CHAPTER-5

Magnetism and Matter

ASSIGNMENT-3

Q1. The maximum torque acting on a rectangular coil of 2cm X 5cm, having 200 turns and carrying a current of 2A is

(a) 0.4 Nm (b) 4 Nm (c) 40 Nm (d) 0.04 Nm

Q2. A toroid of n turns, mean radius R and cross-sectional radius a carries current I. It is placed on a horizontal table taken as X-Y plane. Its magnetic moment M

(a) is non-zero and points in the Z-direction by symmetry.

(b) points along the axis of the toroid.

(c) is zero, otherwise there would be a field falling as $1/r^3$ at large distances outside the toroid.

(d) is pointing radially outwards

Q3. A long magnet is cut into two parts such that the ratio of their lengths is 2:1. What is the ratio pole strength of both the section?

(a). 1:2 (b). 2:1 (c). 4:1 (d) Equal

Q4. The susceptibility of a ferromagnetic material is χ at 27^0 . At what temperature will its susceptibility be 0.5χ.

(a) 54^0C (b) 327^0 C (c) 600^0 C (d) $237\,^0$C

Q5. A paramagnetic sample shows a net magnetism of 8 Am^{-1} when placed in an external magnetic field of 0.6 T at a temperature of 4K. when the same sample is placed in an external magnetic field of 0.2 T at a temperature of 16 K, the magnetization will be

(a) $\frac{32}{3}$ Am^{-1} (b) $\frac{2}{3}$ Am^{-1} (c) 6 Am^{-1} (d) 2.4 Am^{-1}

Q6. The SI unit of Magnetic Permeability is

(a) $WA^{-1}m^{-1}$

(b) $NA^{-1}m^{-1}$

(c) NA^{-2}

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

Q7.Needles N1, N2 and N3 are made of a ferromagnetic, a paramagnetic and a diamagnetic substance respectively. A magnet when brought close to them will

(a) Attract N1 strongly but repel N2 and N3 weakly.

(b) Attract all 3 of them

(c) Attract N1 and N2 strongly but repel N3

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

1MARK QUESTIONS

Q8. 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.

Q9. The permeability of a magnetic material is 0.9983. Name the type of magnetic materials it represents.

Q10.Susceptibility of iron is more than that of copper. What does this statement imply?

Q11. The magnetic field lines prefer to pass through iron than air. Explain why?

Q12. Mention two characteristic properties of the material suitable for making core of a transformer.

2 MARK QUESTIONS

Q13.A hypothetical bar magnet (AB) is cut into two equal parts. One part is now kept over the other, so that the pole C2 is above C1. If M is the magnetic moment of the original magnet, what would be the magnetic moment of the combination, so formed?

Q14. State Gauss's law for magnetism. Explain its significance.

Q15. A iron rod of length L and magnetic moment M is bent in the form of a semicircle. Find its magnetic moment.

Q16. How will you decide whether the magnetic field at a point is due to some current carrying conductor or earth?

Q16(B). A small magnetised needle P is placed at the origin of x-y plane with its magnetic moment pointing along the y-axis. Another identical magnetised needle Q is placed in two positions, one by one.

Case 1: at (a, 0) with its magnetic moment pointing along x-axis.

Case 2: at (0, a) with its magnetic moment pointing along y-axis.

(a) In which case is the potential energy of P and Q minimum?

(b) In which case is P and Q not in equilibrium? Justify your answers.

Q17.The magnetic susceptibility of magnesium at 300K is 1.2×10^5. At what temperature will its magnetic susceptibility become 1.44×10^5?

Q18. Show diagrammatically the behaviour of magnetic field lines in the presence of

(i) paramagnetic and

(ii) diamagnetic substances. How does one explain this distinguishing feature?

Q19.Two substances A and B have their relative permeabilities slightly greater and slightly lessthan 1 respectively. What do you conclude about A and B as far as their magnetic materials areconcerned?

3 MARK QUESTIONS

Q20. A rectangular current carrying loop EFGH is kept in a uniform magnetic field as shown below in the figure.

i) What is the direction of magnetic moment of current loop?

ii) When is the torque acting on the loop (a) maximum (b) minimum?

E F

H G

Q21. Write three important properties of the magnetic field lines due to a bar magnet.

Q22. A short bar magnet placed with its axis at 30° with a uniform magnetic field of 0.1 T experiences a torque of $4X10^{-2}$J. Find the magnetic moment of the magnet.

Q23. A bar magnet of magnetic moment 6 JT^{-1} is aligned at 60 ° with uniform external magnetic field of 0.44T. Calculate the work done to align its magnetic moment i) normal to the magnetic field ii) opposite to the magnetic field.

Q24. A bar magnet of magnetic moment m and moment of inertia I (about centre perpendicular to length) is cut into two equal pieces, perpendicular to its length. Let T be the period of oscillations of the original magnet about an axis through mid-point, perpendicular to the length, in a magnetic field. What would be the similar Time Period T for each piece?

Q25. On what factors does the pole strength of a magnet depends?

Q26. Show that the time period (T) of oscillations of a freely suspended magnetic dipole of magnetic moment (m) in a uniform magnetic field (B) is given by T= $2\pi\sqrt{I/MB}$, where I is a moment of inertia of the magnetic dipole.

Q27. For a magnetising field of intensity 2 x 10^3 Am^{-1}, aluminium at 280 K acquires intensity of magnetisation of 4.8 x 10^{-2} Am^{-1},. If the temperature of the metal is raised to 320 K, what will be the intensity of magnetisation?

5 MARK QUESTIONS

Q28. (a) Two magnets of magnetic moments m and $\sqrt{3}$m are joined to form a cross (+).The combination is suspended freely in a uniform magnetic field. In equilibrium position the magnet of magnetic moment m makes an angle θ with the field. Find θ.

(b) A coil of N turns and radius R carries a current I It is unwound and rewound to make another coil of radius R/2, current I remaining the same. Calculate the ratio of magnetic moments of the new coil and the original coil.

Q29. A small compass needle of magnetic moment 'm' is free to turn about an axis perpendicular to the direction of uniform magnetic field 'B'. The moment of inertia of the needle about the axis is 'I'. The needle is slightly disturbed from its stable position and then released. Prove that it executes simple harmonic motion. Hence deduce the expression for its time period.

Assertion and Reason Type Questions

Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

(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 and R is also false.

Q30. **Assertion** Steady current is the only source of magnetic field.

Reason Only moving charge can create magnetic field.

Q31. **Assertion** A magnetic field does not interact with a stationary charge.

Reason A moving charge produces a magnetic field.

Q32**.** **Assertion** When velocity of electron is perpendicular to **B** it will perform circular motion.

Reason Magnetic force is perpendicular to velocity.

Q33. **Assertion** A beam of electrons can pass undeflected through a region of E and B.

Reason Force on moving charged particles due to magnetic field may be zero in some cases.

Q34. **Assertion** If the path of a charged particle in a region of uniform electric and magnetic field is not a circle, then its kinetic energy will not remain constant.

Reason In a combined electric and magnetic field region, a moving charge experiences a net force $F = qE + q(v \times B)$, where symbols have their usual meanings.

Q35. **Assertion** If we increase the current sensitivity of a galvanometer by increasing the number of turns, its voltage sensitivity also increases.

Reason Resistance of a wire also increases with N.

Q36. **Assertion** When a magnetic dipole is placed in a non uniform magnetic field, only a torque acts on the dipole.

Reason Force would not act on dipole if magnetic field were non uniform.

Q37. **Assertion** Galvanometer can as such be used as an ammeter to measure the value of the current in given circuit

Reason It gives a full-scale deflection for a current of the order of ampere.

Q38. **Assertion** Diamagnetic materials can exhibit magnetism.

Reason Diamagnetic materials have permanent magnetic dipole moments.

Q39. **Assertion** Paramagnetic materials can exhibit magnetism.

Reason Paramagnetic materials have permanent magnetic dipole moments.

CASE STUDY BASED QUESTION

Q40. MAGNETIC BEHAVIOUR OF MATERIALS

Before nineteenth century, scientists believed that magnetic properties were confined to a few materials like iron, cobalt and nickel. But in 1846, Curie and Faraday discovered that all the materials in the universe are magnetic to some extent. These magnetic substances are categorized into two groups. Weak magnetic materials are called diamagnetic and paramagnetic materials. Strong magnetic materials are called ferromagnetic materials. According to the modern theory of magnetism, the magnetic response of any material is due to circulating electrons in the atoms. Each such electron has a magnetic moment in a direction perpendicular to the plane of circulation. In magnetic materials all these magnetic moments due to the orbital and spin motion of all the electrons in any atom, vectorially add upto a resultant magnetic moment. The magnitude and direction of these resultant magnetic moment is responsible for the behaviour of the materials. For diamagnetic materials X is small and negative and for paramagnetic materials X is small and positive. Ferromagnetic materials have large X and are characterized by nonlinear relation between B and H.

Questions: Answer any four of the following

1. The universal (or inherent) property among all substances is
   (a) Diamagnetism
   (b) Paramagnetism
   (c) Ferromagnetism
   (d) Both (a) and (b)
2. When a bar is placed near a strong magnetic field and it is repelled, then the material of bar is
   a) Diamagnetic
   b) Ferromagnetic
   c) Paramagnetic
   d) Anti-ferromagnetic
3. Magnetic susceptibility of a diamagnetic substance
   (a) Decreases with temperature
   (b) Is not affected by temperature
   (c) Increases with temperature
   (d) First increases then decreases with temperature
4. The value of the magnetic susceptibility for a super conductor is
   (a) Zero (b) Infinity (c) +1 (d) -1
5. Which of the following is weakly repelled by a magnetic field
   (a) Iron (b) Cobalt (c) Steel (d) Copper

41. Torque & Potential energy of a Dipole

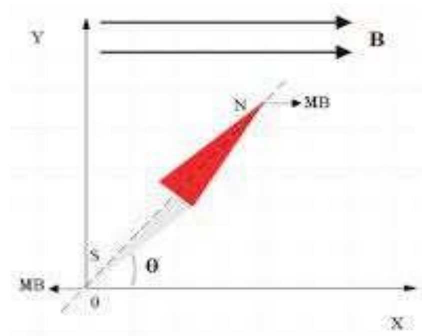
The pattern of iron fillings, i.e. the magnetic field lines give us an approximate idea of magnetic field **B**. We may at times be required to determine the magnitude of B accurately. This is done by placing a small compass needle of known magnetic moment **m** and moment of inertia **I** and allowing it to oscillate in the magnetic field. This arrangement is shown in the fig.

The torque on the needle is τ = m x B

In magnitude τ = mBsinϴ

The magnetic potential energy is given by

U_m = -m.B



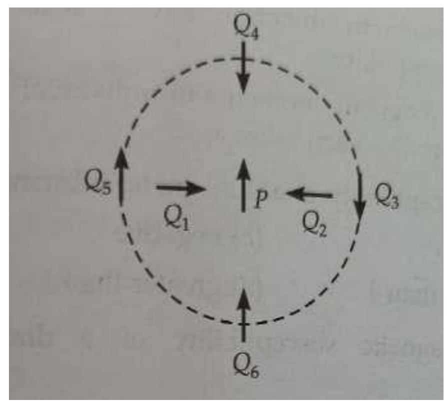
1.A bar magnet is held perpendicular to a uniform magnetic field. If the couple acting on a magnet is to be halved, by rotating it, the angle by which it is to be rotated is

(a) 30^0 (b) 60^0 (c) 45^0 (d) 90^0

2. The couple acting on a magnet of length 10 cm and pole strength 15 Am, kept in a field of V = 2 x 10^{-5} T at an angle 30^0 is

(a) 1.5 x 10^{-5} Nm (b) 1.5 x 10^{-3} Nm © 1.5 x 10^{-2} Nm (d) 1.5 x 10^{-6} Nm

3. The figure below shows the various positions of small magnetised needles P and Q. The arrows show the direction of their magnetic moments. Which configuration corresponds to lowest potential energy among all the configurations shown.



(a) PQ_3 (b) PQ_4 © PQ_5

(d)PQ_6

4. Two wires of the same length are shaped into a square and a circle if they carry the same current, ratio of magnetic moments is

(a) 2 : π (b) π : 2 (c) π : 4 (d) 4 : π

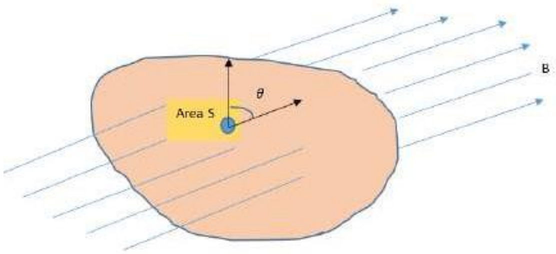
SOURCE BASED QUESTION

42. Gauss Law of Magnetism

Consider a small area element ΔS of a closed surface S .The magnetic flux through ΔS is defined as $\Delta\varphi_B$ = B. ΔS .We divide area element into many small area elements and calculate the individual flux through each. Then net flux φ_B is

$$\sum \Delta\varphi_B = \sum B.\Delta S = 0$$

Compare this with Gauss's Law of electrostatics. The flux through a closed surface in that case is



$\sum B.\Delta S =$ q/$\in_o$ Where q is electric charge enclosed by the surface. The difference between Gauss Law of magnetismand that for electrostatics is a reflection of the fact that isolated magnetic poles (monopoles) are not known to exist. There are no sources or sinks of B: the simplest magnetic element is a dipole or a current loop. All magnetic phenomena can be explained in terms of arrangement of dipoles and /or current loops. "The net magnetic flux throughany closed surface is zero".

1. Statement 1 : We cannot separate the poles of a magnet by breaking it into 2 pieces Statement2 : Magnetic monopoles do not exist
   a) Both the statements are correct
   b) Only statement 1 is correct
   c) Only statement 2 is correct
   d) Both are wrong
2. From Gauss's Law in magnetism we can conclude that
   a) $\sum B.\Delta S$ = q/$\in_o$
   b) Monopoles do not exist
   c) Electric charges exist as monopoles
   d) Current loop is the source of magnetism
3. Which of the following is true?
   a) Magnetic flux through a closed surface is zero
   b) Magnetic field lines are non-intersecting
   c) Magnetic monopoles do not exist
   d) All the above
4. The surface integral of magnetic field over a closed surface is equal to
   a) Zero b) q/$\in_o$ c) total electric flux d) current loop