Class XII Session 2023-24
Subject - Physics
Sample Question Paper - 2

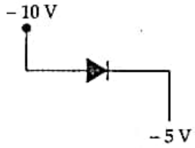
Time Allowed: 3 hours **Maximum Marks: 70**

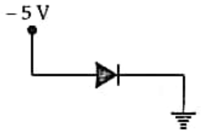
General Instructions:

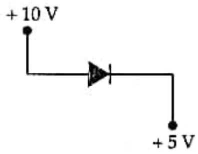
1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. All the sections are compulsory.
4. **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark 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.

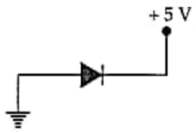
Section A

1. Which of the following p-n junction is forward biased? **[1]**

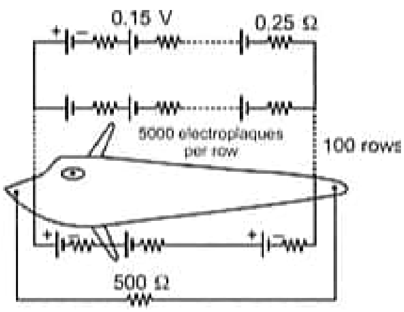
a) 

b) 

c) 

d) 

2. Eels are able to generate current with biological cells called electroplates. The electroplates in an eel are arranged in 100 rows, each row stretching horizontally along the body of the fish containing 5000 electroplaques. The arrangement is suggestively shown below. Each electroplaques has an emf of 0.15 V and internal resistance of 0.25 Ω. **[1]**



The water surrounding the Eel completes a circuit between the head and its tail. If the water surrounding it has a resistance of 500 Q, the current an Eel can produce in water is about

a) 1.5 A | b) 3.0 A
c) 30 A | d) 15 A

3. The focal length (f) of spherical mirror of radius curvature R is: **[1]**

a) $\frac{3}{2R}$ | b) 2R
c) R | d) $\frac{R}{2}$

4. Two bar magnets having same geometry with magnetic moments M and 2M are firstly placed in such a way that their similar poles are on the same side and its period of oscillation is T_1. Now the polarity of one of the magnets is reversed and its time period becomes T_2. Then, **[1]**

a) $T_1 = T_2$ | b) $T_2 = \infty$
c) $T_1 > T_2$ | d) $T_1 < T_2$

5. Two charges -10C and +10C are placed 10 cm apart. Potential at the centre of the line joining the two charges is: **[1]**

a) 4 V | b) zero
c) -2 V | d) 2 V

6. The magnetic field in a circular loop of diameter 0.1 m carrying a current of 1 A is **[1]**

a) $3.8 \times 10^{-5} T$ | b) $4.4 \times 10^{-5} T$
c) $1.25 \times 10^{-5} T$ | d) $2.8 \times 10^{-5} T$

7. What is the unit of self inductance of a coil? **[1]**

a) volt sec A^{-1} | b) $volt^{-1}$ sec A
c) volt sec^{-1} A^{-2} | d) volt sec^{-1} A^{-1}

8. The susceptibility of a magnetic substance is found to depend on temperature and the strength of the magnetising field. The material is a: **[1]**

a) diamagnet | b) superconductor
c) ferromagnet | d) paramagnet

9. In Young's experiment, two coherent sources are placed 0.9 mm apart and the fringes are observed 1 m away. If it produces the second dark fringe at a distance of 1 mm from the central fringe, the wavelength of monochromatic light used would be **[1]**

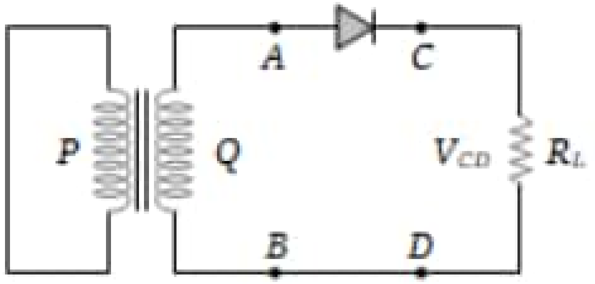
a) 10×10^{-5} cm | b) 6×10^{-5} cm
c) 10×10^{-4} cm | d) 60×10^{-4} cm

10. 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) $\vec{p} \times \vec{E}$

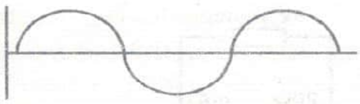
11. In the half wave rectifier circuit shown which one of the following wave forms is true for V_{CD}, the output across **[1]**

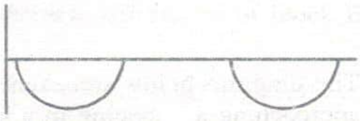
C and D?



a) 

b) 

c) 

d) 

12. According to Cartesian sign convention, distances measured in the same direction as the **[1]**

a) incident light is taken as negative
b) reflected/refracted ray is taken as negative
c) incident light is taken as positive
d) reflected/refracted ray is taken as positive

13. **Assertion (A):** The de Broglie equation has significance for any microscopic or sub-microscopic particle. **[1]**
Reason (R): The de Broglie wavelength is inversely proportional to the mass of the object if velocity is constant.

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:** Positive charge always moves from a higher potential point to a lower potential point. **[1]**
Reason: Electric potential is a vector quantity.

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):** In Young's double-slit experiment if wavelength of incident monochromatic light is just doubled, number of bright fringe on the screen will increase. **[1]**
Reason (R): Maximum number of bright fringe on the screen is inversely proportional to the wavelength of light used.

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):** The alternating current lags behind the e.m.f. by a phase angle of $\frac{\pi}{2}$, when ac flows through an inductor. **[1]**
Reason (R): The inductive reactance increases as the frequency of ac source decreases.

a) Both A and R are true and R is the correct
b) Both A and R are true but R is not the

explanation of A. | correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

Section B

17. i. An electromagnetic wave is traveling in a medium, with a velocity $\vec{v} = v\hat{i}$. Draw a sketch showing the propagation of the electromagnetic wave, indicating the direction of the oscillating electric and magnetic fields. **[2]**

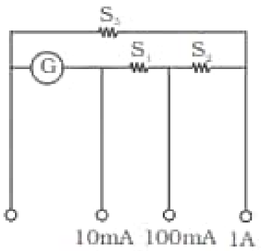
ii. How are the magnitudes of the electric and magnetic fields related to the velocity of the electromagnetic wave?

18. Briefly explain how will you demagnetise a piece of iron completely. **[2]**

19. What happens when a forward bias is applied to the p-n junction? **[2]**

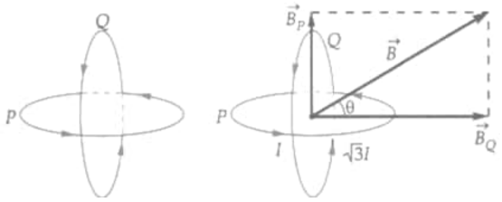
20. Which state of the triply ionised beryllium (Be^{3+}) has the same orbital radius as that of the ground state of hydrogen **[2]**

21. A multirange current meter can be constructed by using a galvanometer circuit as shown in Fig. We want a current meter that can measure 10mA, 100mA and 1A using a galvanometer of resistance 10Ω and that produces maximum deflection for current of 1mA. Find S_1, S_2 and S_3 that have to be used **[2]**



OR

Two identical coils Pand Q each of radius R are lying in perpendicular planes such that they have a common centre. Find the magnitude and direction of the magnetic field at the common centre of the two coils, if they carry currents equal to I and $\sqrt{3}I$ respectively.



Section C

22. A current of 30 amperes is flowing through a wire of cross-sectional area 2 mm^2. Calculate the drift velocity of electrons. Assuming the temperature of the wire to be 27°C, also calculate the rms velocity at this temperature. Which velocity is larger? Given that Boltzman's constant = $1.38 \times 10^{-23} JK^{-1}$, density of copper 8.9 g cm^{-3}, the atomic mass of copper = 63. **[3]**

23. i. Explain how a potential barrier is developed in a p-n junction diode. **[3]**

ii. Draw the circuit arrangement for studying the V-I characteristics of a p-n junction diode in reverse bias. Plot the V-I characteristics in this case.

24. If the frequency of the incident radiation on the cathode of a photo-cell is doubled, how will the following change: **[3]**

i. The kinetic energy of the electrons?

ii. Photoelectric current?

iii. Stopping potential?

Justify your answer.

25. How the size of a nucleus is experimentally determined? Write the relation between the radius and mass number of the nucleus. Show that the density of the nucleus is independent of its mass number. **[3]**

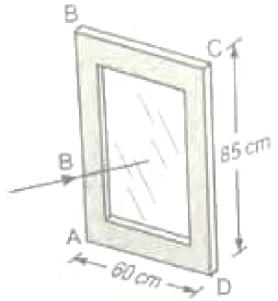
26. **[3]**
 i. Using Bohr's second postulate of quantisation of orbital angular momentum show that the circumference of the electron in the nth orbital state in hydrogen atom is n-times the de-Broglie wavelength associated with it.
 ii. The electron in hydrogen atom is initially in the third excited state. What is the maximum number of spectral lines which can be emitted when it finally moves to the ground state?

27. A beam of light consisting of two wavelengths 600 nm and 500 nm is used in a Young's double slit experiment. The slit separation is 1.0 mm and the screen is kept 0.60 m away from the plane of the slits. Calculate: **[3]**
 a. the distance of the second bright fringe from the central maximum for wavelength 500 nm, and
 b. the least distance from the central maximum where the bright fringes due to both the wavelengths coincide.

28. Define the term self-inductance of a solenoid. Obtain the expression for the magnetic energy stored in an inductor of self-inductance L to build up a current I through it. **[3]**

OR

The aluminium frame ABCD of a window measures 85cm $\times$ 60cm, as illustrated in fig.



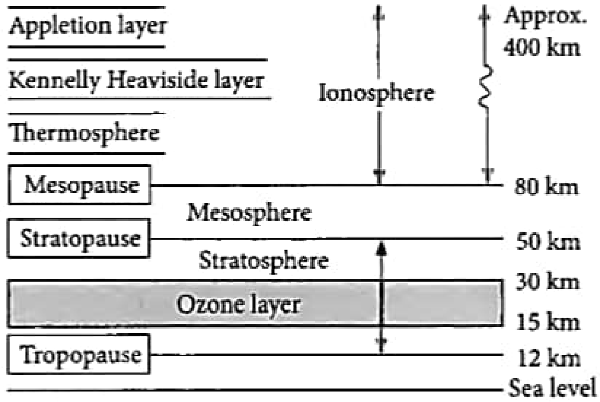
The window is hinged along the edge AB. When the window is closed, the horizontal component of the earth's magnetic field of flux density 1.8×10^{-4}T, is normal to the window.

 i. Calculate the magnetic flux through the window.
 ii. The window is now opened in a time of 0.20s. When open, the plane of the window is parallel to the earth's magnetic field. For the opening of the window, state the change in flux through the window and calculate the average e.m.f. induced in side CD of the frame.
 iii. Suggest, with a reason, whether the e.m.f. calculated in (ii) gives rise to a current in the frame ABCD.

Section D

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

Radio waves are produced by the accelerated motion of charges in conducting wires. Microwaves are produced by special vacuum tubes. Infrared waves are produced by hot bodies and molecules also known as heat waves. UV rays are produced by special lamps and very hot bodies like Sun.



(i) Solar radiation is

i. transverse electromagnetic wave
ii. longitudinal electromagnetic waves
iii. both longitudinal and transverse electromagnetic waves
iv. none of these.

a) Option (i) | b) Option (iv)
c) Option (iii) | d) Option (ii)

(ii) What is the cause of greenhouse effect?

a) Ultraviolet rays | b) X-rays
c) Infrared rays | d) Radiowaves

(iii) Biological importance of ozone layer is

a) it stops ultraviolet rays | b) none of these.
c) it reflects radiowaves | d) It layer reduces greenhouse effect

OR

Earth's atmosphere is richest in

a) ultraviolet | b) infrared
c) X-rays | d) microwaves

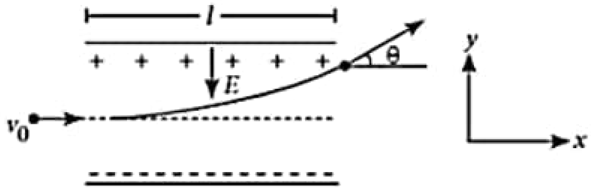
(iv) Ozone is found in

a) troposphere | b) mesosphere
c) ionosphere | d) stratosphere

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

When a charged particle is placed in an electric field, it experiences an electrical force. If this is the only force on the particle, it must be the net force. The net force will cause the particle to accelerate according to Newton's second law. So

$\vec{F}_e = q\vec{E} = m\vec{a}$



If $\vec{E}$ is uniform, then $\vec{a}$ is constant and $\vec{a} = \frac{q\vec{E}}{m}$. If the particle has a positive charge, its acceleration is in the direction of the field. If the particle has a negative charge, its acceleration is in the direction opposite to the electric field. Since the acceleration is constant, the kinematic equations can be used.

(i) A charged particle is free to move in an electric field. It will travel

a) none of these | b) always along a line of force
c) along a line of force, if its initial velocity is zero | d) along a line of force, if it has some initial velocity in the direction of an acute angle with the line of force

(ii) An electron of mass m, charge e falls through a distance h metre in a uniform electric field E. Then time of fall,

a) t = $\sqrt{\frac{2hm}{eE}}$

b) t = $\sqrt{\frac{2eE}{hm}}$

c) t = $\frac{2hm}{eE}$

d) t = $\frac{2eE}{hm}$

(iii) An electron moving with a constant velocity v along X-axis enters a uniform electric field applied along Y-axis. Then the electron moves

a) in a trajectory represented as y = ax

b) in a trajectory represented as y = ax^2

c) without any acceleration along Y-axis

d) with uniform acceleration along Y-axis

(iv) Two equal and opposite charges of masses m_1 and m_2 are accelerated in an uniform electric field through the same distance. What is the ratio of their accelerations if their ratio of masses is $\frac{m_1}{m_2}$ = 0.5?

a) $\frac{a_1}{a_2}$ = 3

b) $\frac{a_1}{a_2}$ = 1

c) $\frac{a_1}{a_2}$ = 2

d) $\frac{a_1}{a_2}$ = 0.5

OR

A particle of mass m carrying charge q is kept at rest in a uniform electric field E and then released. The kinetic energy gained by the particle, when it moves through a distance y is

a) qEy

b) qE^2y

c) qEy^2

d) $\frac{1}{2}qEy^2$

Section E

31. 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. **[5]**

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.

OR

A parallel beam of monochromatic light falls normally on a narrow slit and the light, coming out of the slit, is obtained on a screen, kept behind, parallel to the slit plane.

What kind of pattern do we observe on the screen and why? How does the

i. angular width

ii. linear width of the principal maximum, in this pattern change when the screen is moved, parallel to itself, away from the slit plane?

State two points of difference between this pattern and the interference pattern observed in the Young's double slit experiment.

32. The capacitance of a parallel plate capacitor is 50 pF and the distance between the plates is 4 mm It is charged to 200 V and then the charging battery is removed. Now a dielectric slab (k = 4) of thickness 2 mm is placed. Determine: **[5]**

i. final charge on each plate

ii. final potential difference between the plates

iii. final energy in the capacitor and

iv. energy loss.

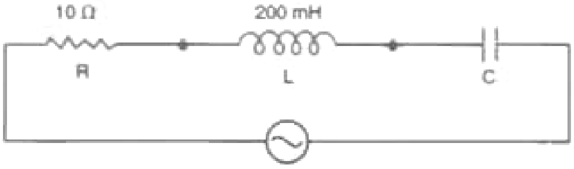
OR

A spherical capacitor has an inner sphere of radius 12 cm and an outer sphere of radius 13 cm. The outer sphere is earthed and the inner sphere is given a charge of $2.5\mu C$. The space between the concentric spheres is filled with a liquid of dielectric constant 32.

a. Determine the capacitance of the capacitor.
b. What is the potential of the sphere?
c. Compare the capacitance of this capacitor with that of an isolated sphere of radius 12 cm. Explain why the latter is much smaller.

33. In the following circuit, calculate: **[5]**

i. the capacitance of the capacitor, if the power factor of the circuit is unity,
ii. the Q-factor of this circuit. What is the significance of the Q-factor in ac circuit? Given the angular frequency of the ac source to be 100 rad/s. Calculate the average power dissipated in the circuit.



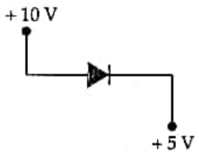
OR

i. Derive an expression for the average power consumed in a series L-C-R circuit connected to AC source for which the phase difference between the voltage and the current in the circuit is ϕ .
ii. Define the quality factor in an AC circuit. Why should the quality factor have high value in receiving circuits? Name the factors on which it depends.

Solution

Section A

1.

(c) 

Explanation: The p-side is at higher potential (+10V) and n-side is at lower potential (+5V).

2. **(a)** 1.5 A

Explanation:

Each row has 5000 electroplates that are connected in series.

Therefore, equivalent emf = 0.15 $\times$5000 = 750 V.

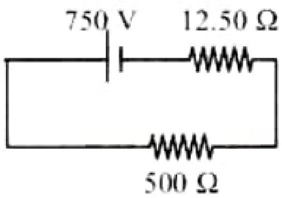
Equivalent internal resistance of combination = 0.25 $\times$ 5000 = 1250

All 100 rows are connected in parallel.

Therefore total voltage = 750 V

Equivalent resistance = $\frac{1250}{100}$ = 12.50 Ω

Thus the resultant circuit of the eel becomes



Current across 500Ω

I $\approx$ 1.5A

= $\frac{V}{R} = \frac{750}{500+12.50}$ = 1.46 A

= 1.5A (approx)

3.

(d) $\frac{R}{2}$

Explanation: The relationship between **the focal length f** and **radius** of **curvature r** for spherical mirror is given by R = 2f.

Therefore, $f = \frac{R}{2}$

4.

(d) $T_1 < T_2$

Explanation: In sum position,

$T_1 = 2\pi\sqrt{\frac{I_1+I_2}{(M_1+M_2)B_H}}$

$= 2\pi\sqrt{\frac{I+I}{(M+2M)B_H}}$

$= 2\pi\sqrt{\frac{2I}{3MB_H}}$

In difference position,

$T_2 = 2\pi\sqrt{\frac{I_1+I_2}{(M_2-M_1)B_H}}$

$= 2\pi\sqrt{\frac{I+I}{(2M-M)B_H}}$

$= 2\pi\sqrt{\frac{2I}{MB_H}}$

$\therefore \frac{T_1}{T_2} = \frac{1}{\sqrt{3}} < 1$ or $T_1 < T_2$

5.

(b) zero

Explanation: Potential at any point due to a point charge is given by

$V=\frac{1}{4\pi\epsilon_0}\frac{q}{r}$

The potential due to both the charges will be equal but of opposite sign.

Potential due to -10 C will be negative (let -V).

Potential due to +10C will be positive (let +V).

Thus net potential at mid point will be,

V_{net} = -V + V = zero

6.

(c) $1.25\times10^{-5}T$

Explanation: $B=\frac{\mu_0 I}{2r}=\frac{4\pi\times10^{-7}\times1}{0.1}$

$=12.56\times10^{-6}$

$=1.25\times10^{-5}T$

7. **(a)** volt sec A^{-1}

Explanation: L = $-\frac{e}{di/dt}=\frac{\text{volt}}{\text{amp/sec}}$ = Henry

8.

(d) paramagnet

Explanation: The susceptibility of a paramagnetic substance depends both on the temperature and strength of the magnetising field.

9.

(b) 6×10^{-5} cm

Explanation: For nth dark fringe,

x'_n = (2n - 1) $\frac{D\lambda}{2d}$

$\therefore 10^{-3}$ = (2 $\times$ 2 - 1) $\frac{1\times\lambda}{2\times0.9\times10^{-3}}$

or λ = 6 $\times$ 10^{-7} cm = 6 $\times$ 10^{-5} cm

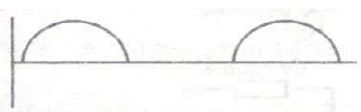
10.

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

Explanation: Torque on a dipole,

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

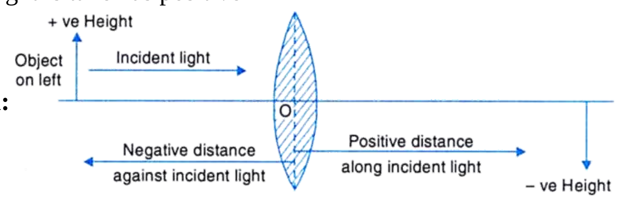
11.

(b) 

Explanation: When an alternating voltage is applied across a half wave rectifier, a pulsating voltage appears across the load only during the half cycles of the ac input i.e., only when the diode is forward biased.

12.

(c) incident light is taken as positive

Explanation: 

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

Explanation: $\lambda=\frac{h}{mv}$

For constant v, $\lambda\propto\frac{1}{m}$

λ is significantly measurable only in case of microscopic or sub-microscopic particles.

14.

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

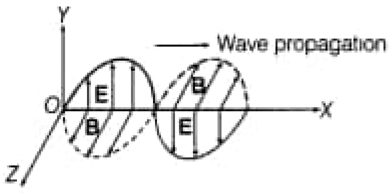
Explanation: If two points P and Q in an electric field are separated by an infinitesimal distance Δx and have a potential difference ΔV between them, E= $-\frac{\Delta V}{\Delta x}$. Here, negative sign implies that $\vec{E}$ has got a direction opposite to the potential gradient, i.e, in the direction of $\vec{E}$, the potential decreases, i.e, positive charge always moves from a higher potential point to a lower potential point.

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

16.
    (c) A is true but R is false.
    Explanation: When ac flows through an inductor current lags behind the emf., by phase of $\frac{p}{2}$, inductive reactance, X_L = ωL = $\pi.2f.L$, so when frequency increases correspondingly inductive reactance also increases.

Section B

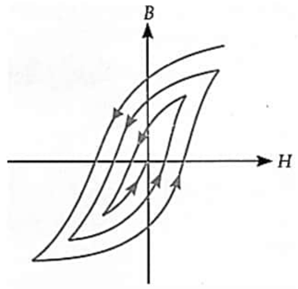
17. i. Given: velocity, $\vec{v}$ = v$\hat{i}$
    This means electric field E will be along Y-axis and magnetic field B will be along Z-axis because the two fields are perpendicular to each other and perpendicular to the direction of propagation of the wave. The figure below shows us the propagation of the electro -magnetic wave.



A linearly polarised EM waves

   ii. Speed of electromagnetic wave is given by :-
    c = $\frac{E_0}{B_0} = \frac{E}{B}$
    where E_0 and B_0 are the peak values of the electric ($\vec{E}$) and the magnetic ($\vec{B}$) vibrations respectively. E and B are instantaneous values of electric ($\vec{E}$) and magnetic ($\vec{B}$) field vectors respectively.

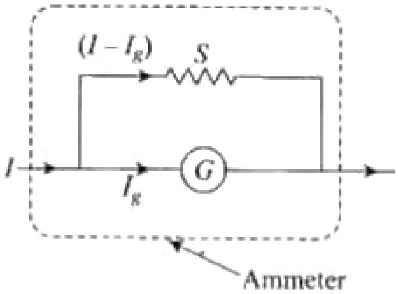
18. To demagnetise a sample, it is placed inside a solenoid carrying decreasing alternating current. The sample goes through several cycles of magnetisation under an alternating magnetising field of decreasing amplitude. Then the hysteresis loop becomes smaller and smaller until no residual magnetism is left in the sample.



19. When a p-n junction is forward biased:
    i. the potential barrier across decreases
    ii. the width of the depletion layer decreases
    iii. the effective resistance across the junction decreases
    iv. the junction conducts current

20. Radius of nth orbit is given by $r_n = \frac{n^2h^2}{4\pi^2 mkZe^2}$ i.e; $r_n \propto \frac{n^2}{Z}$
    Let $r_n(Be^{3+}) = r_1(H)$
    $x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$
    or $\frac{n^2}{4} = \frac{1^2}{1}$ or n =2

21. Key concept: A galvanometer can be converted into ammeter by connecting a very low resistance wire (shunt S) connected in parallel with galvanometer. The relationship is given by $l_gG = (l - l_g)$ S, where l_g is the range of galvanometer, G is the resistance of galvanometer.



For measuring I_1 = 10 mA : $I_g.G = (I_1 - I_G)(S_1 + S_2 + S_3)$

thus $(S_1+S_2+S_3) = \frac{1\times10}{9} = \frac{10}{9}\Omega$......(1)

For measuring I_2 = 100 mA : $I_G(G + S_1) = (I_2 - I_G)(S_2 + S_3)$

$(S_2+S_3) = \frac{1\times(10+S_1)}{(100-1)} = \frac{10+S_1}{99}$......(2)

For measuring I_3 = 1 A : $I_G(G + S_1 + S_2) = (I_3 - I_G)(S_3)$

$S_3 = \frac{1\times[10+S_1+S_2]}{(1000-1)} =$ ....(3)

by using 2nd and 1st equation, we get $S_1 = 1\ \Omega$

thus from 2nd equation, we get S_2+S_3 = 11/99=1/9....(4)

from 3rd equation , we get $S_3 = \frac{11+S_2}{999}$ ....(5)

By solving 4th and 5th equation, we get $S_2 = 0.1\ \Omega$

and from (4)th equation, we get

$S_3 = 0.01\ \Omega$ these are the required values .

OR

$\vec{B}_p = \frac{\mu_0 I}{2R}$, vertically upwards

$\vec{B}_Q = \frac{\mu_0\sqrt{3}I}{2R}$, along with horizontal

The resultant field at the centre is

B = $\sqrt{B_P^2 + B_Q^2} = \left[\left(\frac{\mu_0 I}{2R}\right)^2 + \left(\frac{\mu_0\sqrt{3}I}{2R}\right)^2\right]^{1/2}$

= $\frac{\mu_0 I}{2R}(1+3)^{1/2} = \left(\frac{\mu_0 I}{R}\right)$

$\tan\theta = \frac{BP}{BQ} = \frac{1}{\sqrt{3}}$

$\Rightarrow \theta = 30^o$

Section C

22. No. of atoms in 63 gram of copper = 6.023×10^{23}

No. of atoms in 8.9 gram or 1 cm^3 of copper

= $\frac{6.023 \times 10^{23} \times 8.9}{63}$

No. of atoms per m^3 of copper

= $\frac{6.023 \times 10^{23} \times 8.9 \times 10^6}{63}$

Electron density,

n = $\frac{6.023 \times 10^{23} \times 8.9 \times 10^6}{63}$ = $8.48 \times 10^{28}\ m^{-3}$

Also I = 30 A, A = 2 mm^2 = $2 \times 10^{-6} m^2$,

e = 1.6×10^{-19}C

∴ Drift velocity,

$v_d = \frac{I}{enA} = \frac{30}{1.6 \times 10^{-19} \times 8.48 \times 10^{28} \times 2 \times 10^{-6}}$

= $1.1 \times 10^{-3}\ ms^{-1}$

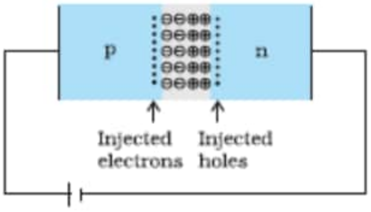
The rms velocity of electrons at 27°C (= 300 K) is given by

$v_{rms} = \sqrt{\frac{3k_BT}{m}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23}}{9 \times 10^{-31}}}$

= $1.17 \times 10^5\ ms^{-1}$

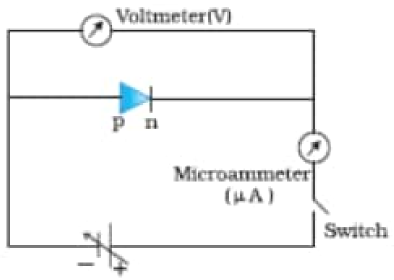
The rms velocity is about 10^8 times the drift velocity.

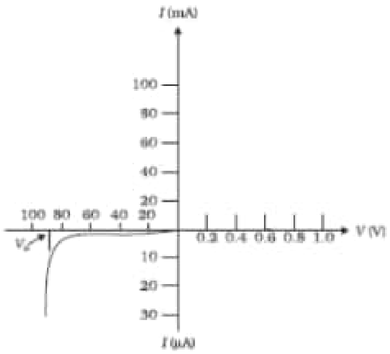
23. i.



During the formation of p - n junction diode; due to the concentration gradient across p and n sides of a diode, holes diffuse from p side to n side and electrons diffuse from n side to p side giving rise to development of immobile positive charges on the n side and the negative charges on the p side across the junction. Thus a potential barrier is formed at the junction.

ii. The VI characteristics are obtained by connecting the battery, to the diode, through a potentiometer the battery, to the diode, through a (or ,rheostat). The applied voltage to the diode is changed. The applied voltage to the diode is changed. The values of current, for different values of voltage, are noted and a graph between V and I is plotted. The V-I characteristics of a diode, have the form the form shown here.





24. i. The K.E. of the photoelectron becomes more than double of its original energy. As the work function of the metal is fixed, so incident photon of higher energy will impart more energy to the photoelectron.

ii. The increase in frequency of incident radiation has no effect on photoelectric current. This is because of the incident photon of increased energy cannot eject more than one electron from the metal surface.

iii. With the increase in frequency, the K.E. of the photoelectron increases, so the stopping potential also increases.

25. Radius of nucleus is determined by Rutherford α−particle scattering experiment by using the concept of distance of closest approach.

The relation between radius and mass number of the nucleus is $R = R_0\ A^{1/3}$

where, $R_0 = 1.1 \times 10^{-15}$ is the range of nuclear force, R = radius of nucleus and A = mass number

The expression for radius of nucleus can be used to compute the density of the nucleus. Let us find the density of the nucleus of an atom, whose mass number is A.

Now, Density of the nucleus, $\rho = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}} = \frac{mA}{\frac{4}{3}\pi\left(R_0 A^{1/3}\right)^3}$

$\rho = \frac{mA}{\frac{4}{3}\pi R_0^3 A} \Rightarrow \rho = \frac{m}{\frac{4}{3}\pi R_0^3}$

So as per above formula, density of nucleus does not depend on mass number of nucleus rather it is same for all the atoms and it is roughly in the order of 10^{17} kg/m^3 which is very large as compared to our everyday observed densities.

26. i. Bohr's second postulate states that the electron revolves around the nucleus in certain privileged orbit which satisfy certain quantum condition that angular momentum of an electron is an integral multiple of $h/2\pi$

i.e $L = mvr = nh/2\pi$

$2\pi r = n(h/mv)$,

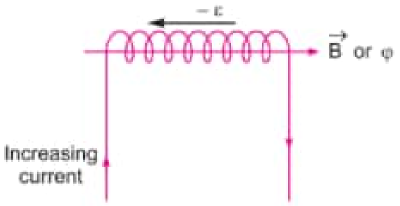
Circumference of electron in n^{th} orbit = n $\times$ de-Broglie wavelength associated with electron.

ii. Number of spectral lines obtained due to transition of electron from n = 4 (3^d excited state) to n = 1 (ground state) is
$N=\frac{n(n-1)}{2}$
$N=\frac{(4)(4-1)}{2}=6$

27. a. n = 2
position of fringes is given as x = $\frac{nD\lambda}{d}$
= $\frac{2\times0.60\times500\times10^{-9}}{1\times10^{-3}}$
= 0.6 mm

b. Let n bright fringes of wavelength 600 nm coincide with (n + 1) bright fringes of wavelength 500 nm
$n\frac{D\lambda_1}{d}$ = $\frac{(n+1)D\lambda_2}{d}$
$\frac{600}{500}$ = $1+\frac{1}{n}$
$\frac{1}{5}=\frac{1}{n}$
n = 5
x = $\frac{5\times D\lambda}{d}$
= $\frac{5\times500\times10^{-9}\times0.6}{1\times10^{-3}}$
= 1.5 nm

28. Using formula, $|-\varepsilon|=L\frac{dI}{dt}$
If $\frac{dI}{dt}=1$ A/s, then L = $|-\varepsilon|$
Self inductance of the coil is equal to the magnitude of induced emf produced in the coil itself when the current varies at rate 1 A/s.
Expression for magnetic energy:



When a time varying current flows through the coil, back emf $(-\varepsilon)$ produces, which opposes the growth of the current flow. It means some work needs to be done against induced emf in establishing a current I. This work done will be stored as magnetic potential energy.
For the current I at any instant, the rate of work done is
$\frac{dW}{dt}=(-\varepsilon)I$
Only for inductive effect of the coil $|-\varepsilon|=L\frac{dI}{dt}$
$\therefore\quad \frac{dW}{dt}=L\left(\frac{dI}{dt}\right)I \quad\Rightarrow dW=LIdI$
From work-energy theorem,
dU = LIdI
$\therefore U=\int_0^I LIdI=\frac{1}{2}LI^2$

OR

i. Here, B = 1.8 $\times$ 10^{-4}T,
Area of the window, A = 85 $\times$ 60 cm^2 = 85 $\times$ 60 $\times$ 10^{-4} m^2
Now, magnetic flux through the window,
ϕ = BA = 1.8 $\times$ 10^{-4} $\times$ 85 $\times$ 60 $\times$ 10^{-4}
= 9.18 $\times$ 10^{-5} T

ii. When the window is open, the plane of the window is parallel to the earth's magnetic field. Therefore, the magnetic flux through the window zero.
Change in magnetic flux through the window,
$\Delta\phi$ = 9.18 $\times$ 10^{-5} - 0 = 9.18 $\times$ 10^{-5} Wb
Time in which window is opened, Δt = 0.20s
Therefore, e.m.f. induced in the side CD,

$e = \frac{\Delta\phi}{\Delta t} = \frac{9.18\times10^{-5}}{0.20}$

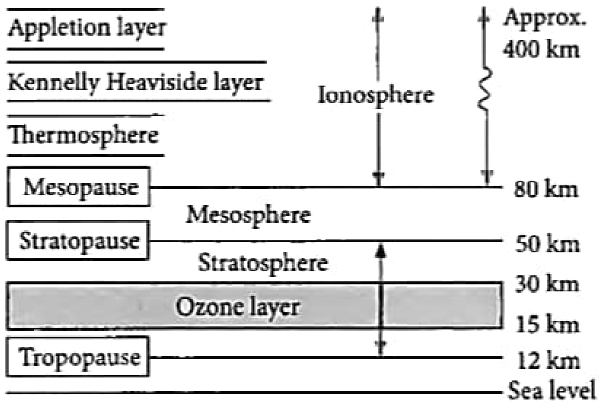
= 4.59×10^{-4} V

iii. Since the frame of the window is a closed circuit and arm CD acts as a source of e.m.f., a current will flow in the frame.

Section D

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

Radio waves are produced by the accelerated motion of charges in conducting wires. Microwaves are produced by special vacuum tubes. Infrared waves are produced by hot bodies and molecules also known as heat waves. UV rays are produced by special lamps and very hot bodies like Sun.



(i) **(a)** Option (i)

Explanation: transverse electromagnetic wave

(ii) **(c)** Infrared rays

Explanation: Greenhouse effect is due to infrared rays.

(iii) **(a)** it stops ultraviolet rays

Explanation: Ozone layer absorbs the harmful ultraviolet radiations coming from the sun.

OR

(b) infrared

Explanation: The atmosphere of earth is richest in infrared radiation.

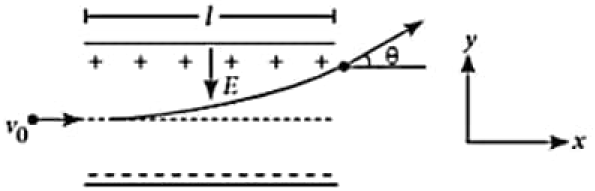
(iv) **(d)** stratosphere

Explanation: Ozone layer lies in stratosphere.

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

When a charged particle is placed in an electric field, it experiences an electrical force. If this is the only force on the particle, it must be the net force. The net force will cause the particle to accelerate according to Newton's second law. So

$\vec{F}_e = q\vec{E} = m\vec{a}$



If $\vec{E}$ is uniform, then $\vec{a}$ is constant and $\vec{a} = \frac{q\vec{E}}{m}$. If the particle has a positive charge, its acceleration is in the direction of the field. If the particle has a negative charge, its acceleration is in the direction opposite to the electric field. Since the acceleration is constant, the kinematic equations can be used.

(i) **(c)** along a line of force, if its initial velocity is zero

Explanation: If charge particle is put at rest in electric field, then it will move along line of force.

(ii) **(a)** t = $\sqrt{\frac{2hm}{eE}}$

Explanation: From Newton's law

F = $m\vec{a}$ or qE = $m\vec{a} \Rightarrow a = \frac{qE}{m} = \frac{eE}{m}$

Using, s = ut + $\frac{1}{2}$at^2

$\therefore$ h = $0 + \frac{1}{2} \times \frac{eE}{m}t^2 \Rightarrow t = \sqrt{\frac{2hm}{eE}}$

(iii) **(b)** in a trajectory represented as $y = ax^2$

Explanation: in a trajectory represented as $y = ax^2$

(iv) **(c)** $\frac{a_1}{a_2}$ = 2

Explanation: Force is same in magnitude for both.

$\therefore m_1a_1 = m_2a_2$;

$\frac{a_1}{a_2} = \frac{m_2}{m_1} = \frac{1}{0.5}$ = 2

OR

(a) qEy

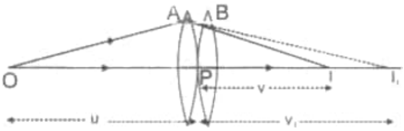
Explanation: Here, u = 0; a = $\frac{qE}{m}$; s = y

Using, $v^2 - u^2 = 2as \Rightarrow v^2 = 2\frac{qE}{m}y$

$\therefore$ K.E. = $\frac{1}{2}mv^2$ = qEy

Section E

31. 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 = $\frac{c}{\mu} = \frac{c}{\sqrt{2}}$

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

OR

The light on passing through the narrow slit undergoes diffraction. A diffraction pattern consisting of alternate bright and dark bands is obtained on the screen.

i. Angular width of principal maximum,

$2\theta = \frac{2\lambda}{a}$

It is not affected when screen is moved away (D increases) from the slit plane.

ii. Now linear width x of the central maximum is given by

$x = \frac{2\lambda D}{a}$

Thus if the screen is moved away the linear width of the central maximum will increase too.

Difference between interference and diffraction

i. In interference all the fringes will be of equal intensity but in diffraction the central maximum will have high intensity and in the rest of the fringes intensity falls rapidly.

ii. In interference all the fringes will be of equal width but in diffraction the central maximum will have the highest width and for the other fringes width will diminish fast.

32. The capacitance of an air-filled capacitor $C_0 = \frac{\varepsilon_0 A}{d}$ ...(i)

Capacitance with a dielectric slab of thickness t (< d) is

$C = \frac{\varepsilon_0 A}{d - t + t/\kappa}$ ...(ii)

i. The charge on capacitor plates, when 200 V p.d. is applied, becomes q = C_0V_0 = 50 × 10^{-12}× 200 = 10^{-8}C

Even after the battery is removed, the charge of 10^{-8} C on the capacitor plates remains the same.

ii. On placing the dielectric slab, suppose the capacitance becomes C and potential difference V. Then q = C_0V_0 = CV

or $V = \frac{C_0}{C} V_0 = \frac{d-t+t/\kappa}{d} V_0$ [Using (i) and (ii)]

$= \frac{4-2+2/4}{4} \times 200 = 125$ V

iii. Final energy in the capacitor is U = $\frac{1}{2}$qV = $\frac{1}{2}$× 10^{-8} × 125 = 6.25 × 10^{-7} J

iv. Energy loss = U_0 - U = $\frac{1}{2}$q(V_0 - V)

= $\frac{1}{2}$× 10^{-8} × (200 - 125) = 3.75 × 10^{-7} J

OR

Given,

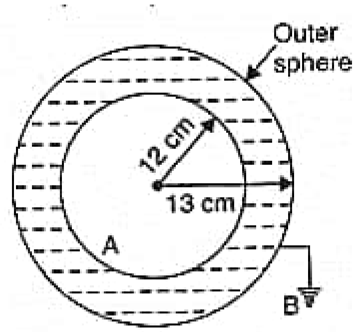
$r_1 = 12cm = 12 \times 10^{-2}m$

$r_2 = 13cm = 13 \times 10^{-2}m$

$q = 2.5\mu C = 2.5 \times 10^{-6}C$

k = 32

a. From formula,



$C = kC_0$

$C = k.4\pi\varepsilon_0 \frac{r_1 r_2}{r_2 - r_1}$

$= \frac{32 \times 13 \times 10^{-2} \times 12 \times 10^{-2}}{9 \times 10^9 (13 \times 10^{-2} - 12 \times 10^{-2})} \left[\therefore 4\pi\varepsilon_0 = \frac{1}{9 \times 10^9}\right]$

$= \frac{32 \times 13 \times 12}{9} \times 10^{-11} = \frac{1644}{3} \times 10^{-11}$

$= 5.54 \times 10^{-9} F$

b. Potential of inner sphere,

$V = \frac{q}{C} = \frac{2.5 \times 10^{-6}}{5.54 \times 10^{-9}} = 4.5 \times 10^2 V$

c. Capacitance of sphere

$= 4\pi\varepsilon_0$

$= \frac{12 \times 10^{-2}}{9 \times 10^9} = 1.33 \times 10^{-11} F$

Total potential in case of concentric spheres is distributed over two spheres and the potential difference between the two spheres becomes smaller that is why the capacitance of an isolated sphere is much small than that of concentric spheres. Since the capacitance is inversely proportional to the potential difference $\left(C = \frac{Q}{V}\right)$.

33. i. Calculation of Capacitance

As power factor is unity,

∴ $X_L = X_C$ also L=200mH and R= 10 Ω

$\Rightarrow \omega = \frac{1}{\sqrt{LC}}$

100 = $\frac{1}{\sqrt{200 \times 10^{-3} \times C}}$

10^4 × 2 × 10^2 × 10^{-3} × C = 1

hence ca[pacitance is given by ,C = $\frac{1}{2 \times 10^3}$ F

= 0.5 × 10^{-3} F

= 0.5mF

ii. Q-factor of circuit and its importance Calculation of average power dissipated

Quality factor, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

$= \frac{1}{10}\sqrt{\frac{200 \times 10^{-3}}{0.5 \times 10^{-3}}}$

$= \frac{1}{10} \times$ 20 = 2

Significance: It measures the sharpness of resnance.

Average Power dissipated,

P = V_{rms} I_{rms} cos ϕ

$= 50 \times \frac{50}{10} \times$ 1 W

= 250 watts

OR

i. In series LCR circuit, Voltage, V = V_0 sinωt

Current in circuit, I = I_0 sin$(\omega t - \phi)$

Instantaneous Power, P = VI

= $V_0 I_0 \sin \omega t \sin(\omega t + \phi)$

= $\frac{1}{2} V_0 I_0 2 \sin \omega t \sin(\omega t + \phi)$ = $\frac{1}{2} V_0 I_0 [\cos \phi - \cos(2\omega t + \phi)]$

Average value of cos(2ωt + ϕ) over a complete cycle is zero i.e.,

$\cos(2\omega t + \phi) = 0$.

$\therefore$ Average power over a complete cycle,

P_{av} = $\frac{1}{2} V_0 I_0 \cos \phi$ = $\frac{V_0}{\sqrt{2}} \frac{I_0}{\sqrt{2}} \cos \phi$

P_{av} = $V_{\text{rms}} I_{\text{rms}} \cos \phi$

ii. **Quality Factor (Q):** In series LCR circuit, the ratio of the voltage drop across inductor (or capacitor) to the voltage drop across resistor under resonance condition is called the quality factor.

Q = $\frac{\omega_r LI}{RI}$ = $\omega_r \frac{L}{R}$ = $\frac{1}{\sqrt{LC}} \cdot \frac{L}{R}$

$\Rightarrow$ Q = $\frac{1}{R}\sqrt{\frac{L}{C}}$

Also, Q = $\frac{\omega_r}{\omega_2 - \omega_1}$

where ω_1 - ω_2 is the bandwidth of the resonant curve. Smaller is the bandwidth, larger is the quality factor and selectivity (or sharpness of resonance) of the circuit. That is why in receiving circuits, the quality factor must be very high. The quality factor depends on the values of resistance, inductance, and capacitance of the circuit.