ASSIGNMENT 3 - ANSWERS

1. (a) 0.4 Nm
2. (c) is zero, otherwise there would be a field falling as $1/r^3$ at large distances outside the toroid.
3.(d). Equal
4. (b) 327^0 C

$$\frac{x_1}{x_2} = \frac{T_2}{T_1}$$

$$\frac{x_1}{0.5\,x_1} = \frac{T_2}{273+27}$$

$T_2 = 600\,K = 600 - 273 = 327^0$ C

5.(b) $\frac{2}{3}$ Am $^{-1}$

Here M_1 = 8 Am^{-1} and B_1 = 0.6 T

$T_1 = 4$, B_2 = 0.2 T, $T_2 = 16\,K$

Then for Paramagnetic materials, Magnetisation, M = (CB/T) from Curies law

Now in first case ,

$$M_1 = \frac{CB_1}{T_1}$$

secondly

$$M_2 = \frac{CB_2}{T_2}$$

$\frac{M_1}{M_2} = \frac{B_1}{B_2}\,x\,\frac{T_2}{T_1}$

$\frac{M_1}{M_2}$ = (0.6/0.2) x (16/4)

$$\frac{8}{M_2} = 3\,x\,4$$

Hence $M_2 = \frac{2}{3}$ Am $^{-1}$

6.$(d) Both\ WA^{-1}m^{-1}$ and NA^{-2}

7. (d) Attract N1 strongly, N2 weakly and repel N3 weakly.

1 MARK

8. When a bar magnet of magnetic moment (M = m2L) is cut into two equal pieces transverse to its length, its (i) the pole strength remains unchanged ii) the magnetic moment is halved.

9. μ is < 1 and > 0, so magnetic material is diamagnetic.

10. Iron is a ferromagnetic substance while and copper is diamagnetic, the susceptibility of iron is much larger.

11. The magnetic field lines prefer to pass through iron than air because the permeability of iron is much larger than air.

12. Two Characteristics Properties

- High magnetic susceptibility
- High permeability

2 MARKS

13. The magnetic moment of each half bar magnet is M /2 but oppositely directed, so net magnetic moment of combination $\frac{M}{2}$ - $\frac{M}{2}$ =0 (zero).

14. According to Gauss's Law in magnetism, the net magnetic flux through a closed surface is Zero. It signifies that in magnetism, isolated monopoles do not exist.

15. M = mL

New magnetic moment is M' = m (2R)

Relation between R and L

π R = L

R = L/ π

M'= m (2L/ π)

16(A). Place a compass needle at the given point .If it stays in the North-South direction, then the magnetic field is due to earth. If the needle points along any direction other than North –South, then the field is due to some current carrying conductor. If the current is switched off, the needle will orient itself along the North-South direction.

16 (B). (a) Case-1 because for lowest potential energy configuration, magnetic moment should be parallel.

(a) Case-2 because stability is inversely proportional to potential energy.

17. The susceptibility of a paramagnetic substance is inversely proportional to the absolute temperature. X a 1/T.

$\chi = c\frac{\mu_0}{T}$

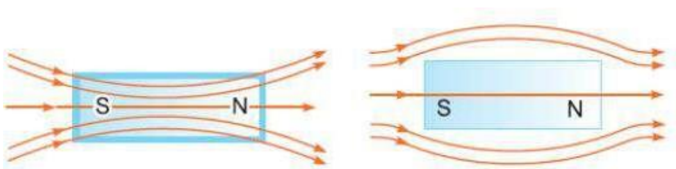
i.e. χ x T = Constant , Given T1 = 300 K

$$\frac{x_1}{x_2} = \frac{T_2}{T_1}$$

$$T_2 = \frac{x_1}{x_2} \quad T_1$$

$$= \frac{1.2 \times 10^5}{1.44 \times 10^5} X\ 300 = 250\ K$$

18. This distinguishing feature is because of the difference in their relative permeability. Relative permeability is the ratio of the permeability of a specific medium to the permeability of free space. The relative permeability of diamagnetic substance is less than 1, so the magnetic lines of force do not prefer passing through the substance whereas the relative permeability of paramagnetic substance.



Paramagnetic substance (i) Diamagnetic substance (ii)

19.The material which has relative permeabilities slightly greater one are paramagnetic whereas the material which has relative permeabilities slightly lesser than one are diamagnetic.

A → Paramagnetic

B → Diamagnetic

3 MARKS

20. (i) Direction of magnetic moment M of the current loop is perpendicular to the plane of the paper and directed inward. (ii) Torque acting on the current loop is a) maximum when M is perpendicular to B b) minimum when M is parallel to B.

21. **(**i) Magnetic field lines start from a North Pole and end on a South Pole. ii) Magnetic field lines form closed loops iii) Magnetic field lines do not intersect each other.

22. r = MB sin θ

M = $\frac{r}{Bsin\theta}$ = $\frac{4X10^{-2}}{0.1 sinsin\, 30}$ = 0.8 JT^{-1}

23. (i) W = MB (cos$\theta 1 - cos\theta 2$)

= 6 X 0.44 X (cos 60 – cos 90)

= 1.32J

(ii) W = 6 X 0.44 X (cos 60 – cos 180)

= 3.96 J

24. The time period of oscillation of the magnet is $T = 2\pi\sqrt{\frac{I}{MB}}$

But $I = \frac{ML^2}{12}$

When the bar magnet is cut into 2 equal pieces, perpendicular to its length, then moment of inertia of each piece of magnet about an axis perpendicular to length, passing through its centre is

$$I' = \frac{(L/2)^2}{12 X 2} = \frac{ML^2}{12}\ \frac{1}{8}$$

Also, magnetic dipole moment M'=M/2

Its time period of oscillation is $T' = 2\pi\sqrt{\frac{I'}{M'B}} = \pi\sqrt{\frac{I}{MB}}$

25. The pole strength of a magnet depends on i) its area of cross section ii) nature of its material i) its state of magnetisation

26. r = MB sin θ

Also r = Iα

MB sin θ = Iα

MB θ = Iα for small angle

$$\alpha = \frac{MB\theta}{I}$$

But $\alpha = \omega^2\ \theta$

So $\omega = \sqrt{\frac{MB}{I}}$

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

27. Given T1 = 280 K

$H_1 = 2 \times 10^3\ Am^{-1}$

$I_1 = 4.8 \times 10^{-2}\ Am^{-1}$

Using the relation,

$$x_1 = \frac{I_1}{H_1}$$

$x_1 = \frac{4.8 \times 10^{-2}}{2 \times 103}$ = 2.4 x 10^{-5}

Now, according to the Curie's law, X a 1/T.

$\frac{x_1}{x_2} = \frac{T_2}{T_1}$ T2 = 320 K

$x_2 = \frac{280}{320}$ x 2.4 x 10^{-5} = 2.1×10^{-5}

Now, the intensity of magnetisation,

$$I_2 = X_2 H_2$$

Since, H is independent of the temperature, i.e. $H_1 = H_2$

$I_2 =$ (2.1×10^{-5}) x (2 x 10^3) = 4.2 x $10^{-2\,2}$ Am^{-1}

5 MARKS

28. Consider a magnetic dipole (or a bar magnet) SN of length 2l having South Pole at S and North Pole at N. The strength of south and north poles are – qm and + qm respectively.

Magnetic moment of magnetic dipole m = qm 2l, its direction is from S to N.

Consider a point P on the axis of magnetic dipole at a distance r from mid-point O of dipole.

The distance of point P from N-pole, r1= (r – l).

The distance of point P from S-pole, r2= (r + l)

Let B1 and B2 be the magnetic field intensities at point P due to north and south poles respectively. The directions of magnetic field due to North Pole is away from N-pole and due to South Pole is towards the S-pole. Therefore,

$B_1 = \frac{\mu_0}{4\pi} \frac{q_m}{(r-l)^2}$ from N to P and

$B_2 = \frac{\mu_0}{4\pi} \frac{q_m}{(r+l)^2}$ from P to S

$B_1 > B_2$ and direction of resultant is from N to P and magnitude is given by

$B = B_1 - B_2 = \frac{\mu_0}{4\pi} \frac{2(qm\, 2l)}{(r^2-l^2)2}$

But qm 2l =M magnetic dipole moment

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

For a short dipole

$$B = \frac{\mu_0}{4\pi} \frac{2M}{r^3}$$

a. If L is the length of the wire

L =N X 2πR = N’ X 2πR/2

No of turns in the new coil N’ = 2N

Original magnetic moment = M = NIA = NI X πR^2

New magnetic moment M’ = N’ I A’ = 2NI X $(\pi R/2)^2$

M’/M =1/2

29. If magnetic compass of dipole moment m is placed at angle θ in uniform magnetic field, and released it experiences a restoring torque

Restoring torque, r = – magnetic force × perpendicular distance = – qmB. (2a sin θ),

τ = – mB sin θ, where qm = pole strength, m = qm.2a (magnetic moment)

Negative sign shows that restoring torque acts in the opposite direction to that of defecting torque. In equilibrium, the equation of motion

$$I \frac{d^2\theta}{dt^2} = MB\theta \quad \text{as } \theta \text{ is very small}$$

$$\frac{d^2\theta}{dt^2} = - \frac{MB}{I} \theta$$

$$\frac{d^2\theta}{dt^2} = - \omega^2 \theta \qquad \alpha = -\omega^2 \theta$$

It represents the simple harmonic motion with angular frequency ω

Expression for Time period:

We have, $\omega^2 = - \frac{MB}{I}$

But T $= \frac{2\pi}{\omega} = 2\pi \sqrt{I/MB}$

Assertion and Reason

30.(d) moving charge, electron, current carrying wire, naturally occurring magnet all these can create magnetic field.

31.(a) Stationary charge doesn't get affected by magnetic field, moving charge creates magnetic field.

32.(a) If F⊥V, at all instants then motion will be circular.

33.(b) For velocity selector the electrons can pass undeflected, when velocity and magnetic field are parallel , in that case force can be zero, both are correct but reason is not correct explanation of assertion.

34.(a) F = q E+ q(v × B) this is called Lorentz force.

Due to electric field, acceleration a $=\frac{qE}{m}$, hence velocity will not remain constant.

35.(c) current sensitivity $I_s = \frac{\phi}{I} = \frac{NAB}{k}$

voltage sensitivity $V_S = \frac{NAB}{kR}$

$V_s = \frac{IS}{R}$

36. (d) In a non-uniform magnetic field both the torque and force will act.

37. (d) Galvanometer is used to detect the direction of current in a circuit, it gives full scale deflection to the current of microampere range.

38.(c) Diamagnetic materials get repelled in magnetic fields so they exhibit magnetism but they don't have unpaired electrons so we can say that they don't have dipole moment.

39.(a) Paramagnetic materials have unpaired electrons so they exhibit magnetism.

Case Study Based Question

40. 1.(a) Diamagnetism

2.(a) Diamagnetic

3.(b) is not affected by temperature

4.(d) -1

5.(d) Copper

41. 1.(b) 60^0

2.(a) 1.5 x 10^{-5} Nm

3.(d) PQ_6

4.(c) π : 4

Source Based

42.1. (a) Both the statements are correct

2. (b) Monopoles do not exist

3. (d) All the above

4. (a) Zero