Class XII Session 2024-25
Subject - Physics
Sample Question Paper - 6

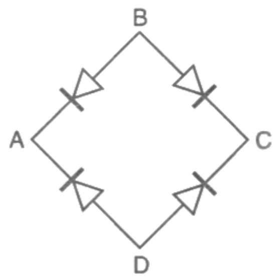
Time Allowed: 3 hours **Maximum Marks: 70**

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. A bridge rectifier is shown in the figure. Alternating input is given across A and C. If the output is taken across BD, then it is: **[1]**



a) full wave rectified
b) zero
c) half wave rectified
d) same as input

2. If P and Q are two batteries connected in series with anode of one connected to anode of the other, producing voltages E_1 and $E_2 > E_1$ respectively. The e.m.f of the pair is **[1]**

a) E_1
b) E_2
c) E_2 - E_1
d) E_2 + E_1

3. An object approaches a convergent lens from the left of the lens with a uniform speed 5 m/s and stops at the focus. The image **[1]**

a) moves away from the lens with a uniform acceleration
b) moves away from the lens with a uniform speed 5 m/s
c) moves towards the lens with a non-uniform acceleration
d) moves away from the lens with a non-uniform acceleration

4. A bar magnet is cut into two equal halves parallel to its magnetic axis. The physical quantity that remains unchanged is: **[1]**

a) moment of inertia
b) pole strength
c) magnetic moment
d) magnitude of magnetisation

5. A capacitor is charged by a battery. Between the plates, during process of charging: **[1]**

a) only conduction current exists.
b) only displacement current exists.
c) both displacement current and conduction current exist.
d) no current exists.

6. A vertical straight conductor carries a current vertically upwards. A point P lies to the east of it at a small distance and another point Q lies to the west in the same direction. The magnetic field at P is: **[1]**

a) greater or less than at Q, depending upon the strength of the current
b) greater than at Q
c) less than at Q
d) same as at Q

7. Given magnetic field B, area A and length l of a solenoid. The magnetic energy per unit volume is **[1]**

a) $\frac{1}{2\mu_0}B^2A$
b) $\frac{3}{2\mu_0}B^2Al$
c) $\frac{1}{2\mu_0}B^3Al$
d) $\frac{B^2}{2\mu_0}$

8. The ratio of magnetic fields due to a small bar magnet in the end on position to the broad side on position is **[1]**

a) 1 : 1
b) 1 : 4
c) 2 : 1
d) 1 : 2

9. Which of the following phenomenon cannot take place with longitudinal waves (e.g., sound waves)? **[1]**

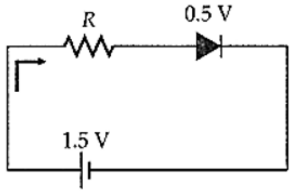
a) polarisation
b) diffraction
c) reflection
d) interference

10. When a negatively charged conductor is connected to earth **[1]**

a) Electrons flow from the earth to the conductor
b) Protons flow from the conductor to the earth
c) No charge flow occurs
d) Electrons flow from the conductor to the earth

11. The diode used in the circuit shown in the figure has a constant voltage drop at 0.5 V at all currents and a maximum power rating of 100 milliwatts. What should be the value of the resistor R, connected in series with **[1]**

diode for obtaining maximum current?



a) 20 Ω
b) 6.76 Ω
c) 5 Ω
d) 5.6 Ω

12. The layered lens is made of two kinds of glass. A point source of light is placed on its principal axis. If the reflections from the boundaries between layers are ignored, the lens will form **[1]**

a) no image at all
b) two images
c) infinite images
d) only one image

13. **Assertion (A):** The de Broglie wavelength of a molecule varies inversely as the square root of temperature. **[1]**
Reason (R): The root mean square velocity of the molecule depends on the temperature.

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:** Two concentric charged inner and outer shell are given. The potential difference between the shells depends on charge of inner shell. **[1]**
Reason: Potential due to charge of outer shell remains same at every point inside the sphere.

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):** Skiers use air glasses. **[1]**
Reason (R): Light reflected by snow is partially polarised.

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):** Transformers are used only in alternating current sources, not in direct current. **[1]**
Reasons (R): Only a.c. can be stepped up or down by means of transformers.

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. Use the formula $\lambda_m T = 0.29$ cm K to obtain the characteristic temperature ranges for different parts of the electromagnetic spectrum. What do the numbers that you obtain tell you? **[2]**

18. Two magnetic poles, one of which is 10 times as strong as the other, exert on each other a force equal to 9.604 **[2]**

mN, when placed 10 cm apart in air. Find the strength of the two poles.

19. Two crystals C_1 and C_2, made of pure silicon, are doped with arsenic and aluminium respectively. **[2]**

a. Identify the extrinsic semiconductors so formed.

b. Why is doping of intrinsic semiconductors necessary?

20. The ground state energy of hydrogen atom is -13.6 eV. If an electron makes a transition from an energy level -1.51 eV to - 3.4 eV, then calculate the wavelength of the spectral line emitted and name the series of hydrogen spectrum to which it belongs. **[2]**

21. A beam of protons with a velocity $4 \times 10^5 m/s$ enters a uniform magnetic field of 0.3 T at an angle 60° to the magnetic field. Find the radius of the helical path taken by the proton beam. Also find the pitch of the helix mp $= 1.67 \times 10^{-27} k$ **[2]**

OR

What will be the path of a charged particle moving in a region of crossed (or transverse) uniform electrostatic and magnetic fields with initial velocity zero?

Section C

22. Two cells of emf 2E and E and internal resistances 2r and r respectively, are connected in parallel. Obtain the expressions for the equivalent emf and the internal resistance of the combination. **[3]**

23. Draw the circuit diagram of a full wave rectifier. Explain its working principle. Show the input waveforms given to the diodes D_1 and D_2 and the corresponding output waveforms obtained at the load connected to the circuit. **[3]**

24. A beam of monochromatic radiation is incident on a photosensitive surface. Answer the following questions giving reasons. **[3]**

i. Do the emitted photoelectrons have the same kinetic energy?

ii. Does the kinetic energy of the emitted electrons depend on the intensity of incident radiation?

iii. On what factors does the number of emitted photoelectrons depend?

25. Deuteron is a bound state of a neutron and a proton with a binding energy B = 2.2 MeV. A γ-ray of energy E is aimed at a deuteron nucleus to try to break it into a (neutron + proton) such that the n and p move in the direction of the incident γ-ray. If E = B, show that this cannot happen. Hence calculate how much bigger than B must E be for such a process to happen. **[3]**

26. Using Bohr's total postulates, derive the expression for the total energy of the electron in the stationary states of hydrogen atom. **[3]**

27. In single slit diffraction, explain why the maxima at $\theta = \left(\mathrm{n} + \frac{1}{2}\right)\left(\frac{\lambda}{\mathrm{a}}\right)$ becomes weaker and weaker as n increases. State two important differences between interference and diffraction pattern. **[3]**

28. i. Define mutual inductance. **[3]**

ii. A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil?

OR

A small flat search coil of area 5 cm^2 with 140 closely wound turns is placed between the poles of a powerful magnet producing magnetic field 0.09 T and then quickly removed out of the field region. Calculate

a. change of magnetic flux through the coil, and

b. emf induced in the coil.

Section D

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

Electrons oscillating in a circuit give rise to radiowaves. A transmitting antenna radiates most effectively the radiowaves of wavelength equal to the size of the antenna. The infrared waves incident on a substance set into oscillation all its electrons, atoms and molecules. This increases the internal energy and hence the temperature of the substance.

(a) If v_g, v_X and v_m are the speeds of gamma rays, X-rays and microwaves respectively in vacuum, then

a) $v_g > v_X > v_m$
b) $v_g < v_X < v_m$
c) $v_g > v_X > v_m$
d) $v_g = v_X = v_m$

(b) Which of the following will deflect in electric field?

a) ultraviolet rays
b) γ-rays
c) X-rays
d) cathode rays

(c) γ-rays are detected by

a) point contact diodes
b) ionization chamber
c) thermopiles
d) photocells

OR

We consider the radiation emitted by the human body. Which one of the following statements is true?

i. The radiation emitted is in the infrared region.
ii. The radiation is emitted only during the day.
iii. The radiation is emitted during the summers and absorbed during the winters.
iv. The radiation emitted lies in the ultraviolet region and hence it is not visible.

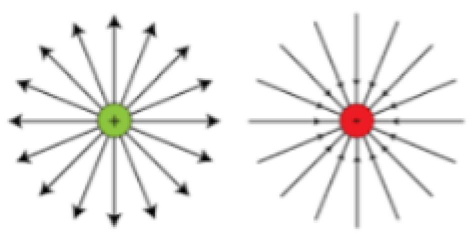
a) Option (iv)
b) Option (ii)
c) Option (iii)
d) Option (i)

(d) The frequency of electromagnetic wave, which best suited to observe a particle of radius 3×10^{-4} cm is the order of

a) 10^{14} Hz
b) 10^{12} Hz
c) 10^{13} Hz
d) 10^{15} Hz

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

A charge is a property associated with the matter due to which it experiences and produces an electric and magnetic field. Charges are scalar in nature and they add up like real numbers. Also, the total charge of an isolated system is always conserved. When the objects rub against each other charges acquired by them must be equal and opposite.



Electric field lines of a positive point charge   Electric field lines of a negative point charge

(a) The cause of charging is:

a) the actual transfer of atoms
b) the actual transfer of protons

c) the actual transfer of electrons

d) the actual transfer of neutrons

(b) Pick the correct statement.

i. The glass rod gives protons to silk when they are rubbed against each other.
ii. The glass rod gives electrons to silk when they are rubbed against each other.
iii. The glass rod gains protons from silk when they are rubbed against each other.
iv. The glass rod gains electrons when they are rubbed against each other.

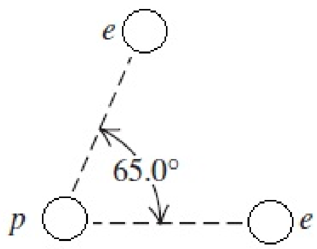
a) Option (i)

b) Option (iv)

c) Option (iii)

d) Option (ii)

(c) If two electrons are each 1.5×10^{-10}m from a proton, as shown in Figure, magnitude of the net electric force they will exert on the proton is



a) 1.97×10^{-8} N

b) 3.83×10^{-8} N

c) 4.63×10^{-8} N

d) 2.73×10^{-8} N

(d) A charge is a property associated with the matter due to which it produces and experiences:

a) electric effects only

b) magnetic effects only

c) both electric and magnetic effects

d) non magnetic effects only

OR

The cause of quantization of electric charges is:

a) transfer of an integral number of electrons

b) transfer of an integral number of neutrons

c) transfer of an integral number of protons

d) transfer of an integral number of Atom

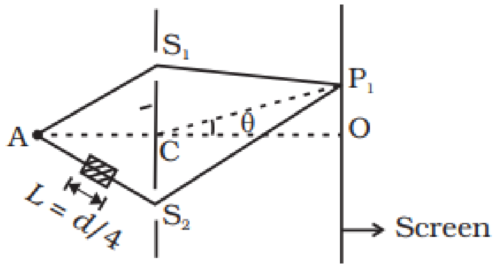
Section E

31. i. A coin is placed inside a denser medium. Why does it appear to be raised? Obtain an expression for the height through which the object appears to be raised in terms of refractive index of the medium and real depth. **[5]**

ii. A compound microscope consists of an objective lens of focal length 2 cm and an eyepiece of focal length 6.25 cm separated by a distance of 15 cm. How far from the objective should an object be placed in order to obtain the final image at the least distance of distinct vision (25 cm)? Calculate the magnifying power of the microscope.

OR

A small transparent slab containing material of $\mu = 1.5$ is placed along AS_2 (Figure). What will be the distance from O of the principal maxima and of the first minima on either side of the principal maxima obtained in the absence of the glass slab?



AC = CO = D, $S_1C = S_2C = d << D$

32. i. Define the capacitance of a capacitor. Obtain the expression for the capacitance of a parallel plate capacitor in vacuum in terms of plate area A and separation d between the plates. **[5]**

ii. A slab of material of dielectric constant k has the same area as the plates of a parallel plate $\frac{3d}{4}$ capacitor but has a thickness -. Find the ratio of the capacitance with dielectric inside it to its capacitance without the dielectric.

OR

a. Explain why, for any charge configuration, the equipotential surface through a point is normal to the electric field at that point.
Draw a sketch of equipotential surfaces due to a single charge (-q), depicting the electric field lines due to the charge.

b. Obtain an expression for the work done to dissociate the system of three charges placed at the vertices of an equilateral triangle of side **a** as shown alongside.

33. a. State the condition for resonance to occur in series LCR a.c. circuit and derive an expression for resonant frequency. **[5]**

b. Draw a plot showing the variation of the peak current (i_m) with frequency of the a.c, source used. Define the quality factor Q of the circuit.

OR

With the help of a diagram, explain the principle of a device which changes a low voltage into a high voltage but does not violate the law of conservation of energy. Give any one reason why the device may not be 100% efficient.

Solution

Section A

1.

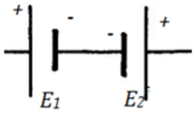
(b) zero

Explanation: zero

2.

(c) E_2 - E_1

Explanation: When cells are connected in opposition the equivalent emf is the difference of their emfs.



3.

(d) moves away from the lens with a non-uniform acceleration

Explanation: When an object approaches a lens with uniform speed, its image moves away from the lens to infinity with non-uniform acceleration.

4.

(d) magnitude of magnetisation

Explanation: magnitude of magnetisation

5.

(b) only displacement current exists.

Explanation: only displacement current exists.

6.

(d) same as at Q

Explanation: As per Biot Savart Law, Magnetic field at a point is inversely proportional to square of distance from the current carrying conductor. Therefore magnitude of magnetic field is same at both points P and Q, irrespective of their position from the conductor.

7.

(d) $\frac{B^2}{2\mu_0}$

Explanation: $U = \frac{1}{2\mu_0} B^2 Al$

$\frac{U}{V} = \frac{B^2}{2\mu_0}$

8.

(c) 2 : 1

Explanation: 2 : 1

9. **(a)** polarisation

Explanation: polarisation

10.

(d) Electrons flow from the conductor to the earth

Explanation: After earthing a positively charged conductor electrons flow from earth to conductor and if a negatively charged conductor is earthed then electrons flows from conductor to earth.

11.

(c) 5 Ω

Explanation: Voltage drop across diode, V_d = 0.5 V

Power rate of diode, P_d = 100 mW = 0.1 W

Resistance of the diode,

$R_d = \frac{V_d^2}{P_d} = \frac{(0.5)^2}{0.1} = 2.5\Omega$

Maximum current through the diode,

$I_d = \frac{V_d}{R_d} = \frac{0.5}{2.5}$ = 0.2 A

Applied voltage, V = 1.5 V

Required total resistance of the circuit,

$R' = \frac{V}{I_d} = \frac{1.5}{0.2} = 7.5\Omega$

Value of the series resistor, $R = R' - R_d$ = 7.5 - 2.5 = 5Ω

12.

(d) only one image

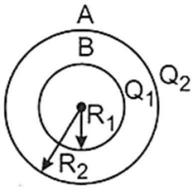
Explanation: It is like a combination of two Plano – convex lenses. Therefore only one image is formed.

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

Explanation: $v_{rms} \propto \sqrt{T}$

$\lambda = \frac{h}{mv} \Rightarrow \lambda \propto \frac{1}{v}$

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

Explanation: 

$V_A = \frac{1}{4\pi\varepsilon_0}\frac{Q_1+Q_2}{R_2}$

$V_B = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1}{R_1} + \frac{Q_2}{R_2}\right)$

$V_B - V_A = \frac{1}{4\pi\varepsilon_0}Q_1\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

15.

(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.

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

Explanation: A transformer works on the principle of mutual induction. It can step up or step down a changing current like a.c. and not d.c

Section B

17. A body at a particular temperature produces a continuous spectrum of wavelengths. In the case of a black body, the wavelength corresponding to the maximum intensity of radiation is given according to Planck's law. It can be given by the relation,

$\lambda_m = \frac{0.29}{T}\text{cmK}$

Where,

λ_m = maximum wavelength

T = temperature

Thus, the temperature for different wavelengths can be obtained as:

For $\lambda_m = 10^{-4}$ cm; $T = \frac{0.29}{10^{-4}}$ = 2900°k

For $\lambda_m = 5 \times 10^{-5}$ cm; $T = \frac{0.29}{5\times10^{-5}}$ = 5800°k

For $\lambda_m = 10^{-6}$ cm; $T = \frac{0.29}{10^{-6}}$ = 290000°k and so on.

The numbers obtained tell us that temperature ranges are required for obtaining radiations in different parts of an electromagnetic spectrum. As the wavelength decreases, the corresponding temperature increases.

18. Here, F = 9.604 mN = 9.604×10^{-3} N

If m_1 = m, m_2 = 10m, r = 10 cm = 0·1 m

As $F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2}$

$\therefore 9.604 \times 10^{-3} = \frac{10^{-7} m(10m)}{(0 \cdot 1)^2}$

$m_2 = 96.04$, m = 9.8 Am

$\therefore m_1 = 9.8$ Am, $m_2 = 10$ m = 98 Am

19. a. C_1 is n-type semiconductor and C_2 is the p-type semiconductor.

    b. Doping of intrinsic semiconductors is required to increase the majority of charge carriers based on which n-type and p-type semiconductors can be made and thus can be used.

20. Energy difference = Energy of emitted photon

$= E_2 - E_1$

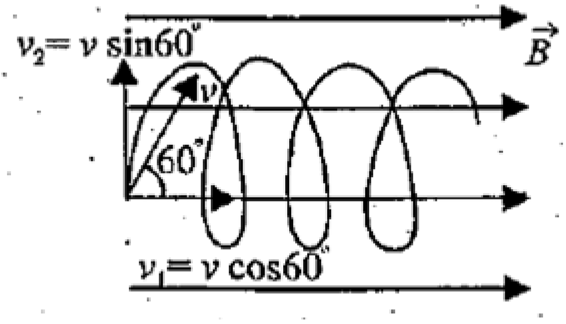
$= -1.51 - (-3.4) = 1.89$ eV $= 1.89 \times 1.6 \times 10^{-19}$ J

$\lambda = \frac{hc}{E_2 - E_1}$

$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{1.89 \times 1.6 \times 10^{-19}} = \frac{19.8}{3.024} \times 10^{-7}$

$= 6.548 \times 10^{-7}$ m $= 6548 \overset{o}{A}$

This wavelength belongs to Balmer series of hydrogen spectrum.

21. 

v_1 is responsible for horizontal motion of proton

v_2 is responsible for circular motion of proton

Now, $\frac{mv_2^2}{r} = qv_2 B$

$\therefore \mathbf{r} = \frac{mv_2}{qB}$

$r = \frac{1.67 \times 10^{-27} \times 4 \times 10^5 \sin 60}{1.6 \times 10^{-19} \times 0.3}$

$= 1.2 \times 10^{-2} = 1.2 cm$

$T = \frac{2\pi r}{v \sin \theta} = 2.175 \times 10^{-7} S$

$\therefore P = v \cos \theta T$

$= 4 \times 10^5 \times \frac{1}{2} \times 2.175 \times 10^{-7} = 4.35 cm$

OR

Cycloid (e.g., the path of a point on the rim of moving wheel) with its forward motion normal to both $\vec{E}$ and $\vec{B}$.

Section C

22. Given, emf of first cell = 2E

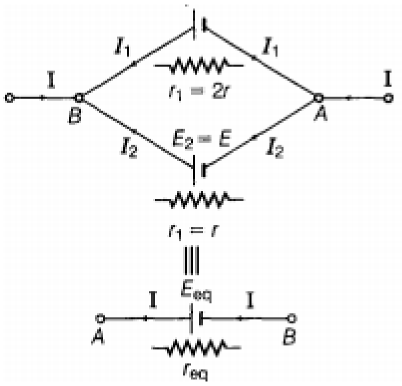
emf of second cell = E

Internal resistance of first cell = 2r

Internal resistance of second cell = r

Net current, $I = I_1 + I_2$ ...(i)

$E_1 = 2E$



For cell-I

$V = V_A - V_B = 2E - I_1(2r)$

$\Rightarrow \quad I_1 = \frac{2E-V}{2r}$ ....(ii)

For cell-II, $V = V_A - V_B = E - I_2 r$

$\Rightarrow \quad I_2 = \frac{E-V}{r}$ ...(iii)

$\because$ From Eqs. (ii) and (iii), substituting in Eq. (i), we get

$I = \frac{2E-V}{2r} + \frac{E-V}{r}$

On rearranging the term, we get

$V = \frac{4E}{3} - I\left(\frac{2r}{3}\right)$

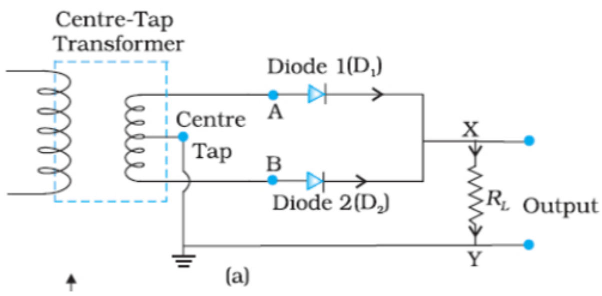
But for equivalent of combination,

$V = E_{eq} - I(r_{eq})$

On comparing,

$E_{eq} = \frac{4E}{3}, r_{eq} = \frac{2r}{3}$

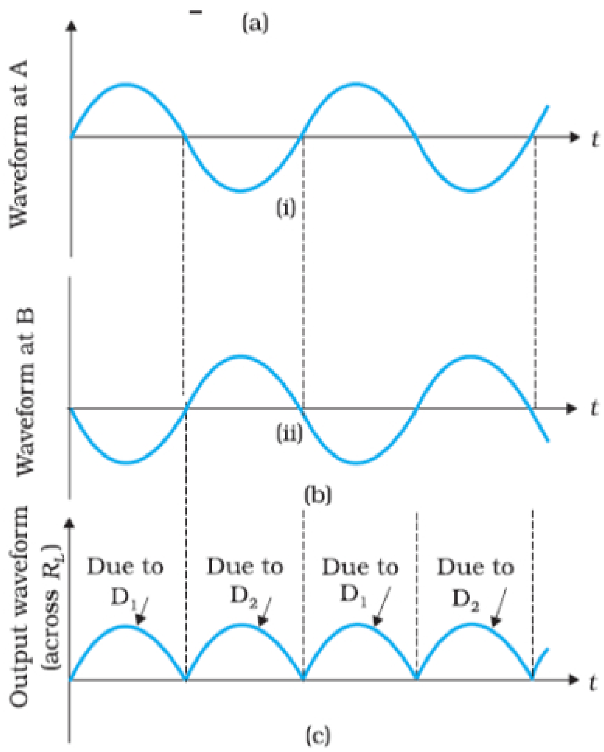
23. Circuit:-



Principle:- Diode conducts only in forward biasing.

Input D_1

D_2



24. i. Yes, all emitted photoelectrons have same kinetic energy as the kinetic energy of emitted photoelectrons depends upon frequency of the incident radiation for a given photosensitive surface.
    ii. No, the kinetic energy of the emitted electrons does not depend on the intensity of incident radiation. If the intensity of the incident light radiation is increased, then the number of incident photons falling per second on the metal surface also increases but the energy of each photon remains the same as the frequency of the radiation is not changing. The maximum kinetic energy of a photoelectron depends only on the frequency of incident radiation and not on the intensity of incident radiation.
    iii. The number of emitted photoelectrons depends only on intensity of incident light.
25. Binding energy of a deuteron is, B = 2.2 MeV Let kinetic energy and the momentum of neutron and proton be K_n, K_p, and P_n, P_p respectively. From the conservation of energy,

    $E - B = K_n + K_p = \frac{p_n^2}{2m} + \frac{p_p^2}{2m}$

    Now applying conservation of momentum is given by,

    $p_n + p_p = \frac{E}{C}$

    As E = B, Eq. (i) $p_n^2 + p_p^2 = 0$

    It only happens if $p_n = p_p$ So, the Eq. (ii) cannot be satisfied and the process cannot take place.

    Let us take E = B + x, where x << B for the process to take place. Putting the value of p_n from Eq. (ii) in Eq. (i), we get

    or $2p_p^2 - \left(\frac{2E}{c}\right)p_p + \left(\frac{E^2}{c^2} - 2mx\right) = 0$

    Solving the quadratic equation, we get

    $p_p = \frac{\frac{2E}{c} + \sqrt{\frac{4E^2}{c^2} - 8\left(\frac{E^2}{c^2} - 2mx\right)}}{4}$

    For the real value p_p, the discriminant is positive, Hence

    $\frac{4E^2}{c^2} = 8\left(\frac{E^2}{c^2} - 2mx\right)$

    $16mx = \frac{4E^2}{c^2} \Rightarrow x = \frac{E^2}{4mc^2}$

    But x << B, hence E << B

    $\Rightarrow x = \frac{B^2}{4mc^2}$
26. According to Bohr's postulates, in a hydrogen atom, a single electron revolves around a nucleus of charge +e. For an electron moving with a uniform speed in a circular orbit of a given radius, the centripetal force is provided by Coulomb force of attraction between the electron and the nucleus. The gravitational attraction may be neglected as the mass of electron and proton is very small. So,

    $mv^2/r = ke^2/r^2$ (where, $k = 1/4\pi\varepsilon_0$)

or $mv^2 = ke^2/r$.............(i)

where, m = mass of electron, r = radius of electronic orbit, v = velocity of electron

Again, by Bohr's second postulates

$mvr = nh/2\pi$

where, n = 1, 2, 3, ... or $v = nh/2\pi mr$

Putting the value of v in Eq. (i)

$m\left(\frac{nh}{2\pi mr}\right)^2 = \frac{ke^2}{r} \Rightarrow r = \frac{n^2h^2}{4\pi^2kme^2}$ ....(ii)

Kinetic energy of electron ,

$E_K = \frac{1}{2}mv^2 = \frac{ke^2}{2r}\left(\because \frac{mv^2}{r} = \frac{ke^2}{r^2}\right)$

Using Eq(ii), we get

$E_K = \frac{ke^2}{2}\frac{4\pi^2kme^2}{n^2h^2} = \frac{2\pi^2k^2me^4}{n^2h^2}$

Potential energy of electron,

$E_P = -\frac{k(e)\times(e)}{r} = -\frac{ke^2}{r}$

Using Eq(ii), we get

$E_P = -ke^2 \times \frac{4\pi^2kme^2}{n^2h^2} = -\frac{4\pi^2k^2me^4}{n^2h^2}$

Hence, total energy of the electron in the n^{th} orbit

$E = E_P + E_K = -\frac{4\pi^2k^2me^4}{n^2h^2} + \frac{2\pi^2k^2me^4}{n^2h^2}$

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

27. As n increases. deviation of light from straight direction increases thus the light spread out more and which result in decreasing intensity of bright fringes.

    In interference pattern the fringes are of equal width (dark and bright) and are of equal intensity and in diffraction the central maxima is brightest and its width is wider twice as compare to the other maxima and intensity of bands goes on decreasing as we move away from the Centre.

28. i. Mutual inductance is numerically equal to the induced emf in the secondary coil when the current in the primary coil changes by unity. Or **Mutual Inductance** is the interaction of one coils magnetic field on another coil as it induces a voltage in the adjacent coil.

    ii. Mutual inductance of a pair of coils, μ = 1.5 H

    Initial current, I_1 = 0 A

    Final current I_2 = 20 A

    Change in current will be: $\Delta I = l_2 - l_1$

    20 - 0 = 20 A

    and we know,

    $\Delta\phi = M\Delta I$,

    where, $\Delta\phi$ is change in magnetic flux

    $\Delta\phi = 1.5 \times 20 = 30$ Wb

    Hence, change in the flux linkage will be 30 Wb.

OR

    i. Flux, $\phi = NBA \cos\theta$

    $\theta = 0^o$,

    Thus $\phi_1 = NBA = 140 \times 0.09\& \times 5 \times 10^{-4} = 6.3 \times 10^{-3}$ Wb

    When coil is quickly removed, flux becomes zero i.e. $\phi_2 = 0$

    Thus,

    $\Delta\phi = \phi_2 - \phi_1 = 0 - 6.3 \times 10^{-3} = -6.3 \times 10^{-3}$ Wb

    ii. Let in time dt = 1s, the coil is quickly removed. So, induced emf,

    $e = \frac{-d\phi}{dt} = -\frac{(-6.3\times10^{-3})}{1} = 6.3 \times 10^{-3}$ V

Section D

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

Electrons oscillating in a circuit give rise to radiowaves. A transmitting antenna radiates most effectively the radiowaves of wavelength equal to the size of the antenna. The infrared waves incident on a substance set into oscillation all its electrons, atoms and molecules. This increases the internal energy and hence the temperature of the substance.

(i) **(d)** $v_g = v_X = v_m$

Explanation: All electromagnetic waves travel in vacuum with the same speed.

(ii) **(d)** cathode rays

Explanation: Cathode rays (beam of electrons) get deflected in an electric field.

(iii) **(b)** ionization chamber

Explanation: γ-rays are detected by ionization chamber.

OR

(d) Option (i)

Explanation: Everybody at a temperature T > 0 K emits radiation in the infrared region.

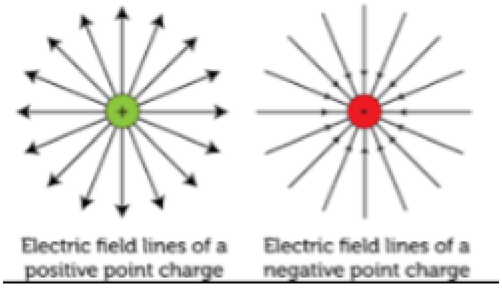
(iv) **(a)** 10^{14} Hz

Explanation: Size of particle = $\lambda = \frac{c}{v}$

$\nu = \frac{c}{\lambda} = \frac{3 \times 10^{10} \text{ cm s}^{-1}}{3 \times 10^{-4} \text{ cm}} = 3 \times 10^{14}$ Hz

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

A charge is a property associated with the matter due to which it experiences and produces an electric and magnetic field. Charges are scalar in nature and they add up like real numbers. Also, the total charge of an isolated system is always conserved. When the objects rub against each other charges acquired by them must be equal and opposite.



(i) **(c)** the actual transfer of electrons

Explanation: the actual transfer of electrons

(ii) **(d)** Option (ii)

Explanation: The glass rod gives electrons to silk when they are rubbed against each other.

(iii) **(a)** 1.97×10^{-8} N

Explanation: 1.97×10^{-8} N

(iv) **(c)** both electric and magnetic effects

Explanation: both electric and magnetic effects

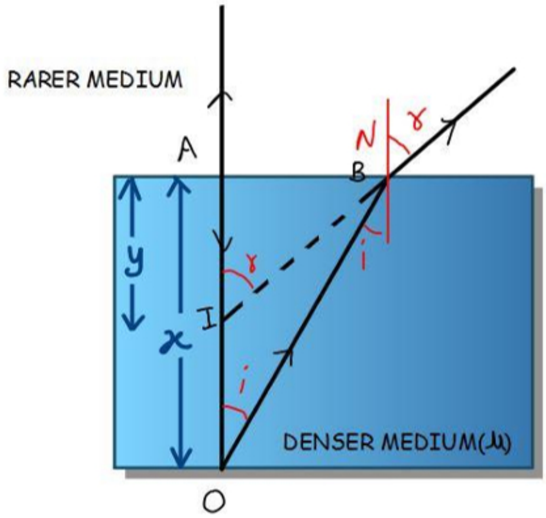
OR

(a) transfer of an integral number of electrons

Explanation: transfer of an integral number of electrons

Section E

31. i. Due to refraction of light



In $\triangle$OAB,

sin i = $\frac{AB}{OB}$

In $\triangle$IAB, sin r = $\frac{AB}{IB}$

According to Snell's law

$\frac{1}{\mu}$ = $\frac{\sin i}{\sin r}$ = $\frac{IB}{OB}$ When angles are small, OB $\approx$ OA and IB $\approx$ IA

μ = $\frac{OA}{IA}$ = $\frac{x}{y}$

Height through which object is raised = x - y

= x - $\frac{x}{\mu}$

= x $\left(1-\frac{1}{\mu}\right)$

ii. f_0 = 2 cm

f_e = 6.25 cm

L = v_0 + $|u_e|$ = 15 cm

v_e = -25 cm

$\frac{1}{V_e}-\frac{1}{u_e}=\frac{1}{f_e}$;

$\frac{1}{-25}$ - $\frac{1}{u_e}$ = $\frac{1}{6.25}$

u_e = -5 cm

Now, L = v_0 + |-5| = 15 cm

V_o = 10 cm

Now, $\frac{1}{f_o}$ = $\frac{1}{V_o}$ - $\frac{1}{u_o}$

u_0 = 2.5 cm

MP = $\frac{V_o}{u_o}\left[1+\frac{D}{f_o}\right]$

= -20

OR

As is clear from figure and difference between waves reaching P_1 from A is

$=2d\sin\theta+(u-1)l$

For principal maximum, path difference = 0

i.e., $2d\sin\theta+(\mu-1)l=0$

2d $=\sin\theta+(1.5-1)\frac{d}{4}=0, \sin\theta=\frac{-1}{16}$

$\therefore OP_1=(CO)\tan\theta\cong D\left(-\frac{1}{16}\right)$

For the first minimum, an angle θ_1, say,

path difference $=2d\sin\theta_1+0.5l=\pm\lambda/2$

$\sin\theta_1=\frac{\pm\lambda/2-0.5l}{2d}$

As diffraction occurs when d = λ,

$\therefore\sin\theta_1=\frac{\pm\lambda/2-\lambda/8}{2\lambda}=\pm\frac{1}{4}-\frac{1}{16}$

on the positive side, $\sin\theta_1 = +\frac{1}{4} - \frac{1}{16} = \frac{3}{16}$, on the negative side,

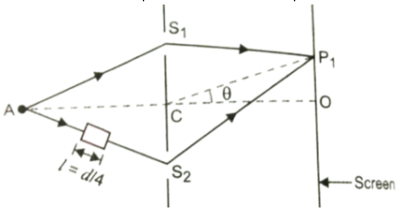
$\sin\theta_1' = -\frac{1}{4} - \frac{1}{16} = \frac{-5}{16}$

The first principal maximum on the positive side is at distance (above O)

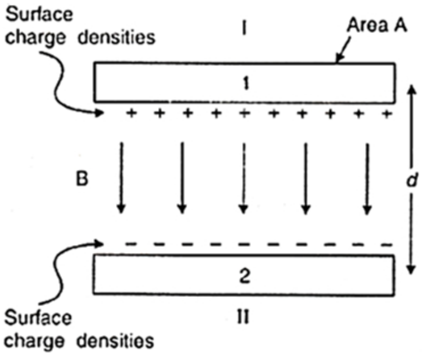
= D than $\theta_1 = D\frac{\sin\theta_1}{\sqrt{1-\sin^2\theta_1}} = \frac{D.3/16}{\sqrt{1-9/256}} = \frac{3D}{\sqrt{16^2-3^2}}$

On the negative side, the distance of first principal maximum (below O) will be

$= D\theta_1' = D\frac{\sin\theta_1'}{\sqrt{1-\sin^2\theta_1}} = \frac{D(-5/16)}{\sqrt{1-(5/16)^2}} = \frac{-5D}{\sqrt{16^2-5^2}}$



32. a. The capacitance C of a capacitor is defined as the ratio of the maximum charge Q that can be stored in a capacitor to the applied voltage V across its plates.



Electric field between the plates of capacitor

E = $\frac{\sigma}{\varepsilon_0} = \frac{\mathrm{Q}}{\mathrm{A}\varepsilon_0}$

$\therefore$ V = Ed = $\frac{\mathrm{Q}d}{\mathrm{A}\varepsilon_0}$

Capacitance, C = $\frac{\mathrm{Q}}{\mathrm{V}} = \frac{\varepsilon_0\,\mathrm{A}}{d}$

b. Ratio of capacitances

i. Capacitance equals the magnitude of the charge on each plate needed to raise the potential difference between the plates by unity.

ii. Capacitance without dielectric,

$C = \frac{A\varepsilon_0}{d}$

Capacitance when filled with dielectric having thickness $\frac{3d}{4}$

$C = \frac{A\varepsilon_0}{\left(d-t+\frac{t}{x}\right)}$

$= \frac{AE_0}{\left(d-\frac{3d}{4}+\frac{3d}{4\kappa}\right)}$ [As t = $\frac{3d}{4}$]

$= \frac{4\varepsilon_0 kA}{d(x+3)}$

Ratio $\frac{C'}{C} = \frac{A\varepsilon_0 4\kappa}{d(k+3)} \times \frac{d}{A\varepsilon_0}$

$= \frac{4\kappa}{(x+3)}$

OR

a. The work done in moving a charge from one point to another on an equipotential surface is zero. If the field is not normal to an equipotential surface, it would have a non zero component along the surface. This would imply that work would have to be done to move a charge on the surface which is contradictory to the definition of equipotential surface.

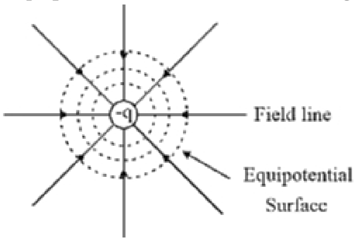
Mathematically

Work done to move a charge dq, on a surface, can be expressed as $dW = dq(\vec{E}\cdot\overrightarrow{dr})$

But dW = 0 on an equipotential surface

$\therefore \vec{E} \perp \overrightarrow{dr}$

Equipotential surfaces for a charge -q is shown alongside.

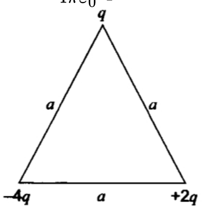


b. Work required to dissociate the system of three charges

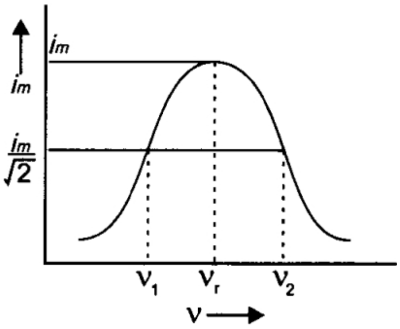
= - P.E. of the system

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

$= -\frac{1}{4\pi\varepsilon_0}\left[-4q^2+2q^2-8q^2\right] = +\frac{10q^2}{4\pi\varepsilon_0 a}$



33. **Condition for resonance to occur in series LCR ac circuit:** For resonance the current produced in the circuit and emf applied must always be in the same phase.



Phase difference (ϕ) in series LCR circuit is given by

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

For resonant ϕ = 0 ⇒ X_C - X_L = 0

or X_C - X_L

If ω_r is resonant frequency, then $X_C = \frac{1}{\omega_r C}$ and $X_c = \omega_r L$

$\frac{1}{\omega_r C} = \omega_r L \Rightarrow \omega_r = \frac{1}{\sqrt{LC}}$

Linear resonant frequency, $\nu_r = \frac{\omega_r}{2\pi} = \frac{1}{2\pi\sqrt{LC}}$

The graph of variation of peak current i_m with frequency is shown in fig.

Half power frequencies are the frequencies on either side of resonant frequency for which current reduces to half of its maximum value. In fig. v_1 and v_2 are half power frequencies.

Quality Factor (Q): The quality factor is defined as the ratio of resonant frequency to the width of half power frequencies.

i.e., $Q = \frac{\omega_r}{\omega_2 - \omega_1} = \frac{\nu_r}{\nu_2 - \nu_1} = \frac{\omega_r L}{R}$

OR

Device - transformer

ε_p = -N_p $\frac{\Delta\phi}{\Delta t}$ ...(i)

and emf induced in the secondary coil

= -N_S $\frac{\Delta\phi}{\Delta t}$ ...(ii)

From (i) and (ii)

$\frac{\varepsilon_S}{\varepsilon_p}$ = $\frac{N_S}{N_p}$ ...(iii)

$\frac{V_S}{V_p}$ = $\frac{\varepsilon_S}{\varepsilon_p}$ = $\frac{N_S}{N_p}$ = r (say) ...(iv)

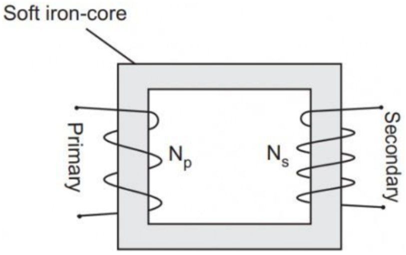
$V_p i_p$ = V_S i_S

$\therefore$ $\frac{i_S}{i_p}$ = $\frac{V_p}{V_S}$ = $\frac{N_p}{N_S}$ = $\frac{1}{r}$ ...(v)

In step up transformer, $N_s > N_p \rightarrow r > 1$;

So $V_S > V_p$ and $i_S < i_p$

i.e., step up transformer increases the voltage.



Two coils on separate limbs of the core

Principle: It is based on the principle of mutual inductance and transforms the alternating low voltage to alternating high voltage and in this the number of turns in secondary coil is more than that in primary coil. (i.e., $N_S > Np$).

Efficiency: Assuming no energy losses, the transformer is 100% efficient i.e. $I_P V_P = I_s V_s$