos0^0 = Blx$]

$\Rightarrow d\phi = \text{Bldx} \Rightarrow \frac{d\phi}{dt} = Bl\frac{dx}{dt} = Blv$ $\left[\because v = \frac{dx}{dt}\right]$

If resistance of loop is R, then $I = \frac{vBl}{R}$

ii. Magnetic force = BIl sin 90°

$= \left(\frac{vBl}{R}\right) Bl = \frac{vB^2l^2}{R}$

Now, External force must be equal to magnetic force

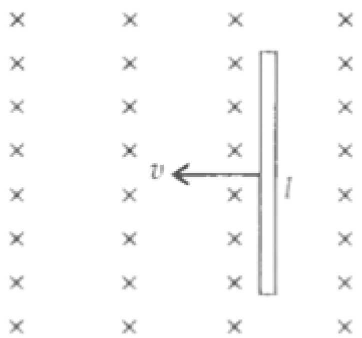
$\therefore$ External force $= \frac{vB^2l^2}{R}$

iii. As, $P = I^2R = \left(\frac{vBl}{R}\right)^2 \times R = \frac{v^2B^2l^2}{R^2} \times R$

$\therefore P = \frac{v^2B^2l^2}{R}$

OR

i.



ϕ_B = Blx

$\varepsilon = \frac{-d\phi_B}{dt}$

$= -Bl\frac{dx}{dt}$

= Blv

ii. $\omega = 360 \times \frac{2\pi}{60} = 12\pi$ rad/s thus , emf induced is given by:-

$\varepsilon = \frac{1}{2}B_Hl^2\omega$

$\therefore 400 \times 10^{-3} = \frac{1}{2} \times B_H \times \left(60\times10^{-2}\right)^2 \times 12\pi$

∴thus the horizontal component of magnetic field $B_H = \frac{5}{27\pi}$ = 0.06 T

No change in emf if no. of spokes is increased.

Section D

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

Maxwell showed that the speed of an electromagnetic wave depends on the permeability and permittivity of the medium through which it travels. The speed of an electromagnetic wave in free space is given by c = $\frac{1}{\sqrt{\mu_0\varepsilon_0}}$. The fact led Maxwell to predict that light is an electromagnetic wave. The emergence of the speed of light from purely electromagnetic considerations is the crowning achievement of Maxwell's electromagnetic theory. The speed of an electromagnetic wave in any medium of permeability μ and permittivity ε will be $\frac{c}{\sqrt{K\mu_r}}$ where K is the dielectric constant of the medium and μ_r is the relative permeability.

(i) **(b)** $ML^{-1}T^{-2}$

Explanation: $\frac{1}{2}\varepsilon_0 E^2$ = energy density = $\frac{\text{Energy}}{\text{Volume}}$

$\therefore \left[\frac{1}{2}\varepsilon_0 E^2\right] = \frac{ML^2T^{-2}}{L^3}$ = $[ML^{-1}T^{-2}]$

(ii) **(c)** $[\varepsilon_0]$ = $M^{-1}L^{-3}T^4A^2$

Explanation: As $\varepsilon_0 = \frac{q_1q_2}{4\pi FR^2}$ (from Coulomb's law)

$\varepsilon_0 = \frac{C^2}{Nm^2}\frac{[AT]^2}{MLT^{-2}L^2}$ = $M^{-1}L^{-3}T^4A^2$

(iii) **(a)** wavelength is halved and the frequency remains unchanged.

Explanation: The frequency of the electromagnetic wave remains same when it passes from one medium to another.

Refractive index of the medium, n = $\sqrt{\frac{\varepsilon}{\varepsilon_0}} = \sqrt{\frac{4}{1}}$ = 2

Wavelength of the electromagnetic wave in the medium,

$\lambda_{\text{med}} = \frac{\lambda}{n} = \frac{\lambda}{2}$

OR

(a) β-rays

Explanation: β-rays consists of electrons which are not electromagnetic in nature.

(iv) **(c)** the speed of light c = 3×10^8 m s^{-1} in free space

Explanation: The velocity of electromagnetic waves in free space (vacuum) is equal to velocity of light in vacuum (i.e., 3×10^8 m s^{-1}).

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

The smallest charge that can exist in nature is the charge of an electron. During friction, it is only the transfer of electrons that makes the body charged. Hence net charge on anybody is an integral multiple of the charge of an electron [1.6×10^{-19} C] i.e.

q = ±ne

where n = 1, 2, 3, 4,...

Hence nobody can have a charge represented as 1.1e, 2.7e, $\frac{3}{5}$e, etc.

Recently, it has been discovered that elementary particles such as protons or neutrons are composed of more elemental units called quarks.

(i) **(d)** Circular line of force

Explanation: Circular line of force

(ii) **(d)** 3.2×10^{-18} C

Explanation: From, q = ne, n = $\frac{q}{e} = \frac{3.2\times10^{-18}}{1.6\times10^{-19}}$ = 20

As n is an integer, hence this value of charge is possible.

(iii) **(a)** 6.25×10^9

Explanation: Charge on the body is q = ne

∴ No. of electrons present on the body is n = $\frac{q}{e} = \frac{1\times10^{-9}C}{1.6\times10^{-19}C}$ = 6.25×10^9

(iv) **(b)** 198.19 years

Explanation: Here, n = 10^9 electrons per second

Charge given per second, q = ne = $10^9 \times 1.6 \times 10^{-19}$ C

q = 1.6×19^{-10} C

Total charge, Q = 1 C(given)

$\therefore$ Time required $= \frac{Q}{q} = \frac{1}{1.6\times10^{-10}} s$ = 6.25×10^9 s

$\therefore \frac{6.25\times10^9}{3600\times24\times365}$year = 198.19 years

OR

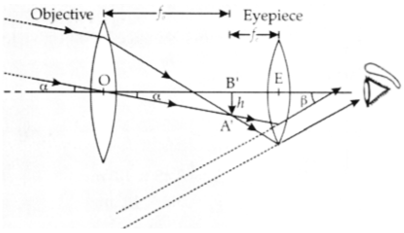
(d) 2×10^{12}

Explanation: As q = ne, n = $\frac{3.2\times10^{-7}}{1.6\times10^{-19}}$

$\Rightarrow$ n = 2×10^{12} electrons

Section E

31. i. Ray diagram of the astronomical telescope as shown in the figure:



ii. The two aberrations that objectives of refracting telescope suffer from are given below;

a. **Spherical aberrations:** Because of the surface geometry of the lens, sharp point image of star is difficult to obtain on a point.

b. **In reflecting telescope**, we use a parabolic mirror to remove this aberration.

c. **Chromatic aberrations:** Different colors of light have a different refractive index with respect to glass. Hence different colors would focus at different points. Hence the image of the white object would appear as different color point images. This is known as chromatic aberrations.

d. **In reflecting telescope**, image is formed with reflected rays hence this aberration is removed.

OR

i. There are two sets of apparatus of Young's double-slit experiment. In Set A: Stable interference pattern, the positions of maxima and minima do not change with time.

In Set B: Positions of maxima and minima will change rapidly with time and an average uniform intensity distribution will be observed on the screen.

ii. Expression for the intensity of stable interference pattern in set-A

If the displacement produced by slit S_1 is given by

$y_1 = a\cos \omega t$

then, the displacement produced by S_2 would be

$y_2 = a\cos (\omega t + \phi)$

and the resultant displacement will be given by

$y = y_1 + y_2$

$= a[\cos \omega t + \cos (\omega t + \phi)]$

$= 2a\cos (\frac{\phi}{2})\cos (\omega t + \frac{\phi}{2})$

The amplitude of the resultant displacement is $2a\cos (\frac{\phi}{2})$ and therefore the intensity at that point will be

$I = 4I_0\cos^2(\frac{\phi}{2})$

$\phi = 0$

$\therefore I = 4I_0$

In set B, the intensity will be given by the average intensity is given by :-

$I = 4I_0\cos^2(\frac{\phi}{2})$

$I = 2I_0$

32. i. Consider a parallel plate capacitor which is connected across a battery. The electrons are transferred from the negative terminal of the battery to the metallic plate connected to the negative terminal and acquires a negative charge. Similarly, the electrons move from the second plate to the positive terminal of the battery and acquire a positive charge. This process continues until the potential difference between the two plates becomes equal to the potential difference between the terminals of the battery. Thus, the charge is developed on the capacitor.

Let 'dW' be the work done by the battery in increasing the charge on the capacitor is given by, having the charge q and potential V is:

dW = V dq

where V = $\frac{q}{C}$

$\therefore$ dW = $\frac{q}{C}$dq

Total work done in charging up the capacitor is given by,

W = $\int$ dW = $\int_0^Q \frac{q}{c}$dq

$\therefore$ W = $\frac{Q^2}{2C}$

Hence total energy stored in the plates of the capacitor is given by, W = $\frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$

ii. Charge on the plates of the capacitor is given by q = CV

When uncharged capacitor of same capacitance is connected to the charged capacitor, sharing of charges takes place between the two capacitors till both the capacitors acquire same potential $\frac{V}{2}$

Energy stored in the combination of capacitors is given by,

$U_2 = \frac{1}{2}C(\frac{V}{2})^2 + \frac{1}{2}C(\frac{V}{2})^2 = \frac{CV^2}{4}$

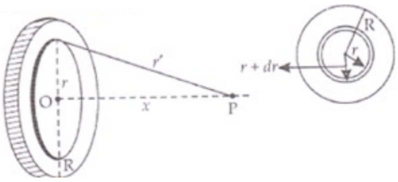
Energy stored by a single capacitor before connecting is given by, $U_1 = \frac{1}{2}CV^2$

Ratio of energy stored in the combination to that in the single capacitor is given by,

$\frac{U_2}{U_1} = \frac{CV^2/4}{CV^2/2}$ = 1 : 2 , Hence these are required results.

OR

Consider a point P on the axis perpendicular to the plane of disc and at distance x from the center O of the disc as shown in the figure.



Now consider a ring of radius r of thickness dr on a disc of radius R, as shown in the figure, Let us consider disc is divided into a large number of rings, Again let the charge on the ring is dq then potential dV due to ring at P, will be

$dV = \frac{kdq}{r'}\left[\because r' = \sqrt{r^2 + x^2}\right]$

dq is the charge on the ring = σ area of ring

$= \sigma \cdot \left[\pi(r + dr)^2 - \pi r^2\right]$

$dq = \sigma \cdot \pi\left[r^2 + dr^2 + 2rdr - r^2\right]$

Because dr is small, therefore, dr_2 is negligible.

$\therefore \text{dq} = \sigma\pi(2rdr) = 2\pi r\sigma \cdot dr$

$\therefore \text{dV} = \frac{k.2\pi r\sigma dr}{\sqrt{(r^2+x^2)}}$

So the potential due to charged disc

$\int_0^V dV = \int_0^R \frac{k.2\pi\sigma dr}{\sqrt{r^2+x^2}}$

$V = k.2\pi\sigma \cdot \int_0^R \frac{rdr}{(r^2+x^2)^{12}} = k.\pi\sigma\int_0^R r\cdot\left(r^2+x^2\right)^{-1/2}2dr = \frac{k\pi\sigma[\sqrt{r^2+x^2}]_0^R}{1/2}$

$= 2\pi k\sigma\left[\left(R^2+x^2\right)^{1/2} - x\right] = \frac{2\pi\sigma}{4\pi\varepsilon_0}\left[\left(R^2+x^2\right)^{1/2} - x\right]$

[$\because$ $\pi R^2\sigma$ = Q(charge on disc) $\sigma = \frac{Q}{\pi R^2}$

$= \frac{\pi 2R^2\sigma}{4\pi\varepsilon_0 R^2}[\sqrt{R^2+x^2} - x]$ thus the potential due to a disc is given by,

$V = \frac{2Q}{4\pi\varepsilon_0 R^2}[\sqrt{R^2+x^2} - x]$

33. Yes; the statement is not true for rms voltage.

It is true that in any ac circuit, the applied voltage is equal to the average sum of the Instantaneous voltages across the series elements of the circuit. $e = e_L + e_C + e_R$, where e is the instantaneous voltage. However, this is not true for rms voltage because voltages across different elements may not be in phase.

OR

Inductance, L = 80 mH = 80×10^{-3} H

Capacitance, C = 60 μF = 60×10^{-6} F

Supply voltage, V = 230 V

Frequency, ν = 50 Hz

Angular frequency, $\omega = 2\pi\nu = 100\,\pi$ rad/s

Peak voltage, $V_0 = V\sqrt{2} = 230\sqrt{2}\mathrm{V}$

a. Maximum current is given as:

$I_0 = \frac{V_0}{\left(\omega L - \frac{1}{\omega C}\right)}$

$= \frac{230\sqrt{2}}{\left(100\pi \times 80 \times 10^{-3} - \frac{1}{100\pi \times 60 \times 10^{-6}}\right)}$

$= \frac{230\sqrt{2}}{\left(8\pi - \frac{1000}{6\pi}\right)}$ = -11.63 A

The negative sign appears because $\omega L < \frac{1}{\omega C}$

Amplitude of maximum current, $|I_0| = 11.63\mathrm{A}$

Hence, rms value of current. $I = \frac{I_0}{\sqrt{2}} = \frac{-11.63}{\sqrt{2}}$ =- 8.22 A

b. Potential difference across the inductor.

$v_L = I \times \omega L$

$= 8.22 \times 100\,\pi \times 80 \times 10^{-3}$

= 206.61 V

Potential difference across the capacitor,

$V_c = I \times \frac{1}{\omega C}$

$= 8.22 \times \frac{1}{100\pi \times 60 \times 10^{-6}} = 436.84\mathrm{V}$

c. Average power consumed over a **complete cycle by the source** to the inductor is zero as actual voltage leads the current by $\frac{\pi}{2}$.

d. Average power consumed over a complete cycle by the source to the capacitor is zero as voltage lags current by $\frac{\pi}{2}$.

e. The total power absorbed (averaged over one cycle) is zero.