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Answers Key:

Case Study Questions

1. (i) Since, diamagnetic subtances gets magnetised in opposíte direction, therefore it will try to reduce the magnctíc field in the direction of magnetising field. Hence, diamagnetic material is oriented towards the region in which magnetising field is weaker.
(ii) Given, B = 6.28 $\times 10^{-2}$ T
H = 100 Am^{-1}
$\therefore$ Magnetic permeability.
$\mu = \frac{B}{H} = \frac{6.28\times10^{-2}}{100}$
= 6.28 $\times 10^{-4}$ TmA^{-1}
Relative magnetic permeability,
$\mu_r = \frac{\mu}{\mu_0} = \frac{6.28\times10^{-4}}{4\pi\times10^{-7}} = 5 \times 10^2 = 500$
$\therefore$ Magnetic susceptibility
$X_m = \mu_r - 1 = 500 - 1 = 499$
(iii)

Diamagnetic Substances	ParamagneticSubstances
These substances are feebly repelled by a magnet.	These substances are feebly attracted by a magnet.
In non-uniform magnetic field, the diamagnetic substances are attracted towards the weaker fields, i.e. they move from stronger to weaker magnetic field.	In non-uniform magnetic field, paramagnetic substances move from weaker to stronger part of the magnetic field slowly.
Their permeability is less than one (μ <1).	Their permeability is slightly greater than one (μ >1).

(iv) There are some ferromagnetic materials in which the magnetisation disappears on the removal of external magnetic field, e.g. soft iron. Such materials are called soft magnetic materials or soft ferromagnets. e.g. Iron, cobalt, nickel, gadolinium, etc.

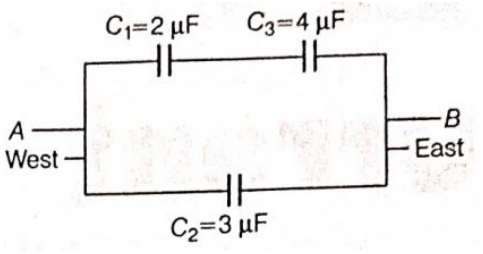
2. 1.(b) It measures the emf of a cell very accurately
2.(a) decreasing potential gradient along the wire.
3.(b) a condition of no current flow through the galvanometer
4.(d) 3: 1

5 Marks

3. (a) The values displayed by Ashok are:
(i) The presence of mind.
(ii) Higher degree of general awareness.
(iii) Convincing capacity
(b) When the current was passed through, the magnetic flux linked through the bird changed and so induced current flew in the bird's body. Its wings due to opposite current experienced mutual repulsion and the bird flew away.

4. The supply frequency and the natural frequency are equal at resonance condition in the circuit.
Given Resistance of the resistor, R = 20 Ω
Given Inductance of the inductor, L = 1.5 H
Given Capacitance of the capacitor , C = 35 μF = 30 x 10^{-6} F
An AC source with a voltage of V = 200 V is connected to the LCR circuit,
We know that the Impedance of the above combination can be calculated by the following relation,
$Z = \sqrt{R^2 + (X_L - X_C)^2}$
At resonant condition in the circuit , $X_L = X_C$
Therefore , Z = R = 20 Ω
We know that Current in the network is given by the relation :
$I = \frac{V}{Z} = \frac{200}{20} = 10A$
Therefore, the average power that is being transferred to the circuit in one full cycle :
V I = 200 x 10 = 2000 W

5. (i) When C_1 and C_3, are in series and C_2, is in parallel as shown, then



$C_{eq} = \frac{2\times4}{2+4} + 3 = \frac{4}{3} + 3 = \frac{13}{3}\mu F$
(ii) Maximum value of the equivalent capacitance is obtained when all capacitors are connected in parallel combination.

i.e. $C_{eq} = C_1 + C_2 + C_3$
$= 2 + 3 + 4 = 9\ \mu F$
or $C_{eq} = C_{max} = 9\ \mu F$
and minimum value is obtained, when all capacitors are connected in series combination,
i.e. $C_{eq} = \frac{C_1 \times C_2 \times C_3}{C_1C_2 + C_2C_3 + C_3C_1}$
$= \frac{2 \times 3 \times 4}{2 \times 3 + 3 \times 4 + 4 \times 2}$
or $C_{eq} = C_{min} = \frac{12}{13}\mu F$

3 Marks

6. Potential gradient,
$K = \frac{1.1}{440}$ = 0.0025 V/cm.
Potential difference across R = 0.0025 x 220 = 0.550 V
Error in voltmeter reading = reading in voltmeter - reading of potentiometer
= 0.5 - 0.550
= - 0.05 V

7. Here, $C = 80\ \mu F = 80 \times 10^{-6} F, L = 5.0 H$
$R = 40\Omega,\ E_v = 240\ V$
(i) $\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5.0 \times 80 \times 10^{-6}}} = \frac{10^3}{20}$
(ii) At resonating frequency, $Z = R = 40\Omega$
$I_v = \frac{E_v}{Z} = \frac{240}{40} = 6A$
(iii) $V_C = I_v\ .\ X_C = 6 \times \frac{1}{\omega C} = 6 \times \frac{1}{50 \times 80 \times 10^{-6}}$
$= 1500\ V$

8. (i) The total charge of the capacitor remains conserved on introduction of dielectric slab. Also, the capacitance of capacitor increases to K times of original values.
$\therefore$ CV = C′ V ′= (KC) V′ $\Rightarrow V' = \frac{V}{K}$
$\therefore$ New electric field,
$E' = \frac{V'}{d} = \left(\frac{V/K}{d}\right) = \left(\frac{V}{d}\right)\frac{1}{k} = \frac{E}{K}$
$\therefore$ On introduction of dielectric medium, new electric field E′ becomes $\frac{1}{K}$ times of its original value (decrease).
(ii) The thickness of dieletric slab is $\frac{d}{2}$, i.e. $t = \frac{d}{2}$
The capacitance of a capacitor due to dielectric slab,
$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{K}}$
$= \frac{\varepsilon_0 A}{d - \frac{d}{2} + \frac{d}{2K}} = \frac{2\varepsilon_0 A}{d\left(1 + \frac{1}{K}\right)}$

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9. Initial current, I_1 = 5.0 A
Final current, I_2 = 0.0 A
Change in current dl = $I^{-1} - I^{-2}$ = 5A
Time taken for the change, t = 0.1 s
Average emf, e = 200 V
For self-inductance (L) of the coil, we have the relation for average emf as:
$e = L\frac{di}{dt}$
$L = \frac{e}{\frac{di}{dt}}$
$= \frac{200}{\frac{5}{0.1}} = 4H$
Hence, the self induction of the coil is 4 H.

10. Given, height, h = 300 m, $V = \frac{\text{volume}}{\text{second}} = 100\ \text{m}^3/\text{s}$
η = 60%, g = 9.8 m/s^2
Electric power = ?
Hydroelectric power $= \frac{\text{Work}}{\text{Time}}$
$= \frac{\text{Force} \times \text{Displacement}}{\text{Time}}$
= Force x Velocity
= Pressure x Area x Velocity
= Pressure x Volume = p x V
$\therefore$ Power available $= \frac{60}{100}pV = \frac{3}{5} \times h \times \rho \times g \times V$
$= \frac{3}{5} \times 300 \times 10^3 \times 9.8 \times 100$ [$\because$ density of water = 10^3 kg/m^3)
= 1.764 x 10^8 = 176.4 MW

11. When initially K_1 is closed and K_2 is open then capacitor C_1 and C_2 are connected in series with battery and have equal charge on capacitors C_1 and C_2 are,
$Q_1 = Q_2 = q = \left(\frac{C_1C_2}{C_1+C_2}\right)E$
$= \left(\frac{6C \times 3C}{6C+3C}\right) \times 9 = 18\mu C$
$Q_1 = Q_2$ = 18 μC and
Q_3 = 0
Now, when K_1 is opened and K_2 is closed, the battery and capacitor C_1, are disconnected from the circuit. The charge in capacitor C, will remain constant equal to $Q_1 = Q_2$ = 18 μC. The charged capacitor C_2 now connects in parallel with uncharged capacitor C_3, consider common potential of parallel combination at V′. Then, $C_2V' + C_3V' = Q_2$
$\Rightarrow V' = \frac{Q_2}{C_2+C_3} = \frac{18}{3C+3C} = 3V$
Hence, Q_2' = 3CV′ = 9 μC
Q_3' = 3CV′ = 9 μC

$Q_1' = 18\mu C$

12. (A) Heat produced,

$H = \frac{V^2}{R}t$

$\Rightarrow H \alpha V^2$

$\frac{H'}{H} = \frac{V'^2}{V^2}$

$\frac{9H}{H} = \frac{V'^2}{V^2}$

$V'^2 = 9V^2$

$V' = 3V$

So, potential difference is increased by a factor of 3.

(B) Current,

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

$I = \frac{12}{4+2} = \frac{12}{6} = 2\ A$

Ammeter reading = 2 A

Potential difference,

V = E - Ir

V = 12 - 2 x 2

= 12 - 4

V = 8V

Voltmeter reading = 8V.

2 Marks

13. 1:4

14. The position of stable equilibrium corresponds to θ = 0°. The position of unstable equilibrium corresponds to θ = 180°

$\therefore$ Work done $= \int_{\theta=0^\circ}^{\theta=180^\circ} pE\sin\theta d\theta = pE[-\cos\theta]_{0^\circ}^{180^\circ} = 2pE$

15. R_0 = 5 Ω, R_{100} = 5.23 Ω and R_t = 5.795 Ω

Now, $t = \frac{R_t - R_0}{R_{100} - R_0} \times 100, \quad R_t = R_0(1+\alpha t)$

$= \frac{5.795-5}{5.23-5} \times 100$

$= \frac{0.795}{0.23} \times 100 = 345.65^\circ C$

16. Magnetic field at axis,

$B = \frac{\mu_0}{4\pi}\frac{2Mr}{(r^2-l^2)^2}$

M = 2ml

Given: 2l = 0.10

$B = \frac{10^{-7}\times 2\times 12\times 0.10\times 0.2}{[(0.2)^2-(0.05)^2]^2}$

B = 3.4 x 10^{-5} T.

17. Here l = 6A

N = 200

Flux per turn = 12 x 10^{-4} Wb

Total flux, Φ = 200 x 12 x 10^{-4}

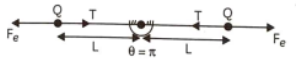
Φ = 0.24 Wb

As Φ = MI

$\Rightarrow M = \frac{\phi}{I} = \frac{0.24}{\sigma} = 0.04H.$

Multiple Choice Question

18. (b) Only magnetic field
19. (b) the coil moving in a time varying magnetic field
20. (a) 1 MeV
21. (b) 4
22. (c) determination of electric field due to symmetric charge distributions
23. (a) F
24. (d) no force experienced.
25. (c) MB (1 - cos θ)
26. (b) $\frac{\omega l}{R}$
27. Due to electrostatic force of repulsion between the balls, the string would become horizontal. Therefore, angle between the two small balls is 180°. From free body diagram, the tension in the string will be equal to the electrostatic force of repulsion,



$\Rightarrow T = F_e$

$\Rightarrow T = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q\times Q}{(2L)^2}$

$\Rightarrow T = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q^2}{4L^2}$

28. $E = -\frac{dV}{dx}$

$= -\frac{d(3+2x^2)}{dx} = -4x$

The value varies in x direction hence the electric field in the given region is non-uniform along x-axis.

29. (d) 4
30. **Explanation:**

As magnetic field at equator is antiparallel to magnetic field at pole.

31. In a non-uniform magnetic field magnetic needle experiences a torque and force both. Torque is experienced in both uniform and non-uniform magnetic field. While force is zero in uniform magnetic field

32. When coil A moves towards coil B with a constant velocity, the rate of change of magnetic flux through coil A due to coil B remains constant. As a result, a constant current is induced in coil A, flowing in the same direction as the current in coil B, according to Lenz's law.

33. **Explanation:**
We know that,

$$I = \frac{V}{Z}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$$Z = \sqrt{R^2 + \left(\frac{1}{2\pi f C}\right)^2}$$

$$Z = \sqrt{(300)^2 + \left(\frac{1}{2\pi \times 50 \times \frac{4}{\pi} \times 10^{-6}}\right)^2}$$

$Z = \sqrt{(300)^2 + (400)^2}$

$Z = 500\Omega$

from eqn. (i),

$I = \frac{V}{Z}$

$I = \frac{200\ V}{500\Omega}$

$I = 0.4\ A$

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