Class XII Session 2024-25
Subject - Physics
Sample Question Paper - 10

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. If μ_e and μ_h are electron and hole mobility, E be the applied electric field, the current density j for intrinsic semiconductor is equal to **[1]**

a) $n_i e\left(\mu_e+\mu_h\right) E$
b) $\frac{n_i e\left(\mu_e+\mu_h\right)}{E}$
c) $n_i e\left(\mu_e-\mu_h\right) E$
d) $\frac{E}{n_i e\left(\mu_e+\mu_h\right)}$

2. If the temperature of cold junction of a thermocouple is lowered, then the neutral temperature: **[1]**

a) becomes zero
b) increases
c) decreases
d) remains the same

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

a) $1 \cdot 40$
b) $3 \cdot 00$
c) $1 \cdot 50$
d) $1 \cdot 33$

4. A Rowland ring of mean radius 15 cm has 3500 turns of wire wound on a ferromagnetic core of relative permeability 800. What is the magnetic field B in the core for a magnetising current of 1.2A? **[1]**

a) 3.48 T
b) 5.48 T
c) 4.08 T
d) 4.48 T

5. In electrolytic capacitors positive terminal is **[1]**

a) one on which aluminium oxide film is not formed

b) one on which aluminium oxide film is formed

c) none of the these

d) either of the two terminals

6. A wire of length L carrying current i is placed perpendicular to the magnetic induction B. The total force on the wire is **[1]**

a) LB/i

b) iL/B

c) iLB

d) iB/L

7. Inductance plays the role of **[1]**

a) inertia

b) friction

c) force

d) source of emf

8. The value of 1 Bohr magneton is: [Given h = 6.62×10^{-34} Js, e = 1.6×10^{-19} C and $m_e = 9.1 \times 10^{-31}$ kg] **[1]**

a) 7.27×10^{-24} Am^2

b) 9.27×10^{-24} Am^2

c) 10.57×10^{-24} Am^2

d) 8.57×10^{-24} Am^2

9. What happens to fringe width in the Young's double slit experiment, if it is performed in glycerine instead of air? **[1]**

a) The fringes shrink

b) The fringes disappear

c) The fringes remain unchanged

d) The fringes get enlarged

10. The attractive force between 2 charges is related to the distance between them as **[1]**

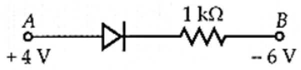
a) r

b) $\frac{1}{r^2}$

c) $r^{\frac{1}{2}}$

d) $\frac{1}{r}$

11. Consider the junction diode as ideal. The value of current flowing through AB is **[1]**



a) 10^{-2} A

b) 0 A

c) 10^{-1} A

d) 10^{-3} A

12. Magnifying power of a microscope depends on **[1]**

a) focal length of eyepiece and objective.

b) colour of light.

c) focal length of objective and color of light.

d) focal length of eyepiece and color of light.

13. **Assertion (A):** The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies. **[1]**

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

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):** Positive charge always moves from a higher potential point to a lower potential point. **[1]**

Reason (R): Electric potential is a vector quantity.

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.

15. **Assertion (A):** Interference pattern is made by using yellow light instead of red light, the fringes becomes narrower. **[1]**

Reason (R): In Young's double slit experiment, fringe width is given by $\beta = \frac{\lambda D}{d}$.

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):** An alternating current of frequency 50 Hz becomes zero, 100 times in one second. **[1]**

Reason (R): Alternating current changes direction and becomes zero twice in a cycle.

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. Gamma rays and radio waves travel with the same velocity in free space. Distinguish between them in terms of their origin and the main application. **[2]**

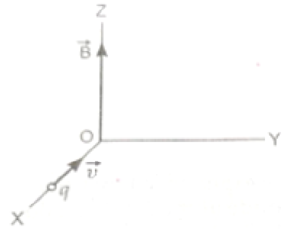
18. A straight solenoid of length 50 cm has 1000 turns and a mean cross-sectional area of 2×10^{-4} m^2. It is placed with its axis at 30°, with a uniform magnetic field of 0.32 T. Find the torque acting on the solenoid when a current of 2A is passed through it. **[2]**

19. Draw the energy band diagram of (i) n-type, and (ii) p-type semiconductors at temperature T > 0 K. **[2]**

In the case of n-type Si-semiconductor, the donor energy level is slightly below the bottom of conduction band whereas in p-type semiconductor, the acceptor energy level is slightly above the top of valence band. Explain, giving examples, what role do these energy levels play in conduction and valence bands.

20. In the first excited state of the hydrogen atom, its radius is found to be 21.2×10^{-11} m. Calculate its Bohr radius in the ground state. Also, calculate the total energy of the atom in the second excited state. **[2]**

21. As shown in figure, a charge q moving along the X-axis with a velocity $\vec{v}$ is subjected to a uniform magnetic field $\vec{B}$ acting along the Z-axis as it crosses the origin O. **[2]**



i. Trace its trajectory.

ii. Does the charge gain kinetic energy, as it enters the magnetic field? Justify your answer.

OR

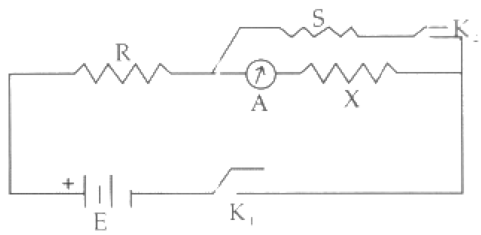
Depict the field-line pattern due to a current-carrying solenoid of finite length.

i. In what way do these lines differ from those due to an electric dipole?

ii. Why can't two magnetic field lines intersect each other?

Section C

22. The reading of the (ideal) ammeter, in the circuit shown here, is equal too. **[3]**



i. I when key K_1 is closed but key K_2 is open.

ii. $\frac{I}{2}$ when both keys K_1 and K_2 are closed.

Find the expression of the resistance of X in terms of the resistances of R and S.

23. Draw the circuit diagram showing how a p-n junction diode is **[3]**

i. forward biased

ii. reverse biased

How is the width of depletion layer affected in the two cases?

24. Red light, however bright it is, cannot produce the emission of electrons from a clean zinc surface. But even weak ultraviolet radiation can do so. Why? **[3]**

Electrons are emitted from the cathode of negligible work function, when photons of wavelength λ are incident on it. Derive the expression for the de Broglie wavelength of the electrons emitted in terms of the wavelength of the incident light.

25. i. Draw a plot showing the variation of potential energy of a pair of nucleons as a function of their separation. Mark the regions where the nuclear force is **[3]**

a. attractive and

b. repulsive.

ii. In the nuclear reaction ${}_0n^1 +^{235}_{92} U \rightarrow^{a}_{54} Xe +^{94}_{b} Sr + 2_0n^1$ determine the values of a and b.

26. Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength $975\overset{o}{A}$. **[3]**

i. How many different lines are possible in the resulting spectrum?

ii. Calculate the longest wavelength amongst them. You may assume the ionization energy for hydrogen atom as 13.6 eV.

27. How is the spacing between fringes in a double slit experiment affected if: **[3]**

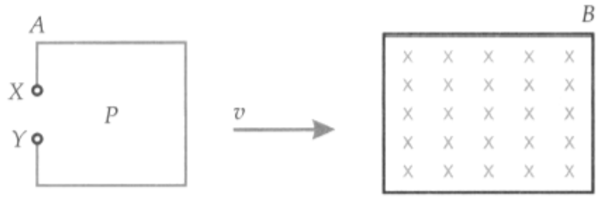
a. the slits separation is increased,

b. the colour of light used is changed from red to blue,

c. the whole apparatus is submerged in a oil of refractive index 1.2?

Justify your anwer in each case.

28. A rectangular coil P is moved from a point A to another point B with uniform velocity 'v' through a region of a uniform magnetic field acting normally inwards as shown in the figure. Show graphically (i) the variation of magnetic flux associated with the coil with time, (ii) the variation of induced emf across points X and Y of the coil with time. **[3]**

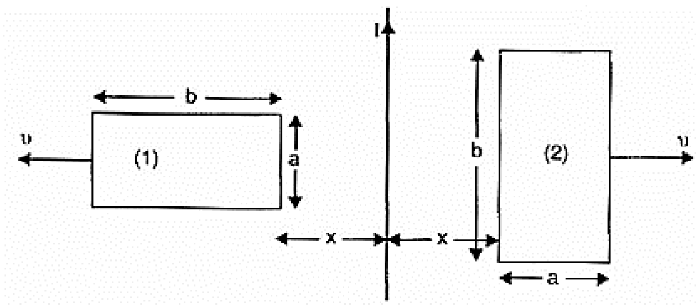


Explain the nature of variation in magnetic flux as represented by the graph in the first case.

OR

The figure shows two identical rectangular loops (1) and (2) placed on a table along with a straight long current carrying conductor between them.

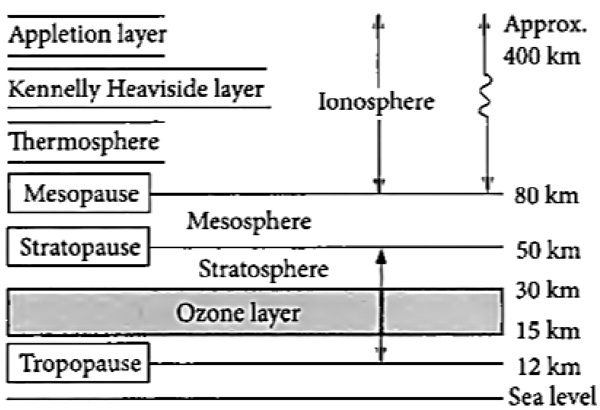
i. What will be the directions of the induced current in the loops when they are pulled away from the conductor with same velocity v?
ii. Will the emf induced in the two loops be equal?



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.



(a) 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)

(b) What is the cause of greenhouse effect?

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

(c) 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

Ozone is found in

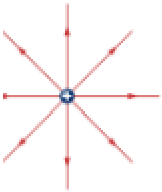
a) troposphere
b) mesosphere
c) ionosphere
d) stratosphere

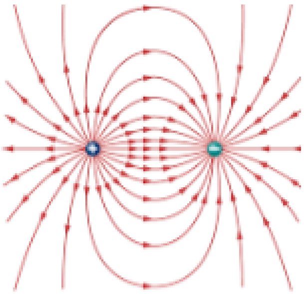
(d) Earth's atmosphere is richest in

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

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

Electric field lines as a path, straight or curved in an electric field such that tangent to it at any point gives the direction of electric field intensity at the point. Electric field lines are continuous curves they start from a positive charged body and end at the negatively charged body. (Refer image)


(a)


(b)

(a) Electric field due to a single charge is:

a) cylindrically symmetric
b) symmetric
c) asymmetric
d) spherically symmetric

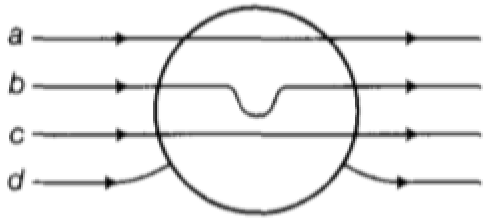
(b) The SI unit of electric field intensity is:

a) N/C
b) N
c) C/m^2
d) N/m^2

(c) Pick the wrong statement.

a) Electric field lines are continuous curves.
b) Electric field lines can intersect each other.
c) Electric field lines are always normal to the surface of a conductor.
d) The electrostatic field does not form a closed loop.

(d) A metallic sphere is placed in a uniform electric field as shown in the figure. Which path is followed by electric field lines?



a) path 'd'

b) path 'c'

c) path 'a'

d) path 'b'

OR

Pick the true statements about electric field lines.

a) Electric field lines provide information about the field strength.

b) Electric field lines provide information about the type of charge.

c) All of these.

d) Electric field lines provide information about the direction of the electric field.

Section E

31. i. Derive lens maker's formula for a biconvex lens. **[5]**

ii. A point object is placed at a distance of 12 cm on the principal axis of a convex lens of focal length 10 cm. A convex mirror is placed coaxially on the other side of the lens at a distance of 10 cm. If the final image coincides with the object, sketch the ray diagram, and find the focal length of the convex mirror.

OR

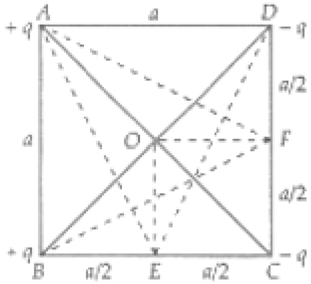
i. There are two sets of apparatus of Young's double-slit experiment. Inset A, the phase difference between the two waves emanating from the slits does not change with time, whereas in set B, the phase difference between the two waves from the slits changes rapidly with time. What difference will be 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. Find the expression for the energy stored in the capacitor. Also find the energy lost when the charged capacitor is disconnected from the source and connected in parallel with the uncharged capacitor. Where does this loss of energy appear? **[5]**

OR

Four charges + q, + q, - q and - q are placed respectively at the corners A, B, C and D of a square of side a arranged in the given order. Calculate the electric potential at the centre O .lf A a E and F are the midpoints of sides BC and CD respectively, what will be the work done in carrying a charge e from O to E and from O to F?



33. A series L-C-R circuit is connected to an AC source. Using the phasor diagram, derive the expression for the **[5]**

impedance of the circuit. Plot a graph to show the variation of current with frequency of the source, explaining the nature of its variation.

OR

a. Derive an expression for the impedance of a series L-C-R circuit connected to an AC supply of variable frequency.
b. Explain briefly how the phenomenon of resonance in the circuit can be used in the tuning mechanism of a radio or a TV set?

Solution

Section A

1. **(a)** $n_i e\left(\mu_e+\mu_h\right) E$

   Explanation: I = I_e + I_h = $en_e Av_e + en_h Av_h$

   = $eA\left(n_e \mu_e+n_h \mu_h\right) E$

   j = $\frac{I}{A}=en_i\left(\mu_e+\mu_h\right) E$

2. **(d)** remains the same

   Explanation: Neutral temperature is independent of temperature of cold junction.

3. **(b)** $3 \cdot 00$

   Explanation: Here, λ = 5,000 $\overset{\circ}{A}$ = 5 $\times$ 10^{-7} m and ν = 2 $\times$ 10^{14} Hz

   Therefore, speed of light in the material,

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

   Hence, the refractive index of the material,

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

4. **(d)** 4.48 T

   Explanation: $B=\frac{\mu_o \mu_r N i}{2 \pi r}=\frac{4 \pi \times 10^{-7} \times 800 \times 3500 \times 1.2}{2 \pi \times 15 \times 10^{-2}}$ = 4.48 T

5. **(b)** one on which aluminium oxide film is formed

   Explanation: Aluminium electrolytic capacitors have the Aluminium foil anode (positive terminal) which is etched and covered with a layer of Aluminium Oxide which acts as a dielectric. The whole assembly is covered using a paper separator soaked in electrolyte such as, Borax or Glycol and covered by Aluminium foil which acts as cathode (negative electrode)

6. **(c)** iLB

   Explanation: Magnitude of the Force experienced by a current carrying conductor placed in a magnetic field is $ILB \sin \theta$. If the angle between the directions of the current and the magnetic field is 90^o, F = iLB

7. **(a)** inertia

   Explanation: inertia

8. **(b)** 9.27 $\times$ 10^{-24} Am^2

   Explanation: 1 Bohr magneton

   = $\frac{eh}{4 \pi m_e}$

   = $\frac{1.6 \times 10^{-19} \times 6.62 \times 10^{-34}}{4 \pi \times 9.1 \times 10^{-31}}$

   = 9.27 $\times$ 10^{-24} Am^2

9. **(a)** The fringes shrink

   Explanation: The fringes shrink

10. **(b)** $\frac{1}{r^2}$

    Explanation: According to Coulomb's law the force between two charges is inversely proportional to the square of distance between the two charges. So $F \alpha \frac{1}{r^2}$.

11. **(a)** 10^{-2} A

    Explanation: An ideal diode does not offer any resistance during forward biasing.

$\therefore I = \frac{V_A - V_B}{R}$

$= \frac{4-(-6)}{1000} A = 10^{-2}$ A

12. **(a)** focal length of eyepiece and objective.

Explanation: Magnification $\frac{m \propto 1}{f_o f_e}$

So, magnifying power of a microscope depends on focal length of eyepiece and objective only.

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

Explanation: Photoelectrons produced by monochromatic light have different velocities and hence different energies. Actually all the electrons do not occupy the same level of energy. So, electrons coming out from different levels have different velocities and hence different energies. So, the assertion is true. The electrons coming out from inside the metal surface, face collisions with the other atoms in the metal. So, energies become different. Hence the reason is true and it explains the assertion.

14.

(c) A is true but R is false.

Explanation: If two points P and Q in an electric field are separated by an infinitesimal distance Δ x 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.

(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

Section B

17.

	Gamma rays	**Radio waves**
Origin	Nuclear decay	Lightning
	From hottest and most energetic objects in the universe, such as neutron stars, pulsars, supernova explosions, and regions around black holes	From broadcast radio towers, cell phones and radars.
Application	In radiotherapy, sterilisation and disinfection	In fixed and mobile radio communication, radar and other navigation systems, communication satellites, computer networks

18. Torque of solenoid is given by

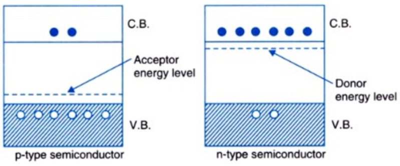
τ = MB sin θ

= (NIA) B sin θ

$= 1000 \times 2 \times 2 \times 10^{-4} \times 0.32 \times \frac{1}{2}$

= 0.064 Nm

19. Energy band diagrams of n-type and p-type semiconductors are shown below:



In the case of n-type semiconductors, The Donor energy level decreases the energy gap between the conduction band and the valence band, electrons from donor impurity atoms will move into the conduction band with a very small supply of energy. Hence, the conduction band will, therefore, have electrons as majority charge carriers. In the case of p-type semiconductor, a very small supply of energy can cause an electron from its valence band to jump to the acceptor energy level. Hence, the valence band will have a dominant density of holes which shows that holes are the majority charge carriers in p-type semiconductors.

20. $r_0 = 21.2 \times 10^{-11}$ m

First excited state means, n = 2

$r_0 = n^2 r_1$

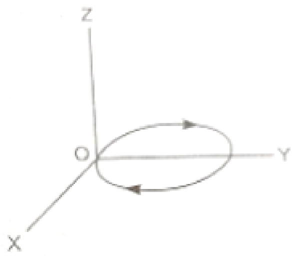
or $r_1 = \frac{r_0}{n^2}$

$r_1 = \frac{21.2\times10^{-11}}{4}\text{m}$

= 5.3×10^{-11} m

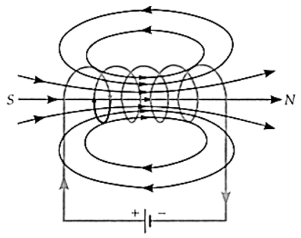
$E = -\frac{13.6}{n^2}$ = -3.4 eV ,hence total energy of atom is given by :- -3.4 eV

21. i. As the charged particle crosses the origin O with velocity $\vec{v}$ (along negative X-axis), it comes under the effect of magnetic field $\vec{B}$ (acting along positive Z-axis). A force equal to $\vec{F}$ = q($\vec{v} \times \vec{B}$) acts on the charged particle positive Y-axis. As a result, the particle moves along a circular path in XY-plane as shown in figure.



ii. The force on the charged particle due to magnetic field is always perpendicular to its path and therefore, work done by magnetic field on the moving charge is zero. Hence, the charged particle will not gain kinetic energy.

OR



i. The magnetic lines of force of a solenoid form closed loops while the electric lines of force of an electric dipole start from the positive charge and end at the negative charge.
ii. Such curves are called magnetic lines of force. No two such lines of force can intersect. If they do so, then there will be two tangents and hence two directions of the magnetic field at the point of intersection which is impossible.

Section C

22. i. Current I when K_2 is open

$I = \frac{E}{R+X}$

ii. Current I'when K_2 is closed

$I' = \frac{E}{R+\left(\frac{SX}{S+X}\right)} = \frac{E(S+X)}{R(S+X)+SX}$ (so , S and X are parallel)

Current flowing through X, $(I' = I/2)$

$\frac{I}{2} = \frac{I'S}{S+X} = \frac{ES}{R(S+X)+SX}$ (by putting the value of I ,we get)

$\Rightarrow \quad \frac{E}{2(R+X)} = \frac{ES}{R(S+X)+SX}$

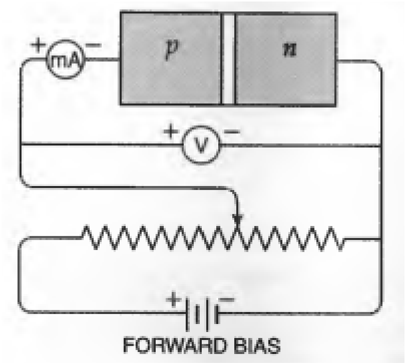
$\Rightarrow$ 2(R + X)S = R(S + X) + SX

2RS + 2XS = RS + RX + SX

RS = RX - SX

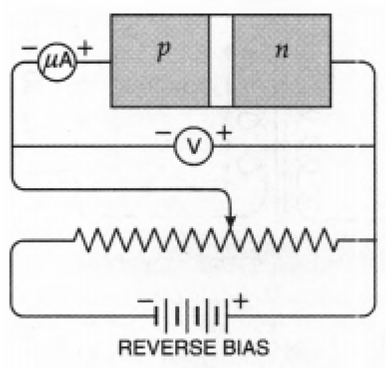
$X = \frac{RS}{(R-S)}$

23. i. The forward-bias connections of a p-n junction are as shown in Fig.



When the p-n junction is forward biased, the depletion layer becomes thin. It is because, the polarity of the external d.c. source opposes the fictitious battery developed across the junction. As a result, the potential drop across the junction decreases making the depletion layer thin. It leads to the low resistance of the junction diode during forward bias.

ii. The reverse-bias connections of a p-n junction are as shown in Fig.



When the p-n junction is reverse biased, the depletion layer becomes thick. It is because, the external d.c. source aids the fictitious battery. It results in the increase of potential drop across the junction and the depletion layer appears thick. Because of the increased thickness of the depletion layer, the p-n junction offers high resistance during reverse bias.

24. The frequency of ultraviolet radiations is more while that of red light is less than the threshold frequency for a zinc surface, so ultraviolet radiations can cause the emission of electrons and red light cannot.

From Einstein's photoelectric equation, K.E. of a photoelectron is

$\frac{1}{2}m\nu^2 = h\nu - W_0 = h\nu - 0 = \frac{hc}{\lambda}$

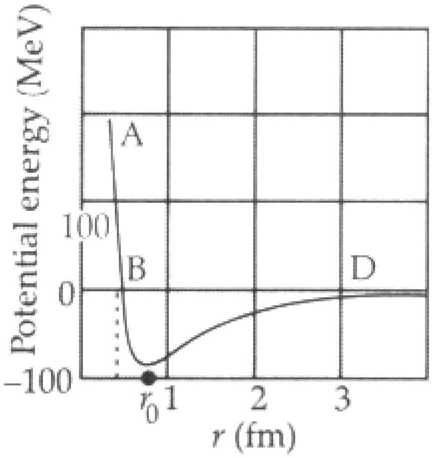
or $v = \sqrt{\frac{2hc}{m\lambda}}$

de Broglie wavelength of electrons,

$\lambda_e = \frac{h}{mv}$

$= \frac{h}{m}\sqrt{\frac{m\lambda}{2hc}} = \sqrt{\frac{h\lambda}{2mc}}$

25. i.



For r > r_0, the force is attractive

For r < r_0, the force is repulsive

ii. We have, In nuclear reactions , mass no .is conserved Hence ,

$1 + 235 = a + 94 + 2 \times 1$

$\therefore a = 236 - 96 = 140$

In nuclear reactions , charge no. is conserved .so $0 + 92 = 54 + b + 2 \times 0$

$\therefore b = 92 - 54 = 38$

26. i. Energy of the ground state (n = 1) = – (ionization energy) = –13.6 eV

The wavelength of the incident radiation, $\lambda = 975\ \mathring{A}$

$\therefore$ The energy of the incident photon = hc/λ

$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{975 \times 10^{-10} \times 1.6 \times 10^{-19}} = 12.75$ eV

Let electron is exerted to nth orbit,

$\Rightarrow 12.75 = 13.6\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$

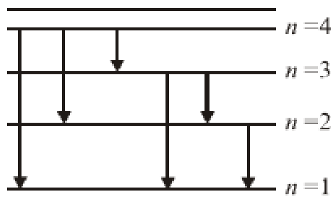
$\Rightarrow n = 4$

The quantum transitions to the less excited states gives six possible lines as follows:

$n = 4 : (4 \rightarrow 3), (4 \rightarrow 2), (4 \rightarrow 1)$

$n = 3 : (3 \rightarrow 2), (3 \rightarrow 1)$

$n = 2 : (2 \rightarrow 1)$



ii. The longest wavelength emitted is for the transitions $(4 \rightarrow 3)$ where energy difference is minimum.

$E_{min} = (E_4 - E_3) = 13.6\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = 0.661$ eV

Thus $\lambda_{max} = \frac{hc}{E_{min}}$

$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{0.661 \times 1.6 \times 10^{-19}}$ m

$\approx 18807\ \mathring{A}$

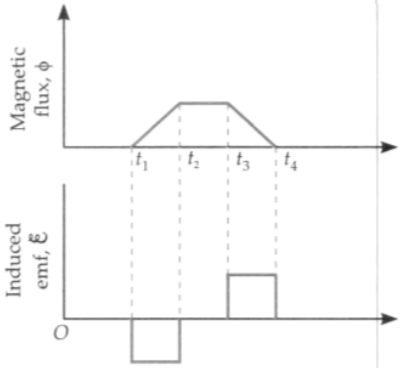
27. $\beta = n\frac{\lambda D}{d}$

a. As d increases, β decreases so spacing between fringes also decreases.

b. As λ decreases, β also decreases so spacing between fringes also decreases.

c. As whole apparatus is submerged in oil, λ decreases So β decreases and spacing between fringes will be narrow.

28. The graphs given in the figure show the variation of flux ϕ with time t and induced emf ε with time t, respectively.



Explanation of variation of magnetic time. Magnetic flux is proportional to the coil linked with flux. Initially, the coil lies magnetic field, flux through it is zero. As the field at time t_1 the flux begins to increase. with time. Between times t_2 and t_3, in the magnetic field, so flux remains: After this the flux decreases linearly with reduces to zero at time t_4, when the coil co the magnetic field.

OR

i. The direction of induced current will be such that it tends to maintain the original flux. So induced current flows anticlockwise in loop 1 and clockwise in loop 2.

ii. No, the emf's induced in the two loops will not be equal.

Since, the rate of change of flux is more in the second coil, emf induced in the second coil is more than that in the first coil.

Emf in the first coil, $E_1 = Bav$

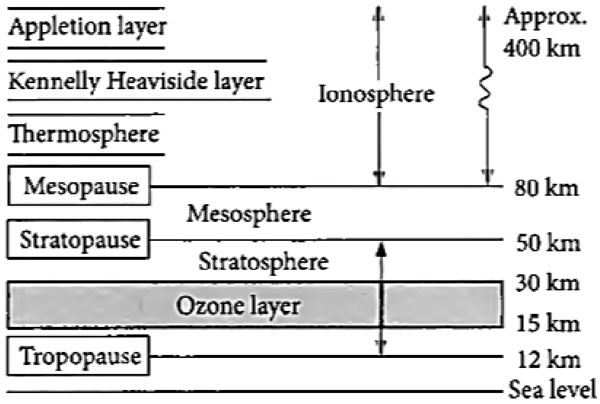
Emf in the school coil, $E_2 = Bbv$

Since, b > a therefore, $E_2 > E_1$

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.

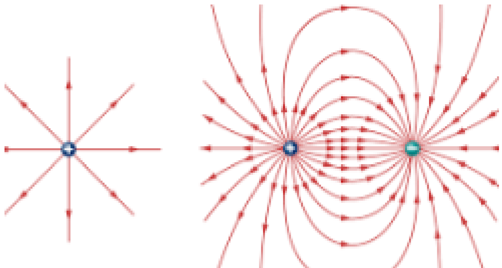
OR

(d) stratosphere
Explanation: Ozone layer lies in stratosphere.

(iv) **(b)** infrared
Explanation: The atmosphere of earth is richest in infrared radiation.

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

Electric field lines as a path, straight or curved in an electric field such that tangent to it at any point gives the direction of electric field intensity at the point. Electric field lines are continuous curves they start from a positive charged body and end at the negatively charged body. (Refer image)



(a) (b)

(i) **(d)** spherically symmetric
Explanation: spherically symmetric

(ii) **(a)** N/C
Explanation: N/C

(iii) **(b)** Electric field lines can intersect each other.
Explanation: Electric field lines can intersect each other.

(iv) **(a)** path 'd'

Explanation: path 'd'

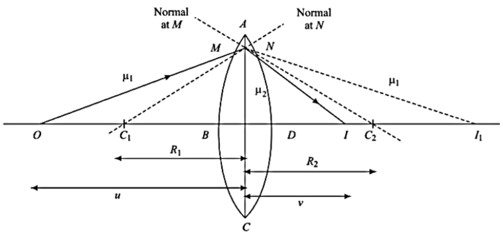
OR

(c) All of these.

Explanation: All of these.

Section E

31. i.



The complete derivation of the lens maker formula is described below. For refraction at surface ABC, we have

$\frac{\mu_2}{v_1} - \frac{\mu_1}{u} = \frac{\mu_2-\mu_1}{R_1}$ ...(i) (Here μ_2, μ_1 are the refractive index of the material)

For refraction at surface ADC, we have

$\frac{\mu_1}{v} - \frac{\mu_2}{v_1} = \frac{\mu_1-\mu_2}{R_2}$ ...(ii)

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

$\frac{\mu_1}{v} - \frac{\mu_1}{u} = (\mu_2 - \mu_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$\frac{1}{v} - \frac{1}{u} = \left[\frac{(\mu_2-\mu_1)}{\mu_1}\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ ...(iii)

If the object is placed at infinity (u=∞), the image will be formed at the focus, i.e. v = f

Therefore

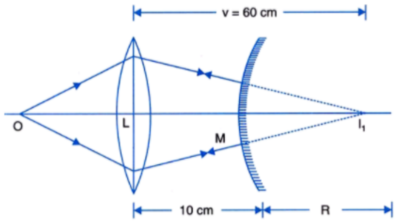
$\frac{1}{f} - \frac{1}{\infty} = (\mu_{21} - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ ...(iv)

From eq. (iii) and (iv), we have

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

This is Lens maker formula.

ii. For refraction at convex lens, we have



Object distance, u = -12 cm

Image distance, v =?

Forcal length, f = + 10 cm

Using lens formula, we have

$\frac{1}{v} - \frac{1}{(-12)} = \frac{1}{10}$

i.e. v = + 60 cm

Thus, in the absence of a convex mirror, the convex lens will form the image I_1, at a distance of 60cm behind the lens. As the mirror is at a distance of 10cm from the lens, image I_1 will be at a distance of (60 - 10) = 50 cm from the mirror, i.e., MI_1 = 50 cm.

Now, as the final image I_2 is formed at the object itself, the rays after reflection from the mirror retrace its path, i.e., the rays on the mirror are incident normally, i.e., I_1 is the centre of the mirror so that

R = MI_1 = +50 cm

and f = $\frac{R}{2} = \frac{50}{2}$ = 25 cm

Which is the focal length of the mirror.

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. $Q = Q_1 + Q_2$

$V_1 = V_2$ potential of both capacitors after they are connected with each other.

$\therefore \frac{Q_1}{C_1} = \frac{Q_2}{C_2} \Rightarrow Q = \left(\frac{C_1}{C_2} + 1\right) Q_2$

$Q_2 = \frac{QC_2}{C_1+C_2}\ Q_1 = \frac{QC_1}{C_1+C_2}$

$V_2 = V_1 = \frac{Q}{C_1+C_2} = \frac{Q_2}{C_2} = \frac{Q_1}{C_1}$

$U_f = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2 = \frac{1}{2}(C_1 + C_2)\ \frac{Q^2}{(C_1+C_2)^2} = \frac{Q^2}{2(C_1+C_2)}$

$U_i = \frac{Q^2}{2C_1}$

$U_i - U_f = \frac{Q^2}{2C_1} - \frac{Q^2}{2(C_1+C_2)} = \frac{Q^2(C_2)}{(C_1)(C_1+C_2)}$

The lost energy appears in the form of heat.

OR

Let OA = OB = OC = OD = r

Then the potential at the centre O is

$V_O = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{r} + \frac{q}{r} - \frac{q}{r} - \frac{q}{r}\right] = 0$

Again, the potential at point E is

$V_E = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{AE} + \frac{q}{BE} - \frac{q}{CE} - \frac{q}{DE}\right] = 0$ [$\therefore$ AE = DE, BE = CE]

Now, $AF = BF = \sqrt{a^2 + \left(\frac{a}{2}\right)^2} = \frac{\sqrt{5}a}{2}$

$\therefore$ The potential at point F is

$V_F = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{AF} + \frac{q}{BF} - \frac{q}{CF} - \frac{q}{DF}\right]$

$= \frac{2q}{4\pi\varepsilon_0}\left[\frac{1}{AF} - \frac{1}{CF}\right]$ [$\because$ AF = BF, CF = DF]

$= \frac{2q}{4\pi\varepsilon_0}\left[\frac{2}{\sqrt{5}a} - \frac{2}{a}\right] = \frac{q}{\pi\varepsilon_0 a}\left(\frac{1}{\sqrt{5}} - 1\right)$

Work done in moving the charge V from O to E is $W = e[V_E - V_O] = e \times 0 = 0$

Work done in moving the charge 'e' from O to F is

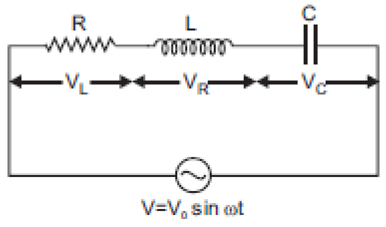
$W = e\left[V_F - V_O\right] = e\left[\frac{q}{\pi\varepsilon_0 a}\left(\frac{1}{\sqrt{5}} - 1\right) - 0\right]$

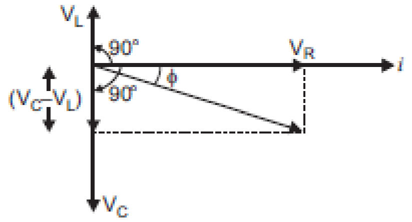
$= \frac{qe}{\pi\varepsilon_0 a}\left(\frac{1}{\sqrt{5}} - 1\right)$

33. Suppose a resistance R, inductance L and capacitance C in series. An alternating source of voltage $V = V_o \sin \omega t$ is applied across it. Since all the components are connected in series, the current flowing through all is same.

Voltage across resistance R is V_R, voltage across inductance L is V_L and voltage across capacitance C is V_C.

V_R and $(V_C - V_L)$ are mutually perpendicular and the phase difference between them is 90^o.





From the figure above, we have

$V^2 = V_R^2 + (V_C - V_L)^2 \Rightarrow V = \sqrt{V_R^2 + (V_C - V_L)^2}$ ..... (i)

and V_R = Ri, $V_C = X_C$ i and $V_L = V_L$ i ..... (ii)

where $X_C = \frac{1}{\omega C}$ = capacitance reactance and $X_L = \omega L$ = inductive reactance

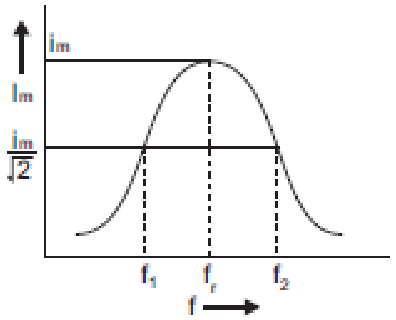
$\therefore \quad V = \sqrt{(Ri)^2 + (X_C i - X_L i)^2}$

$\therefore$ Impendance of circuit, $Z = \frac{V}{i} = \sqrt{R^2 + (X_C - X_L)^2}$

i.e. $Z = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$

The phase difference between current and voltage is given by,

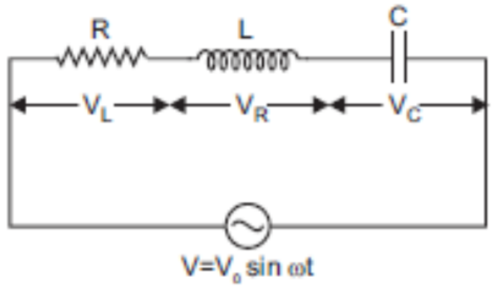
$\tan\phi = \frac{X_C - X_L}{R}$



From the graph, we can see that with increase in frequency, current first increases and then decreases. At resonant frequency, current amplitude is maximum.

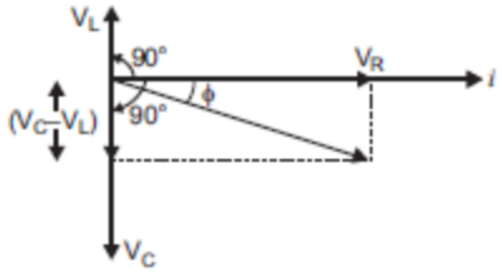
OR

a. Suppose a resistance R, inductance L and capacitance C are connected to series and an alternating voltage V = $V = V_0 sinwt$ is applied across it.



Since L, C and R are connected in series, current flowing through them is the same. The voltage across R is V_R, inductance across L is V_L and across capacitance is V_C.

The voltage V_R and current i are in the same phase, the voltage V_L will lead the current by angle 90^o while the voltage V_C will lag behind the current by 90^o.



Thus, V_R and $(V_C - V_L)$ are mutually perpendicular and the phase difference between them is 90^o. As seen in the fig, we can say that, as the applied voltage across the circuit is V, the resultant of V_R and $V_C - V_L$) will also be V.

So,

$V^2 = V_R^2 + (V_c - V_L)^2$

$\Rightarrow$ V = $\sqrt{V_R^2 + (V_c - V_L)^2}$

But, $V_R = Ri$, $V_c = X_c i$ and $V_L = X_L i$

where, $X_c = \frac{1}{\omega C}$ and $X_L = \omega L$

So, V = $\sqrt{(Ri)^2 + (X_c i - X_L i)^2}$,

Therefore, impendance of the circuit is given by,

Z = $\frac{V}{i}$ = $\sqrt{(R)^2 + (X_c - X_L)^2}$

Z = $\sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$

This is the impedance of the LCR series circuit.

b. A radio or a TV set has an LC circuit capacitor of variable capacitance C. The circuit remains connected with an aerial coil through the phenomenon of mutual inductance. Suppose a radio or TV station has transmitted a program at frequency f, then waves produce an alternating voltage of frequency in area, due to which an emf of the same frequency is induced in LC circuit. When capacitor C is in circuit is varied then for a particular value of capacitance, C, f = $\frac{1}{2\pi\sqrt{LC}}$, the resonance occurs and maximum current flows in the circuit; so the radio or TV gets tuned.