Class :XII || *AHSEC*|| Set-03 || Pre Board Examination , 2024-25
Subject : Physics ||Full marks : 70||Time : Three hours

(The figures in the margin indicate full marks for the questions)

Section A [Each question carries 1 mark]

1.The total electric flux through the faces of the cube with side of length 'a' if a charge q is placed at the centre of the cube is

(a) $q/ 8\varepsilon_0$ (b) q/ ε_0 (c) $q/6\varepsilon_0$ (a) $q/ 4\varepsilon_0$

ANSWER-(C)

2. If n cells each of emf ε and internal resistance r are connected in parallel, then the total emf and internal resistance will be

(a) ε , r/n (b) ε , nr (c) $n\varepsilon$, r/n (d) $n\varepsilon$, nr

ANSWER-(a)

3. cutting a bar magnet into half is like cutting a solenoid. We get two smaller solenoids

(a) with stronger magnetic properties.
(b) with weaker magnetic properties.
(c) with semi magnetic properties.
(d) none of these.

ANSWER-(b)

4. A transformer is employed to

(a) Obtain a suitable dc voltage
(b) Convert dc into ac
(c) Obtain a suitable ac voltage
(d) Convert ac into dc

ANSWER-(c)

5. 1eV is energy acquired by an electron when it is accelerated through potential difference of –

(a) 1 V (b) 10 V (c) 0.1 V (d) none of these

Ans - (a)

6. In a coil of self-induction 5 H, the rate of change of current is 2 A/s. Then emf induced in the coil is

(a) 10 V (b) 5 V (c) —5 V (d) —10 V

Given : Inductance of the coil (L) = 5 H and rate of change of current (dI/dt) = 2A/s. The induced e.m.f = -L(dI/dt) = -5 x 2 = -10 V

7. By what factor must the mass number change for the nuclear radius to become twice?

(a) 3^3 (b) 4^3 (c) 2^3 (d) 5^3

Ans- (c)

8.The spacing between field lines indicates its

____

(a)charge (b)position

(c)strength (d) none of above

9.The maximum current that can be measured by a galvanometer of resistance 40 Ω is 10 mA . It is converted into voltmeter that can read upto 50 V. The resistance to be connected in the series with the galvanometer is

(a) 2010 Ω (b) 4050 Ω (c) 5040 Ω (d) 4960 Ω

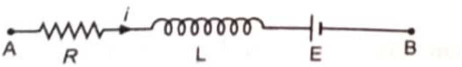
Given - G = 40Ω, I_g = 10 mA = 10×10^{-3} A, and V = 50V

The voltage during conversion is given by ⇒ V = i_g (G + R)

The above equation can be rewritten for R as

$$\Rightarrow R = \frac{V}{I_g} - G = \frac{50}{10 \times 10^{-3}} - 40 = 5000 - 40 = 4960\,\Omega$$

10. In the circuit diagram shown, R = 10 Ω , L = 5 mH , E = 10 V and ***i*** = 1A. The current is decreasing at the rate of 10^3 A/s. Then (V_A — V_B) at this instant is



(a) 10 V (b) 15 V (c) 20 v (d) 25 V

PD across inductor,

$$V_L = L\frac{di}{dt} = (5)(-1.0) = -5V$$

now, $V_a - iR - V_L = E = V_b$

$$\therefore V_{ab} = V_a - V_b = E + iR + V_L = 20 + (2)(10) - 5 = 35V$$

Ans-(c)

11. A plane electromagnetic wave travels in vacuum along z-direction. What can you say about the directions of its electric and magnetic field vectors? If the frequency of the wave is 30 MHz, what is its wavelength?

The electromagnetic wave travels in a vacuum along the z-direction.

The electric field (E) and the magnetic field (H) are in the x-y plane and mutually perpendicular.

Frequency of the wave, $v = 30 \text{ MHz} = 30 \times 10^6 \text{ s}^{-1}$

Speed of light in a vacuum, $c = 3 \times 10^8$ m/s

Wavelength of a wave is given as: $\lambda = \dfrac{c}{v} = \dfrac{3 \times 10^8}{30 \times 10^6} = 10$ m

Or

The oscillating electric field of an electromagnetic wave is given by:

$E = 30 \sin [2 \times 10^{11} t + 300 \pi x] \text{ Vm}^{-1}$

(a) Obtain the value of the wavelength of the electromagnetic wave.

(b) Write down the expression for the oscillating magnetic field.

(a) Given equation is $E_y = 30\sin [2 \times 10^{11} t + 300\pi x] \text{Vm}^{-1}$

Comparing with standard equation $E_y = E_0 \sin(\omega t + kx) \text{Vm}^{-1}$, we get

$$E_0 = 30 \text{ Vm}^{-1}, \omega = 2 \times 10^{11} \text{ rad s}^{-1}, k = \frac{2\pi}{\lambda} = 300\,\pi \text{ m}^{-1}$$

$$\therefore \quad \text{Wavelength, } \lambda = \frac{2\pi}{300\pi} \text{ m} = \frac{1}{150} \text{ m} = 6 \cdot 67 \times 10^{-3} \text{ m}$$

(b) The wave is propagating along X-axis, electric field is oscillating along Y-axis, so the magnetic field must oscillate along Z-axis.

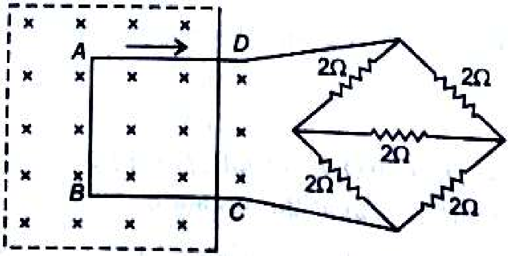
$$\therefore \quad B_0 = \frac{E_0}{C} = \frac{30}{3 \times 10^8} = 10^{-7} \text{ T.}$$

$\therefore$ Equation of oscillating magnetic field is

$$B_Z = B_0 \sin(\omega t + kx)\, T$$

$$\Rightarrow B_z = 10^{-7} \sin(2 \times 10^{11} t + 300\,\pi x)\, T$$

18. A metallic square loop ABCD of size 15 cm and resistance 1.0 Ω is moved at a uniform velocity of v m/s, in a uniform magnetic field of 2 T, the field lines being normal to the plane of the paper. The loop is connected to an electrical network of resistors, each of 2 Ω. Find the speed of the loop, for which 2 mA current flows in the loop.



The circuit ABCD is forming a balanced Wheatstone bridge.

Now, resistance of the circuit,

$$\frac{1}{R} = \frac{1}{(2+2)} + \frac{1}{(2+2)} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$$

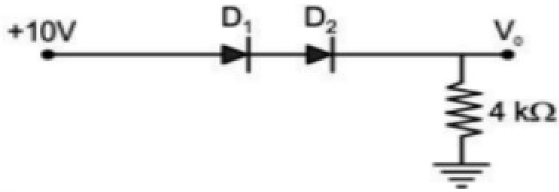
$R = 2\Omega$ and resistance of coil is 1Ω

$\therefore$ Net resistance, $R. = 2 + 1 = 3\Omega$

Motional emf, $\varepsilon = Blv$

$\therefore$ Current $I = \frac{\varepsilon}{R} = \frac{2 \times 0.15 \times 0.1}{3} = 0.01A$

19. The threshold voltage for diodes D_1 and D_2 are 0.3 V and 0.7 V respectively. Determine current in the circuit.Find V_0



$V_{D_1} = 0.3$ V $\quad\quad$ $V_{D_2} = 0.7$ V

So $V_o = 10 - 0.3 - 0.7 = 9$ V

So $10 - V_{D_1} - V_{D_2} = V_o$

$I_D = V_o/R = 9/(4 \times 10^{-3}) = 2.25$ mA

Or

Calculate the orbital period of the electron in the first excited state of hydrogen atom.

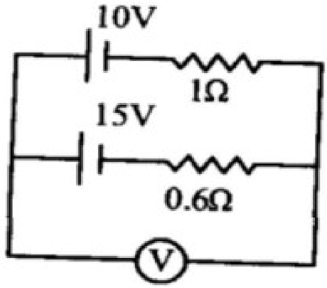
20 .Violet light is incident on a converging lens of focal length f. State with reason, how the focal length of the lens will change, if the violet light is replaced by red light.

We know $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\quad$ $f \propto \frac{1}{(\mu - 1)}$ and $\mu_v > \mu_R$

The increase in refractive index would result in decrease of focal length of lens.

Hence, we can say by replacing red light with violet light, decreases the focal length of the lens used.

21. A 10 V battery with internal resistance 1Ω and a 15V battery with internal resistance 0.6Ω are connected in parallel to a voltmeter as shown in the figure. The reading in the voltmeter will be close to



As the two cells oppose each other hence,
the effective emf in closed circuit is $15 - 10 = 5V$
and net resistance is $1 + 0.6 = 1.6\,\Omega$

Current in the circuit, $\frac{\text{effective emf}}{\text{total resistance}} = \frac{5}{1.6}A$

The potential difference across voltmeter will be same as the terminal voltage of either cell. Since the current is drawn from the cell of $15\,V$

$\therefore V_1 = E_1 - Ir_1 = 15 - \frac{5}{1.6} \times 0.6 = 13.1\,V$

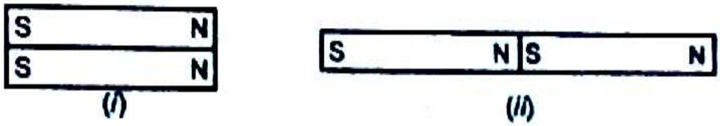
22. (a) Calculate the force per unit length acting between two parallel wires of infinite extent separated by a distance 2 cm each carrying current of 4 A .

$$F_l = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d}$$

When $I_1 = I_2 = 4A$ $d = 2\text{ cm} = 2 \times 10^{-2}$ m

$$F_l = \frac{\mu_0}{4\pi}\frac{2I_1 I_2}{d} = 10^{-7} \times \frac{2 \times 4 \times 4}{2 \times 10^{-2}} = 16 \times 10^{-5}\ \text{Nm}^{-1}$$

(b) Two identical bar magnets of magnetic dipole moment M each are arranged as shown in the figure (i) and figure (ii).

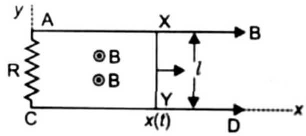


What will be the dipole moment in each case?

In fig(i) Dipole moment = 2M x L = 2ML

In fig(iI) Dipole moment = M x 2L = 2ML

23. A conducting wire XY of mass m and negligible resistance slides smoothly on two parallel conducting wires as shown in figure. The circuit has a resistance R due to AC. AB and CD are perfect conductors. There is a magnetic field B =B(t) $\hat{k}$



(a) Write down equation for emf induced in the wire XY.

(b) Find the current flowing through R .

(i) Let the wire be at $x = x(t)$ at time t.

Flux = $B(t)\, l\, x(t)$

$$E = -\frac{d\phi}{dt} = -\frac{dB(t)}{dt} l x(t) - B(t) l . v(t)$$

(ii) the current flowing through R .

$$I = \frac{E}{R} = -\frac{dB(t)}{R\, dt} l x(t) - B(t) l . v(t)$$

24. The primary coil of an ideal step-up transformer has 100 turns and the transformation ratio is also 100. The input voltage and power are 220 V and 1100 W respectively. Calculate

(a) number of turns in the secondary coil

(b) the current in the primary coil and secondary coil

(c) voltage across the secondary coil

(d) power in the secondary coil

Given, $N_1 = 100, k = 100, V_1 = 220V, P_1 = 1100W$

(a) As, $k = \frac{N_2}{N_1}$ $N_2 = kN_1 = 100 \times 100 = 10000$

(b) $P_1 = V_1 I_1 \Rightarrow I_1 = \frac{P_1}{V_1} = \frac{1100}{220} = 5A$

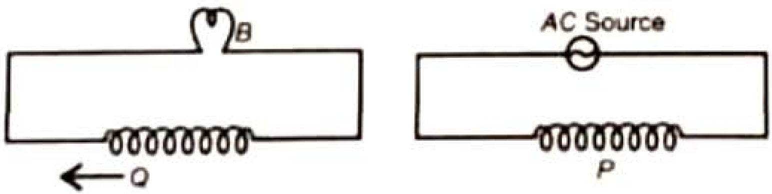
$\frac{I_1}{I_2} = k \Rightarrow I_2 = \frac{I_1}{k} = \frac{5}{100} = 0.05\text{ A}$

(c) $\frac{V_2}{V_1} = k \Rightarrow V_2 = kV_1; V_2 = 100 \times 220 = 22000$

(d) $P_2 = V_2 I_2 \Rightarrow P_2 = 22000 \times \frac{5}{100}; P_2 = 1100\text{ W}$

Or

A coil Q is connected to low voltage bulb B and placed near another coil P as shown below . Give reasons to explain the following observations:



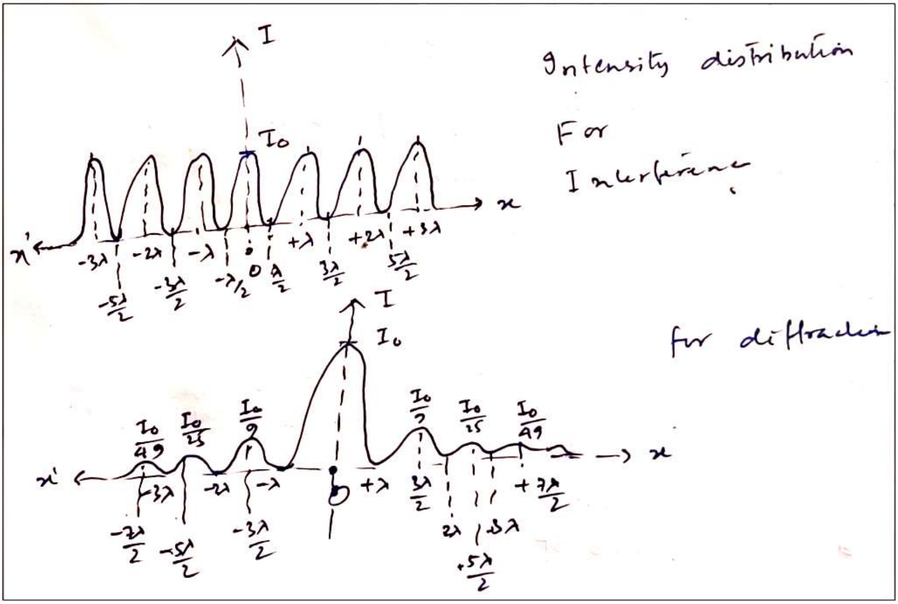
(a) The bulb B lights

(b) Bulb gets dimmer if the coil Q is moved towards left.

(a) The bulb B lights due to induced current in coil Q because of change in magnetic flux linked with it on a consequence of continuous variation of magnitude of alternating current flowing in P.

(b) When coil Q moves towards left the rate of change of magnetic flux linked with Q decreases and so lesser current is induced in Q.

25. (a) Draw the intensity pattern for single slit diffraction and double slit interference.

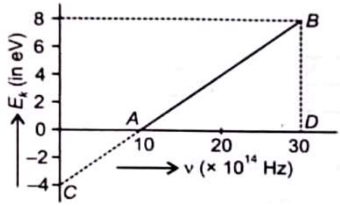


(b) State two differences between interference and diffraction patterns.

Difference :

(i) Interference fringes are of same intensity whereas diffraction fringes are of different intensity.

26. (a) Given below is the graph between frequency (ν) of the incident light and maximum kinetic energy (E_k) of emitted photoelectrons. Find the values of (i) threshold frequency and (ii) work function from the graph.



(i) Threshold frequency,
$v_0 = 10 \times 10^{14} Hz = 10^{15} Hz$
(ii) At, $v = 0$, $E_k = h \times 0 - \phi_0 = -\phi_0$
or $\phi_0 = -E_k = -(-4eV) = 4eV$

(b) In photoelectric effect, why should the photoelectric current increases as the intensity of monochromatic radiation incident on a photosensitive surface is increased? Explain.

Increase in intensity of incident radiation corresponds to an increase in the number of incident photons, resulting an increase in the number of photo electrons emitted.

27. (b) Calculate the wavelength of H_α line in Balmer series of hydrogen atom, given Rydberg's constant R = 1.0947×10^7 m $^{-1}$.

H_α line is first line of Balmer series for which n=3

$$\lambda = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R \times \frac{5}{36}$$

$$\lambda = \frac{36}{5R} = \frac{36}{5 \times 1.1 \times 10^7} m = 6.545 \times 10^{-7} m$$

SECTION - E [Each question carries 5 marks]

28(b)

P and Q are two parallel plates. The distance between them is d. A dielectric material of thickness t(t < d) and dielectric constant K is inserted in between the plates.

In the remaining space (d - t) there is air.

The electric field in the dielectric-filled portion = $E_1 = \frac{\sigma}{\varepsilon_0 K}$

The electric field in the air-filled portion = $E_2 = \frac{\sigma}{\varepsilon_0}$

The potential difference between the plates = V

$$V = E_2 \times (d - t) + E_1 \times t$$

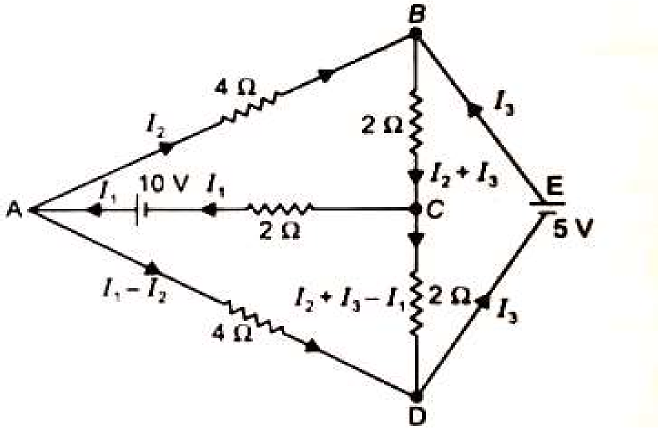
$$\text{Or, } V = \frac{\sigma}{2\varepsilon_0} \times (d - t) + \frac{\sigma}{\varepsilon_0 K} \times t$$

$$\text{Or, } V = \frac{q}{A\varepsilon_0} \times \left[(d - t) + \frac{t}{K}\right]$$

$$\text{Now, capacitance} = C = \frac{q}{V}$$

$$\text{Or, } C = \frac{\varepsilon_0 A}{(d - t) + \frac{t}{K}}$$

29.(b) Determine the current in each branch of the network shown below



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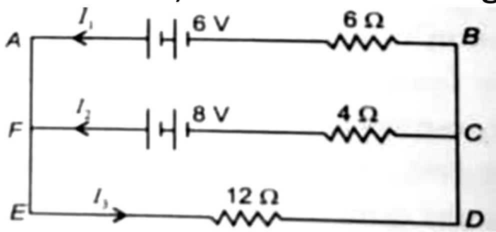
Or

In the network shown here, find the following:



(a) Currents I_1, I_2 and I_3

(b) Terminal potential difference of each battery.

Consider 6 Ω to be the internal resistance of 6 V battery and 4 Ω to be internal resistance of 8 V battery.

30.(b) A compound microscope consists of an objective lens of focal length 2.0 cm and an eyepiece of focal length 6.25 cm separated by a distance of 18 cm. How far from the objective lens should an object be placed in order to obtain the final image at the least distance of distinct vision (25 cm)? Find the magnifying power of the microscope.

$f_0 = 2$ cm, $f_e = 6.25$cm. $v_e = -25$ cm, $u_e = ?$

(a) $\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{-25} - \frac{1}{6.25} = \frac{-1-4}{25} = \frac{-5}{25}$, $u_e = \frac{-25}{5} = -5$ cm.

$v_0 = 18 - 5 = 13$ cm.

$\frac{1}{u_0} = \frac{1}{v_0} - \frac{1}{f_0} = \frac{1}{13} - \frac{1}{2} = \frac{2-13}{26} = \frac{-11}{26}$ $u_0 = \frac{-26}{11} = 2.36$ cm.

magnifying power $m = \frac{v_0}{|u_0|}\left(1 + \frac{d}{f_e}\right) = \frac{10}{2.36}\left(1 + \frac{25}{6.25}\right) = 21.18$