Class XII Session 2024-25
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. C and Si both have the same lattice structure, having 4 bonding electrons in each. However, C is an insulator whereas Si is an intrinsic semiconductor. This is because **[1]**

   A. In case of C the valence band is not completely filled at absolute zero temperature.
   B. In case of C the conduction band is partly filled even at absolute zero temperature.
   C. The four bonding electrons in the case of C lie in the second orbit, whereas in the case of Si they lie in the third.
   D. The four bonding electrons in the case of C lie in the third orbit, whereas for Si they lie in the fourth orbit.

   a) Option B b) Option A
   c) Option D d) Option C

2. According to Joule's law, if potential difference across a conductor of material of resistivity ρ remains constant, then heat produced in the conductor is directly proportional to **[1]**

   a) ρ b) $\frac{1}{\sqrt{\rho}}$
   c) ρ^{-1} d) ρ^2

3. An astronomical telescope of ten fold angular magnification has a length of 44 cm. The focal length of the objective is **[1]**

   a) 44 cm b) 440 cm

c) 4 cm

d) 40 cm

4. Time period of oscillation of a magnetic needle is [1]

a) $T = \sqrt{\frac{I}{MB}}$

b) $T = \pi\sqrt{\frac{MB}{I}}$

c) $T = 2\pi\sqrt{\frac{MB}{I}}$

d) $T = 2\pi\sqrt{\frac{I}{MB}}$

5. The electrostatic force between the metal plates of an isolated parallel capacitor C having a charge Q and area A is: [1]

a) independent of the distance between the plates

b) inversely proportional to the distance between the plates

c) proportional to the square root of the distance between the plates

d) linearly proportional to the distance between the plates

6. A galvanometer of resistance 25Ω is shunted by a 2.5Ω wire. The part of total current I_o that flows through the galvanometer is given by [1]

a) $\frac{I}{I_0} = \frac{2}{11}$

b) $\frac{I}{I_0} = \frac{4}{11}$

c) $\frac{I}{I_0} = \frac{1}{11}$

d) $\frac{I}{I_0} = \frac{3}{11}$

7. Two coils have a mutual inductance 0.005 H. The current changes in the first coil according to equation I = I_0 sin Ωt, where I_0 = 10 A and ω = 100 π rad s^{-1}. The maximum value of emf in the second coil is [1]

a) 12 π

b) 2 π

c) 5 π

d) 6 π

8. The susceptibility of a paramagnetic material is χ at 27° C. At what temperature will its susceptibility be $\frac{\chi}{2}$? [1]

a) 54° C

b) 327° C

c) 237° C

d) 1600° C

9. Consider sunlight incident on a slit of width 10^4 A. The image seen through the slit shall [1]

a) only be a diffused slit white in colour

b) a bright slit white at the center diffusing to regions of different colours

c) a bright slit white at the center diffusing to zero intensities at the edges

d) be a fine sharp slit white in colour at the center

10. Point charges +4q, -q and +4q are kept on the X-axis at points x = 0, x = a and x = 2a respectively: [1]

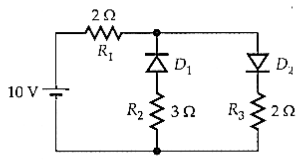
a) all the charges are in unstable equilibrium

b) all the charges are in stable equilibrium

c) none of the charges is in equilibrium

d) only - q is in stable equilibrium

11. The given circuit has two ideal diodes connected as shown in the figure below. The current flowing through the resistance R_1 will be [1]



a) 2.5 A

b) 10.0 A

c) 1.43 A

d) 3.13 A

12. Which of the following principle is used in optical fibre? **[1]**

a) Total internal reflection

b) Scattering

c) Interference

d) Diffraction

13. **Assertion (A):** If a proton and electron are moving with same velocity, then wavelength of de-Broglie wave associated with electron is longer than that associated with proton. **[1]**

Reason (R): The wavelength of de-Broglie wave associated with a moving particle is inversely proportional to its mass.

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:** A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant K is introduced between the plates. The energy which is stored becomes K times. **[1]**

Reason: The surface density of charge on the plate remains constant or unchanged.

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 the fringes become indistinct if one of the slits is covered with cellophane paper. **[1]**

Reason (R): The cellophane paper decreases the wavelength of light.

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):** A bulb connected in series with a solenoid is connected to ac source. If a soft iron core is introduced in the solenoid, the bulb will glow brighter. **[1]**

Reason (R): On introducing soft iron core in the solenoid, the inductance increases.

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. Arrange the following electromagnetic waves in the order of their increasing wavelength : **[2]**

a. γ-rays
b. Microwaves
c. X-rays
d. Radio waves

How are infra-red waves produced? What role does infra-red radiation play in

i. maintaining the Earth's warmth and

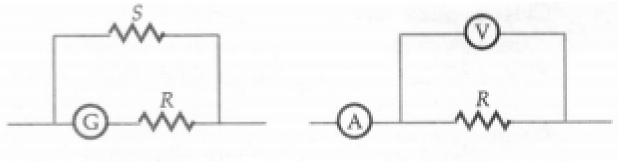
ii. physical therapy?

18. The coercivity of a certain permanent magnet is 4.0×10^4 Am^{-1}. This magnet is placed inside a solenoid 15 cm long and having 600 turns and a current is passed in the solenoid to demangnetise it completely. Find the current. **[2]**

19. Explain the formation of the barrier potential in a p-n junction. **[2]**

20. Write the shortcomings of Rutherford atomic model. Explain how these were overcome by the postulates of Bohr's atomic model. **[2]**

21. A galvanometer has a resistance of 8Ω. It gives a full scale deflection for a current of 10 mA. It is to be converted into an ammeter of range 5 A. The only shunt resistance available is of 0.02 Ω, which is not suitable for this conversion. Find the value of resistance R that must be connected in series with the galvanometer (Fig.) to get ammeter of desired range. **[2]**



OR

a. State Ampere's circuital law connecting the line integral of B over a closed path to the net current crossing the area bounded by the path.

b. Use Ampere's law to derive the formula for the magnetic field due to an infinitely long straight current carrying wire.

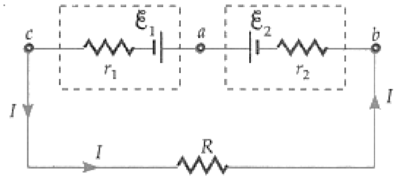
c. Explain carefully why the derivation as in (b) is not valid for magnetic field in a plane normal to a current-carrying straight wire of finite length and passing through the midpoint of the axis.

Section C

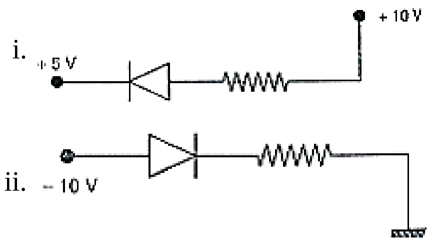
22. In Figure, ε_1 and ε_2 are respectively 2.0 V and 4.0 V and the resistances r_1, r_2 and R are respectively 1.0 Ω, 2.0 Ω and 5.0 Ω. Calculate the current in the circuit. Also, calculate: **[3]**

i. potential difference between the points b and a,

ii. potential difference between a and c.



23. Explain, with the help of a circuit diagram, how the thickness of depletion layer in a p-n junction diode changes when it is forward biased. In the following circuits which one of the two diodes is forward biased and which is reverse biased? **[3]**



24. The data given below gives the photon energy (in eV) for a number of waves whose wavelength values (in nm) are also given. **[3]**

Wavelength (in nm) →	200	400	600	800	1000	1200

Photon energy (in eV) →	6.216	3.108	2.072	1.554	1.243	1.036

(Without doing any calculation/taking any reading), explain how one can use this data to draw an appropriate graph to infer

a. photon energy corresponding to a wavelength of 100 nm.
b. the wavelength value (in nm) corresponding to a photon energy of 1 eV.
c. velocity of light, assuming that the value of Planck's constant is known.

25. Draw a graph showing the variation of binding energy per nucleon with mass number of different nuclei. Write any two salient features of the curve. How does this curve explain the release of energy both in the processes of nuclear fission and fusion? **[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. In a diffraction pattern due to a single slit, how will the angular width of central maximum change, if **[3]**

a. Orange light is used in place of green light,
b. the screen is moved closer to the slit,
c. the slit width is decreased?

Justify your answer in each case.

28. **[3]**
 i. Define the term self-inductance and write its S.I. unit.
 ii. Obtain the expression for the mutual inductance of two long co-axial solenoids S_1 and S_2 wound one over the other, each of length L and radii r_1 and r_2 and n_1 and n_2 number of turns per unit length, when a current I is set up in the outer solenoid S_2.

OR

 i. Will the earth's magnetic field induce current in an artificial satellite with a metal surface that is in orbit around the equator? Around the poles?
 ii. If so how would these currents affect the motion of the satellite?

Section D

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

LASER: Electromagnetic radiation is a natural phenomenon found in almost all areas of daily life, from radio waves to sunlight to x-rays. Laser radiation - like all light - is also a form of electromagnetic radiation. Electromagnetic radiation that has a wavelength between 380 nm and 780 nm is visible to the human eye and is commonly referred to as light. At wavelengths longer than 780 nm, optical radiation is termed infrared (IR) and is invisible to the eye. At wavelengths shorter than 380 nm, optical radiation is termed ultraviolet (UV) and is also invisible to the eye. The term **laser light** refers to a much broader range of the electromagnetic spectrum that just the visible spectrum, anything between 150 nm up to 11000 nm (i.e., from the UV up to the far IR). The term laser is an acronym which stands for **light amplification by stimulated emission of radiation**. Einstein explained the stimulated emission. In an atom, electron may move to higher energy level by absorbing a photon. When the electron comes back to the lower energy level it releases the same photon. This is called spontaneous emission. This may also so happen that the excited electron absorbs another photon, releases two photons and returns to the lower energy state. This is known as stimulated emission.
Laser emission is therefore a light emission whose energy is used, in lithotripsy, for targeting and ablating the

stone inside human body organ.

Apart from medical usage, laser is used for optical disk drive, printer, barcode reader etc.

(a) What is the full form of LASER?

a) light amplification by simultaneous emission of radiation

b) light amplified by synchronous emission of radiation

c) light amplified by stimulated emission of radiation

d) light amplification by stimulated emission of radiation

(b) The **stimulated emission** is the process of

a) absorption of two photon when electron moves from lower to higher energy level

b) release of two photons by absorbing one photon when electron comes back from higher to lower energy level

c) release of a photon when electron comes back from higher to lower energy level

d) absorption of a photon when electron moves from lower to higher energy level

(c) What is the range of amplitude of LASER?

a) 150 nm - 400 nm

b) 700 nm - 11000 nm

c) Both 150 nm - 400 nm and 700 nm - 11000 nm

d) 800 nm - 12000 nm

OR

LASER is used in

a) Ionization

b) Transmitting Satellite signal

c) Optical disk drive

d) Radio communication

(d) Lithotripsy is

a) Laboratory application

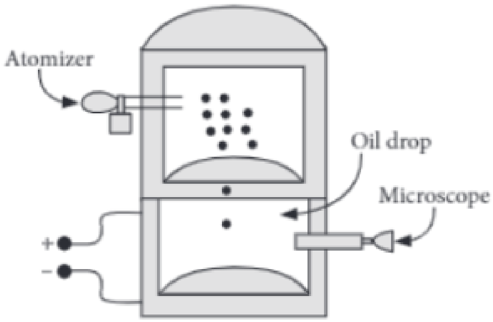
b) An industrial application

c) A medical application

d) Process control application

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

In 1909, Robert Millikan was the first to find the charge of an electron in his now-famous oil-drop experiment. In that experiment, tiny oil drops were sprayed into a uniform electric field between a horizontal pair of oppositely charged plates. The drops were observed with a magnifying eyepiece, and the electric field was adjusted so that the upward force on some negatively charged oil drops was just sufficient to balance the downward force of gravity. That is, when suspended, upward force qE just equaled Mg. Millikan accurately measured the charges on many oil drops and found the values to be whole number multiples of 1.6×10^{-19} C the charge of the electron. For this, he won the Nobel prize.



(a) If a drop of mass 1.08×10^{-14} kg remains stationary in an electric field of 1.68×10^{5} NC^{-1}, then the charge of this drop is

a) 6.40×10^{-19} C
b) 4.8×10^{-19} C
c) 3.2×10^{-19} C
d) 1.6×10^{-19} C

(b) Extra electrons on this particular oil drop (given the presently known charge of the electron) are

a) 4
b) 5
c) 8
d) 3

(c) A negatively charged oil drop is prevented from falling under gravity by applying a vertical electric field 100 V m^{-1}. If the mass of the drop is 1.6×10^{-3} g, the number of electrons carried by the drop is (g = 10 ms^{-2})

a) 10^{9}
b) 10^{18}
c) 10^{12}
d) 10^{15}

(d) The important conclusion given by Millikan's experiment about the charge is

a) charge has no definite value
b) charge is quantized
c) charge is never quantized
d) charge on oil drop always increases

OR

If in Millikan's oil drop experiment, charges on drops are found to be $8\mu C, 12\mu C, 20\mu C$, then quanta of charge is

a) $20\mu C$
b) $12\mu C$
c) $8\mu C$
d) $4\mu C$

Section E

31. Determine the 'effective focal length' of the combination of the two lenses having focal lengths 30 cm and -20cm if they are placed 8.0 cm apart with their principal axes coincident. Does the answer depend on which side of the combination a beam of parallel light is incident? Is the notion of effective focal length of this system useful at all? **[5]**

OR

Give the shape of interference fringes observed

a. in a Young's double-slit experiment
b. in the air wedge experiment
c. in the Lloyd's mirror experiment

d. when a small lamp is placed before a thin mica sheet and light waves reflected from the front and back surfaces of the sheet combine to produce interference pattern on a screen behind the lamp. (Pohl's experiment)
e. from a thin air film formed by placing a convex lens on top of a flat glass plate (Newton's arrangement).

32. a. Derive an expression for the energy stored in a parallel plate capacitor of capacitance C when charged up to voltage V. How is this energy stored in the capacitor? **[5]**
b. A capacitor of capacitance 1 μF is charged by connecting a battery of negligible internal resistance and emf 10 V across it. Calculate the amount of charge supplied by the battery in charging the capacitor fully.

OR

Derive an expression for equivalent capacitance of three capacitors when connected

i. in series and
ii. in parallel.

33. An emf ε = 100 sin 314 t is applied across a pure capacitor of 637 μF. Find **[5]**

i. the instantaneous current I
ii. instantaneous power P
iii. the frequency of power and
iv. the maximum energy stored in the capacitor.

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.

(d) Option C

Explanation: $^{6}C: 1s^2\ 2s^2\ 2p^2$

$^{14}Si: 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

The energy required to take out an electron from the 3rd orbit of Si is much smaller than to take out an electron from the 2nd orbit of C. So, Si has a significant number of free electrons while C has a negligibly small number of free electrons.

2.

(c) ρ^{-1}

Explanation: ρ^{-1}

3.

(d) 40 cm

Explanation: $L = f_o + f_e = 44$ and $|m| = \frac{f_o}{f_e} = 10$

This gives $f_o = 40\text{cm}$

4.

(d) $T = 2\pi\sqrt{\frac{I}{MB}}$

Explanation: Time period of oscillation of a magnetic needle is $T = 2\pi\sqrt{\frac{I}{MB}}$

5. **(a)** independent of the distance between the plates

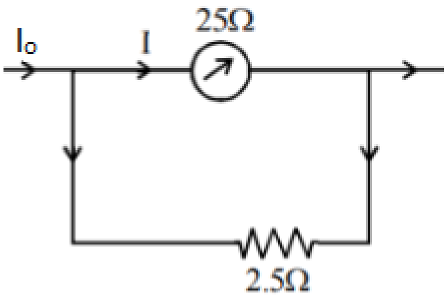
Explanation: $F = QE = Q\frac{\sigma}{2\varepsilon_0} = Q\frac{Q}{2A\varepsilon_0} = \frac{Q^2}{2A\varepsilon_0}$

F is independent of the distance between the plates.

6.

(c) $\frac{I}{I_0} = \frac{1}{11}$

Explanation:



$I = \frac{I_o \times 2.5}{(25+2.5)} = I_o \times \frac{25}{275} = \frac{1}{11} \times I_o$

$\Rightarrow \frac{I}{I_0} = \frac{1}{11}$

7.

(c) 5π

Explanation: $\varepsilon = M\frac{dI}{dt}$

$= M\frac{d}{dt}[I_0 \sin \omega t] = MI_0\omega \cos \omega t$

$\mathcal{E}_{\max} = MI_0\omega$ [Max. value of cos ωt = 1]

$= 0.005 \times 10 \times 100\pi = 5\pi\text{V}$

8.

(b) 327° C

Explanation: $\frac{\chi_2}{\chi_1} = \frac{T_2}{T_1}$

$T_2 = \frac{\chi_1}{\chi_2} \cdot T_1 = \frac{\chi}{\chi/2}(273 + 27)K = 600\ K = 327°\ C$

9.

(d) be a fine sharp slit white in colour at the center

Explanation: Width of slit $10^4\ \overset{o}{A} = 10{,}000\ \overset{o}{A}$

Wavelength of visible light varies from 4000 to 8000 $\overset{o}{A}$. As the width of slit 10000 $\overset{o}{A}$ is comparable to that of wavelength of visible light i.e. 8000 $\overset{o}{A}$. Hence the diffraction occurs with maxima at the centre. So at the centre all colours appear ,mixing of colors forms white colour at the centre .

10. **(a)** all the charges are in unstable equilibrium

Explanation: The net force on each charge is zero. Therefore, all the charges are in equilibrium. If we slightly displace the charge -q to the right, the net force of attraction will further displace it to the right i.e., away from its mean positive. The equilibrium is, therefore, unstable.

11. **(a)** 2.5 A

Explanation: D_1 is reverse biased and D_2 is forward biased. D_1 blocks current. Hence, Current will flow through 10 V cell, R_1, D_2 and R_3.

$\therefore I = \frac{\varepsilon}{R_1 + R_3}$

$= \frac{10\ V}{(2+2)\Omega} = 2.5\ A$

12. **(a)** Total internal reflection

Explanation: Total internal reflection principle is used in optical fibre.

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

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

Both proton and electron are moving with same velocity. So, $\lambda \propto \frac{1}{m}$. So, the reason is true.

Mass of proton > mass of electron.

So, wavelength of electron > wavelength of proton. So, the assertion is true and reason is the proper explanation of the assertion.

14.

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

Explanation: Assertion is correct statement but reason is wrong statement.

15.

(c) A is true but R is false.

Explanation: A is true but R is false.

16.

(d) A is false but R is true.

Explanation: On introducing soft iron core, the bulb will glow dimmer. This is because on introducing soft iron core in the solenoid, its inductance L increases, the inductive reactance, $X_L = \omega L$ increases and hence the current through the bulb decreases.

Section B

17. In the order of increasing wavelength, the e.m. waves are

γ-rays, < X-rays < Microwaves < Radiowaves

Infrared rays are produced by hot bodies or by vibrations of atoms and molecules.

i. Infrared rays maintain earth's warmth through green house effect.
ii. Infrared lamps are used in physical therapy because of the heat produced by infrared rays.

18. The coercivity of $4 \times 10^4\ Am^{-1}$ of the permanent magnet implies that a magnetic intensity $H = 4 \times 10^4\ Am^{-1}$ is required to be applied in opposite direction to demagnetise the magnet.

Here $n = \frac{600}{15\ cm} = \frac{600}{15 \times 10^{-2}\ m} = 4000$ turns/m

As H = nl

$\therefore$ Current, $I = \frac{H}{n} = \frac{4 \times 10^4}{4000} = 10\ A$

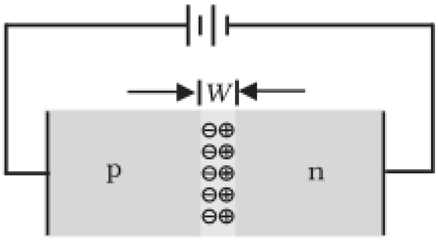
19. When the electrons and holes move towards each other leaving the charged ions negative on the p side and positive on the n side then an electric field is generated and the potential thus formed is called barrier potential.
20. **Shortcomings of Rutherford atomic model:**
    Rutherford proposed planetary model of an atom in which electrons revolve round the nucleus.
    An electron revolving round the nucleus has an acceleration directed towards the nucleus.
    Such accelerated electron must radiate electromagnetic radiation.
    But, if an revolving electron radiates energy, the total energy of the system must decrease. In such situation, the electron must come closer to the nucleus and hit the nucleus. Also, the radiation spectrum of emitted electromagnetic waves should be continuous.
    However, this does not happen in an atom. Atom is not unstable and the spectrum is not continuous. Rutherford atomic model cannot explain these two observations. These are the shortcomings of Rutherford Atomic Model.
    To overcome this discrepancy, Neils Bohr put forward three postulates combining classical Physics and Planck's quantum hypothesis.
    Bohr's 1st postulate provides stability to the atomic model.
    Bohr's 2nd postulate provides justification that electrons may revolve in stationary orbit.
    Bohr's 3rd postulate provides the explanation of line spectrum.
21. P.D. across the series combination of G and R = P.D. across the shunt S
    $I_g(R_g + R) = (I - I_g) R$
    $0.01\ (8 + R) = (5 - 0.01) \times 0.02 = 4.99 \times 0.02$
    or $8 + R = \frac{4.99 \times 0.02}{0.01} = 9.98$
    or R= 9 .9 8 -8 = 1.98 Ω

OR

a. Ampere's Circuital Law: It gives the relationship between the current and the magnetic field created by it. This law says that the integral of magnetic field density (B) along an imaginary closed path is equal to the product of current enclosed by the path and permeability of the medium.
b. Now, from Ampere's Circuital law, $\int B.dI = \mu_0 l$
   $\Rightarrow \int B.dl = \mu_0 l$ [Since angle between B and dl is zero]
   $\Rightarrow B\int dl = \mu_0 l$
   $\Rightarrow B.2\pi r = \mu_0 l$ [Since the total length of dl is equal to circumference of the circle considered]
   $\Rightarrow B = \frac{\mu_0 l}{2\pi r}$ which is the required expression for magnetic field of induction due to a long straight current carrying wire.
c. A straight conductor of finite length cannot by itself form a complete, steady current circuit. Additional conductors are necessary to close the circuit. These will spoil the symmetry of the problem. The difficulty disappears if the conductor is infinitely long.

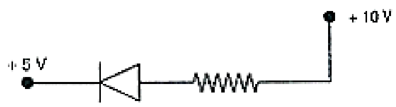
Section C

22. As EMFs ε_1 and ε_2 are opposing each other and $\varepsilon_2 > \varepsilon_1$, so
    Net emf = $\varepsilon_2 - \varepsilon_1 = 4 - 2 = 2$ V
    This emf sends circuit I in the anticlockwise direction.
    Total resistance = $R + r_1 + r_2 = 5 + 1 + 2 = 8\ \Omega$
    Current in the circuit = $\frac{\text{Net emf}}{\text{Total resistance}} = \frac{2}{8} = 0.25$ A
    i. Current inside the cell ε_2 flows from -ve to +ve terminal, so the terminal p.d. of this cell is
       $V_a - V_b = \varepsilon_2 - Ir_2 = 4.0 - 0.25 \times 2.0 = 3.5$ V
    ii. Current inside the cell ε_1 flows from +ve to -ve terminal. Hence the terminal p.d. of this cell is
       $V_a - V_b = \varepsilon_1 + Ir_1 = 2.0 + 0.25 \times 1.0 = 2.25$ V
23. When an external voltage V is applied across a semiconductor diode such that p-side is connected to the positive terminal of the battery and n-side to the negative terminal [Fig.], it is said to be forward biased.

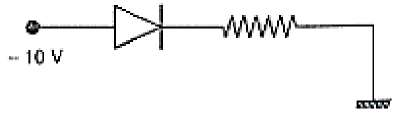


The applied voltage mostly drops across the depletion region and the voltage drop across the p-side and n-side of the junction is negligible. (This is because the resistance of the depletion region – a region where there are no charges – is very high compared to the resistance of n-side and p-side.) The direction of the applied voltage (V) is opposite to the built-in potential V_0. As a result, the depletion layer width decreases [Fig.]

i. In this case, the p-side is at +10V, whereas the n-side is at +5V. As, $V_p > V_n$, hence the diode is forward biased.

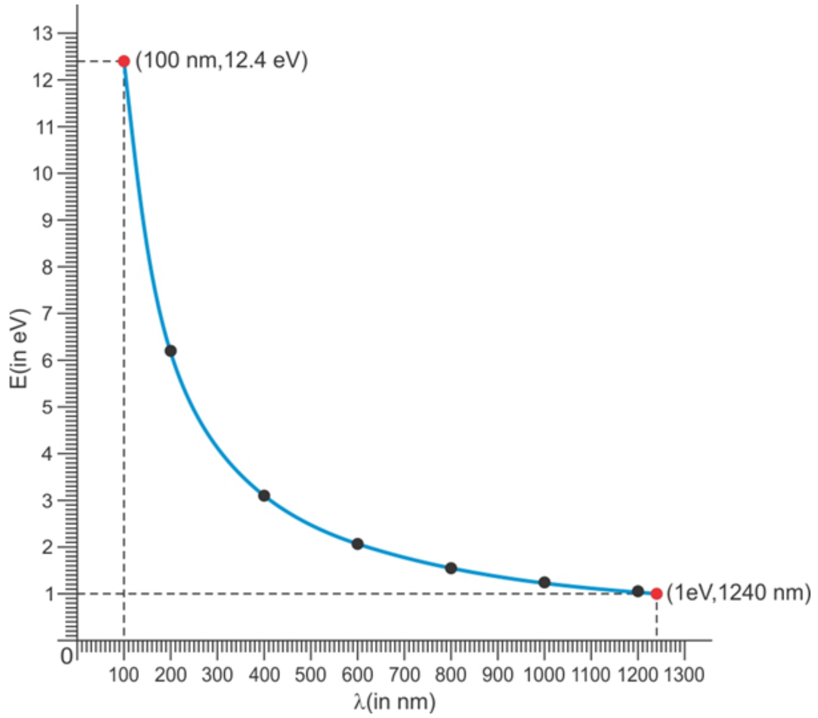


ii. In this case, the p-side is at -10V, whereas the n-side is at 0 V. As, $V_p < V_n$, hence the diode is reverse biased.



24. One can calculate the values of $\frac{1}{\lambda}$ and plot a graph between E (photon energy in eV) and $\frac{1}{\lambda}$ (in nm^{-1}).

The resulting straight line graph can be used to :

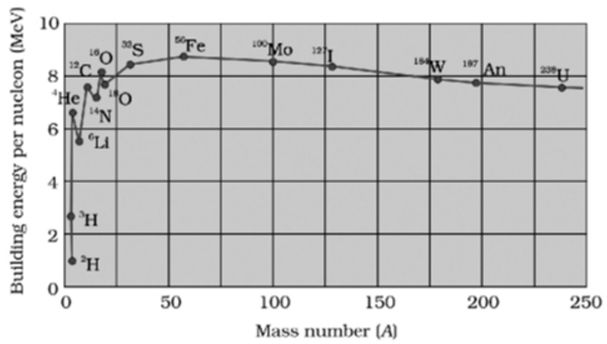


a. Read the value of E, energy corresponding to 100 nm = 12.4 eV

b. The wavelength corresponding to energy of 1 eV is 1240 nm.

c. We have $E = \frac{hc}{\lambda}$

The slope of the graph (after appropriate adjustment of the units) would equal h_e. Since 'h' is known, one can calculate c. thus c= 3.008×10^8 m/s

25. 

Salient feature of B.E. curve

i. B.E/nucleon is pratically constant i.e. independent of the atomic number for nuclei of middle mass number (30 < A < 17)

ii. Binding energy per nucleon is lower for both light nuclei (A < 30) and heavy nuclei (A > 70).

Very heavy nucleus has lower B.E./nucleon will undergo fission and split into two medium sized nuclei with large B.E./nucleon and release tremendous amount of energy (Fission process)

When two very light nuclei, having low binding energy per nucleon combine together and form a medium sized nuclei of higher B.E. per nucleon releases enormous amount of energy (Fusion process)

26. i. Only those orbits are stable for which the angular momentum of revolving electron is an integral multiple of $\left(\frac{h}{2\pi}\right)$ where h is the planck's constant.

According to Bohr's second postulate

$mvr_n = n\frac{h}{2\pi} \Rightarrow 2\pi r_n = \frac{nh}{mv}$

But $\frac{h}{mv} = \frac{h}{p} = \lambda$ (By de Broglie hypothesis)

$\therefore 2\pi r_n = n\lambda$

ii. For third excited state, n = 4

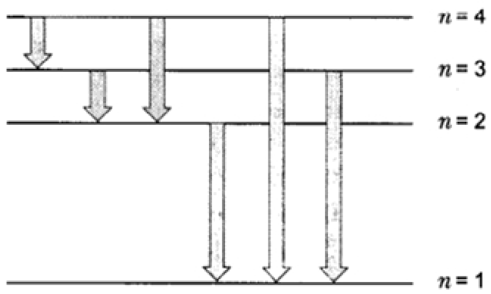
For ground state, n = 1

Hence possible transitions are

$n_i = 4$ to $n_f = 3, 2, 1$

$n_i = 3$ to $n_f = 2, 1$

$n_i = 2$ to $n_f = 1$



Total number of transitions = 6

$E_C - E_B = \frac{hc}{\lambda_1}$ ...(i)

$E_B - E_A = \frac{hc}{\lambda_2}$ ...(ii)

$E_C - E_A = \frac{hc}{\lambda_3}$ ...(iii)

Adding (i) and (ii), we have

$E_C - E_A = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$ ...(iv)

From (iii) and (iv), we have

$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \Rightarrow \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

$\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1+\lambda_2}$

27. angular width of central maxima of a single slit diffraction is given as $2\theta = \frac{2\lambda}{a}$

a. As λ increases (orange light has greater wave length) diffraction angle 2θ will also increase.

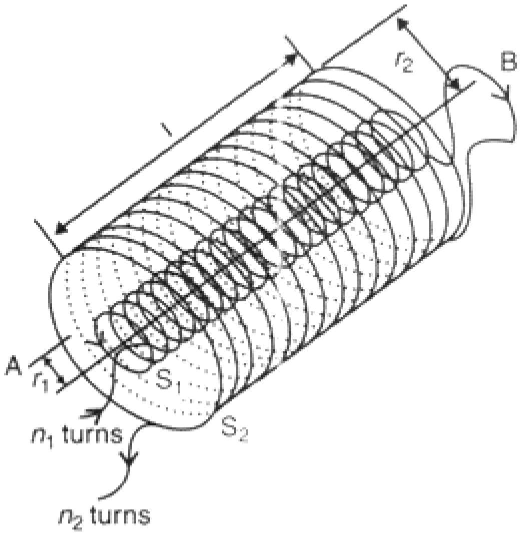
b. Increasing or decreasing closeness of screen and slit does not affect angular width.

c. If a (slit width) decreases, 2θ will increase as $2\theta \propto \frac{1}{a}$

28. i. Self-Inductance is the property by which an opposing induced emf is produced in a coil due to a change in current, or magnetic flux, linked with the coil.

The S.I. unit of self-inductance is Henry (H).

ii. In this question, a long co-axial solenoids S_1 and S_2 wound one over the other, each of length L and radii r_1 and r_2 and n_1 and n_2 number of turns per unit length, when a current I is set up in the outer solenoid S_2.



Let a current l_2 flow in the secondary coil

$\therefore B_2 = \frac{\mu_0 N_2 i_2}{l}$

$\therefore$ Flux linked with the primary coil = $\frac{\mu_0 N_2 N_1 A_1 i_2}{l}$

$= M_{12} i_2$

Hence, $M_{12} = \frac{\mu_0 N_2 N_1 A_2}{l}$

$\mu_0 n_2 n_1 A_1 l \left(n_1 = \frac{N_1}{l}; n_2 = \frac{N_2}{l}\right)$

OR

i. There will be no induced currents in the metal of the satellite, which is orbiting in the equatorial plane. It is because the magnetic flux does not change through the metal of the satellite in such an orbit. In other orbits (including orbit around the poles), the value of the magnetic field will change both in magnitude and direction. Due to this, the magnetic flux through the satellite will change and hence induced currents will be produced in the metal of the satellite.
ii. The induced currents in the metal of the satellite will produce magnet. It will experience a small magnetic interaction with earth so that the force on the satellite will not be purely gravitational. Therefore, there will be a deflection from the gravitational field alone. Part of the effect of interaction would cause the satellite to lose energy, dissipated in the form of heat. Paradoxically, if it loses energy, it will speed up.

Section D

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

LASER: Electromagnetic radiation is a natural phenomenon found in almost all areas of daily life, from radio waves to sunlight to x-rays. Laser radiation - like all light - is also a form of electromagnetic radiation. Electromagnetic radiation that has a wavelength between 380 nm and 780 nm is visible to the human eye and is commonly referred to as light. At wavelengths longer than 780 nm, optical radiation is termed infrared (IR) and is invisible to the eye. At wavelengths shorter than 380 nm, optical radiation is termed ultraviolet (UV) and is also invisible to the eye. The term **laser light** refers to a much broader range of the electromagnetic spectrum that just the visible spectrum, anything between 150 nm up to 11000 nm (i.e., from the UV up to the far IR). The term laser is an acronym which stands for **light amplification by stimulated emission of radiation**. Einstein explained the stimulated emission. In an atom, electron may move to higher energy level by absorbing a photon. When the electron comes back to the lower energy level it releases the same photon. This is called spontaneous emission. This may also so happen that the excited electron absorbs another photon, releases two photons and returns to the lower energy state. This is known as stimulated emission.

Laser emission is therefore a light emission whose energy is used, in lithotripsy, for targeting and ablating the stone inside human body organ.

Apart from medical usage, laser is used for optical disk drive, printer, barcode reader etc.

(i) **(d)** light amplification by stimulated emission of radiation

Explanation: The term laser is an acronym which stands for "light amplification by stimulated emission of radiation".

(ii) **(b)** release of two photons by absorbing one photon when electron comes back from higher to lower energy level

Explanation: Einstein explained the stimulated emission. In an atom, electron may move to higher energy level by absorbing a photon. When the electron comes back to the lower energy level it releases the same photon. This is called spontaneous emission. This may also so happen that the excited electron absorbs another photon, releases two photons and returns to the lower energy state. This is known as stimulated emission.

(iii) **(c)** Both 150 nm - 400 nm and 700 nm - 11000 nm

Explanation: The term "laser light" refers to a much broader range of the electromagnetic spectrum that just the visible spectrum, anything between 150 nm up to 11000 nm (i.e., from the UV up to the far IR).

OR

(c) Optical disk drive

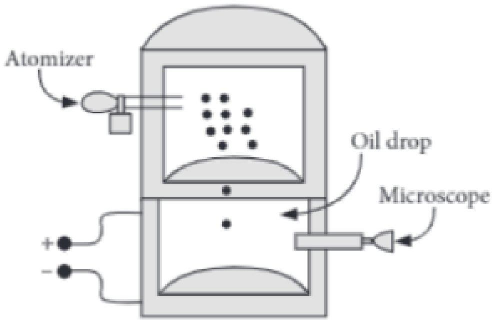
Explanation: An optical disc drive (ODD) is a disc drive that uses laser light or electromagnetic waves within or near the visible light spectrum as part of the process of reading or writing data to or form optical discs.

(iv) **(c)** A medical application

Explanation: Laser emission is therefore a light emission whose energy is used, in lithotripsy, for targeting and ablating the stone inside human body organ.

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

In 1909, Robert Millikan was the first to find the charge of an electron in his now-famous oil-drop experiment. In that experiment, tiny oil drops were sprayed into a uniform electric field between a horizontal pair of oppositely charged plates. The drops were observed with a magnifying eyepiece, and the electric field was adjusted so that the upward force on some negatively charged oil drops was just sufficient to balance the downward force of gravity. That is, when suspended, upward force qE just equaled Mg. Millikan accurately measured the charges on many oil drops and found the values to be whole number multiples of 1.6×10^{-19} C the charge of the electron. For this, he won the Nobel prize.



(i) **(a)** 6.40×10^{-19} C

Explanation: As, qE = mg $\Rightarrow$ q = $\frac{1.08 \times 10^{-14} \times 9.8}{1.68 \times 10^{5}}$ = 6.4×10^{-19} C

(ii) **(a)** 4

Explanation: q = ne or $\Rightarrow$ n = $\frac{6.4 \times 10^{-19}}{1.6 \times 10^{-19}}$ = 4

(iii) **(c)** 10^{12}

Explanation: For the drop to be stationary,

Force on the drop due to electric field = Weight of the drop

qE = mg

$q = \frac{mg}{E} = \frac{1.6 \times 10^{-6} \times 10}{100}$ = 1.6×10^{-7} C

Number of electrons carried by the drop is

$n = \frac{q}{e} = \frac{1.6 \times 10^{-7} C}{1.6 \times 10^{-19} C}$ = 10^{12}

(iv) **(b)** charge is quantized

Explanation: charge is quantized

OR

(d) 4μC

Explanation: Millikan's experiment confirmed that the charges are quantized, i.e., charges are small integer multiples of the base value which is charge on electron. The charges on the drops are found to be multiple of 4. Hence, the quanta of charge is 4 μC.

Section E

31. Here, f_1 = 30 cm, f_2 = -20 cm, d = 8.0 cm

Let a parallel beam be incident on the convex lens first. If second lens were absent, then

$\therefore u_1 = \infty$ and f_1 = 30 cm

As $\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1}$

$\therefore \frac{1}{v_1} - \frac{1}{\infty} = \frac{1}{30}$

or v_1 = 30 cm

This image would now act as virtual object for second lens.

$\therefore u_2$ = +(30 - 8) = +22 cm

f_2 = -20 cm

Since, $\frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{u_2}$

$\therefore \frac{1}{v_2} = \frac{1}{-20} + \frac{1}{22}$

$= \frac{-11+10}{220} = \frac{-1}{220}$

v_2 = -220 cm

$\therefore$ Parallel incident beam would appear to diverge from a point 220 - 4 = 216 cm from the centre of the two lens system.

Assume that a parallel beam of light from the left is incident first on the concave lens.

$\therefore u_1 = -\infty$, f_1 = -20 cm

As $\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1}$

$\therefore \frac{1}{v_1} = \frac{1}{f_1} + \frac{1}{u_1} = \frac{1}{-20} + \frac{1}{-\infty} = -\frac{1}{20}$

v_1 = -20cm

This image acts as a real object for the second lens

u_2 = -(20 + 8) = -28cm, f_2 = 30 cm

Since, $\frac{1}{v_2} - \frac{1}{u_2} = \frac{1}{f_2}$

$\therefore \frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{u_2} = \frac{1}{30} - \frac{1}{28} = \frac{14-15}{420}$

v_2 = -420 cm

The parallel beam appears to diverge from a point 420 - 4 = 416 cm, on the left of the centre of the two lens system.

We finally conclude that the answer depends on the side of the lens system where the parallel beam is incident. Therefore, the notion of effective focal length does not seem to be meaningful here.

OR

a. Interference fringes are straight lines parallel to the two slits.
b. Interference fringes are straight lines parallel to the edge of the wedge.
c. Interference fringes are straight lines parallel to the slit sources.
d. Here the two coherent sources are the point images of the small lamp formed due to the reflection of light waves from the front and back surfaces of the sheet. They form circular fringes.
e. Due to circular symmetry, the loci of points of equal thickness are concentric circles. Hence the fringes are concentric circles with the centre at the point of contact of the lens and the plate.

32. a. Work done in adding a charge dq = dW

= Vdq

= $\frac{q}{c}dq$

$\therefore$ Total Amount of work(W) in charging a capacitor

W = $\int dW = \frac{1}{C}\int_0^Q qdq$

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

= $\frac{(CV)^2}{2C} = \frac{1}{2}CV^2$

The electrostatic Energy/ potential energy is stored in the electric field between the plates.

b. C = 1μF = 1 $\times$ 10^{-6} F; V = 10 volt

Q = CV

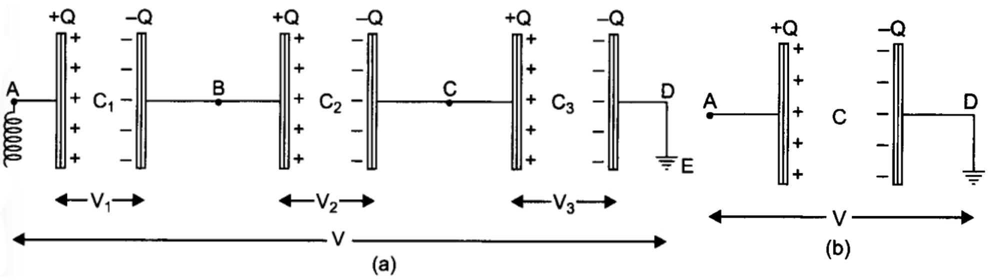
= 1 $\times$ 10^{-6} $\times$ 10

= 10^{-5} coulomb

hence, the amount of charge supplied by the battery in charging the capacitor fully is 10^{-5} coulomb.

OR

i. In fig. (a) three capacitors of capacitances C_1, C_2, C_3 are connected in series between points A and D.



In series first plate of each capacitor has charge +Q and second plate of each capacitor has charge -Q i.e., charge on each capacitor is Q.

Let the potential differences across the capacitors C_1, C_2, C_3 be V_1, V_2, V_3 respectively. As the second plate of first capacitor C_1 and first plate of second capacitor C_2 are connected together, their potentials are equal. Let this common potential be V_B. Similarly the common potential of second plate of C_2 and first plate of C_3 is V_C. The second plate of capacitor C_3 is connected to earth, therefore its potential $V_D = 0$. As charge flows from higher potential to lower potential, therefore $V_A > V_B > V_C > V_D$.

For the first capacitor, $V_1 = V_A - V_B = \frac{Q}{C_1}$ ...(i)

For the second capacitor, $V_2 = V_B - V_C = \frac{Q}{C_2}$ ...(ii)

For the third capacitor, $V_3 = V_C - V_D = \frac{Q}{C_3}$ ...(iii)

Adding (i), (ii) and (iii), we get

$V_1 + V_2 + V_3 = V_A - V_D = Q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$ ...(iv)

If V be the potential difference between A and D, then

$V_A - V_D = V$

$\therefore$ From (iv), we get

$V = (V_1 + V_2 + V_3) = Q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$ ...(v)

If in place of all the three capacitors, only one capacitor is placed between A and D such that on giving it charge Q, the potential difference between its plates become V, then it will be called **equivalent capacitor**. If its capacitance is C, then

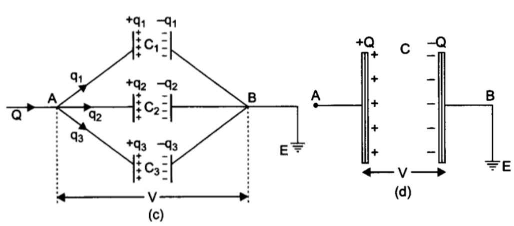
$V = \frac{Q}{C}$ ...(vi)

Comparing (v) and (vi), we get

$\frac{Q}{C} = Q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$ or $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ ...(vii)

Thus in series arrangement, "The reciprocal of equivalent capacitance is equal to the sum of the reciprocals of the individual capacitors."

ii. **Parallel Arrangement:** In fig. (c) three capacitors of capacitance C_1, C_2, C_3 are connected in parallel.



In parallel the potential difference across each capacitor is same V (say). Clearly the potential difference between plates of each capacitor

$V_A - V_B = V$ (say)

The charge Q given to capacitors is divided on capacitors C_1, C_2, C_3.

Let q_1, q_2, q_3 be the charges on capacitors C_1, C_2, C_3 respectively.

Then $Q = q_1 + q_2 + q_3$ ...(I)

and $q_1 = C_1V, q_2 = C_2V, q_3 = C_3V$

Substituting these values in (i), we get

$Q = C_1V + C_2V + C_3V$ or $Q = (C_1 + C_2 + C_3)V$ ...(ii)

If, in place of all the three capacitors, only one capacitor of capacitance C be connected between A and B; such that on giving it charge Q the potential difference between its plates be V, then it will be called equivalent capacitor. If C be the capacitance of equivalent capacitor, then

Q = CV ...(iii)

Comparing equations (ii) and (iii), we get

$CV = (C_1 + C_2 + C_3)V$ or $C = (C_1 + C_2 + C_3)$

Important Note: It may be noted carefully that the formula for the total capacitance in series and parallel combination of capacitors is the reverse of corresponding formula for combination of resistors in current electricity.

33. i. Given $\varepsilon = 100 \sin 314\, t$ volt

As the current in a capacitor leads the voltage by 90^o, so the instantaneous current is given by

$I = I_0 \sin(314t + 90^\circ) = I_0 \cos 314t$

where $I_0 = \frac{\varepsilon_0}{X_C} = \frac{\varepsilon_0}{1/\omega C} = \varepsilon_0 \omega C$

But $\varepsilon_0 = 100$ V, $\omega = 314$ rads^{-1}, $C = 637 \times 10^{-6}$ F

$\therefore I_0 = 100 \times 314 \times 637 \times 10^{-6} = 20$ A

Where $I_0 = \frac{\varepsilon_0}{X_C} = \frac{\varepsilon_0}{1/\omega C} = \varepsilon_0 \omega C$

But $\varepsilon_0 = 100$ V, $\omega = 314$ rad s^{-1}, $C = 637 \times 10^{-6}$ F

$\therefore I_0 = 100 \times 314 \times 637 \times 10^{-6} = 20$ A

Hence I = 20 cos 314 t ampere

ii. Instantaneous power,

$P = \varepsilon I = 100 \sin 314t \times 20 \cos 314t$

= 1000 sin 628 t watt

iii. Angular frequency of power, $\omega_p = 628$ rads^{-1}

$\therefore$ Frequency of power, $f_p = \frac{\omega_p}{2\pi} = \frac{628}{2\pi} = 100$ Hz

iv. The maximum energy stored in the capacitor is

$U_0 = \frac{1}{2} C E_0^2 = \frac{1}{2} \times 637 \times 10^{-6} \times (100)^2 = 3.185$ J

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, $V_0 = V\sqrt{2} = 230\sqrt{2}$V

a. Maximum current is given as:

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

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

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

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

Amplitude of maximum current, $|I_0| = 11.63$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,

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

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