CBSE Test Paper-04

Class - 12 Physics (Magnetism & Matter)

1. A long solenoid with 60 turns of wire per centimeter carries a current of 0.15 A. The wire that makes up the solenoid is wrapped around a solid core of silicon steel K_m = 5200 (The wire of the solenoid is jacketed with an insulator so that none of the current flows into the core.) For a point inside the core, find the magnitude of the total magnetic field
   a. 6.88T
   b. 5.88T
   c. 5.00T
   d. 4.88T
2. For strong electromagnets core is made of
   a. soft ferromagnetic substance
   b. air core
   c. paramagnetic core
   d. diamagnetic core
3. A sample of paramagnetic salt contains 2.0×10^{24} atomic dipoles each of dipole moment $1.5 \times 10^{-23} \mathrm{JT}^{-1}$. The sample is placed under a homogeneous magnetic field of 0.64 T, and cooled to a temperature of 4.2 K. The degree of magnetic saturation achieved is equal to 15%. What is the total dipole moment of the sample for a magnetic field of 0.98 T and a temperature of 2.8 K? (Assume Curie's law)
   a. 8.2 J/T
   b. 10.34 J/T
   c. 5.9 J/T
   d. 6.6 J/T
4. An iron bar magnet of length 10cm and cross section 1 cm^2 has a magnetization of 10^2 A/m. Magnet's pole strength is
   a. 0.0025 Am
   b. 0.0015 Am
   c. 0.01 Am
   d. 0.002 Am

5. A long solenoid with 60 turns of wire per centimeter carries a current of 0.15 A. The wire that makes up the solenoid is wrapped around a solid core of silicon steel K_m = 5200 (The wire of the solenoid is jacketed with an insulator so that none of the current flows into the core.) the magnetization inside the core is
   a. 4.48 MA/m
   b. 4.88 MA/m
   c. 4.68 MA/m
   d. 4.28 MA/m

6. What are permanent magnets? Give one example.

7. Which materials have permeability > 1 ?

8. A magnetic needle free to rotate in a vertical plane orients itself vertically at a certain place on the earth. What are the values of
   i. horizontal component of the earth's magnetic field and
   ii. angle of dip at this place?

9. What should be the orientation of a magnetic dipole in a uniform magnetic field so that its potential energy is maximum?

10. How does the (i) pole strength and (ii) magnetic moment of each part of a bar magnet change if it is cut into two equal pieces along its length?

11. What happens when a diamagnetic substance is placed in a varying magnetic field?

12. Explain the following:
    i. Why do magnetic lines of force form continuous closed loops?
    ii. Why are the field lines repelled (expelled) when a diamagnetic material is placed in an external uniform magnetic field?

13. A wheel with 8 metallic spokes each 50 cm long is rotated with a speed of 120 rev/min in a plane normal to the horizontal component of the earth's magnetic field. The earth's magnetic field at the place is 0.4 G and the angle of dip is 60°. Calculate the emf induced between the axle and the rim of the wheel. How will the value of emf be affected, if the number of spokes were increased?

14. A closely wound solenoid of 2000 turns and area of cross section $1.6 \times 10^{-4} m^2$, carrying a current of 4.0 A, is suspended through its centre allowing it to turn in a horizontal plane.
    a. What is the magnetic moment associated with the solenoid?
    b. What is the force and torque on the solenoid if a uniform horizontal magnetic field of $7.5 \times 10^{-2} T$ is set up at an angle of 30° with the axis of the solenoid?

15. If δ_1 and δ_2 be the angles of dip observed in two planes at right angles to each other and δ is the true angle of dip, then prove that $\cot^2\delta_1 + \cot^2\delta_2 = \cot^2\delta$

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Answers

1. b. 5.88T

   Explanation: $B=\mu_o K_m ni$

   $=4\pi\times10^{-7}\times5200\times60\times10^{2}\times0.15$

   = 5.88T

2. a. soft ferromagnetic substance

   Explanation: Ferromagnetic substances get magnetised stongly in the presence of magnetic field, further due to low coercivity it gets easily be demagnetized. Also hysterisis losses are less.

3. b. 10.34 J/T

   Explanation: Number of atomic dipoles, $n=2.0\times10^{24}$

   Dipole moment of each atomic dipole, $M=1.5\times10^{-23}JT^{-1}$

   When the magnetic field, B_1 = 0.64 T

   The sample is cooled to a temperature, T_1 = 4.2°K

   Total dipole moment of the atomic dipole, $M_{tot}=n\times M$

   $=2\times10^{24}\times1.5\times10^{-23}$

   = 30 JT^{-1}

   Magnetic saturation is achieved at 15%.

   Hence, effective dipole moment, $M_1=\frac{15}{100}\times30=4.5JT^{-1}$

   When the magnetic field, B_2 = 0.98 T

   Temperature, T_2 = 2.8°K

   Its total dipole moment = M_2

   According to Curie’s law, we have the ratio of two magnetic dipoles as:

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

   $\therefore M_2=\frac{B_2T_1M_1}{B_1T_2}$

   $=\frac{0.98\times4.2\times4.5}{2.8\times0.64}=10.336JT^{-1}$

   Therefore, 10.336$JT^{-1}\approx10.34JT^{-1}$is the total dipole moment of the sample for a magnetic field of 0.98 T and a temperature of 2.8 K.

4. c. 0.01 Am

   Explanation: $M = \frac{magnetic\ moment}{volume} = \frac{q_m \times l}{A \times l} = \frac{q_m}{A}$

   Hence pole strength, q_m = M × A = 100 A/m × 10^{-4} m^2 = 10^{-2} Am

5. c. 4.68 MA/m

   Explanation: $M = \frac{B}{\mu_o} = \frac{\mu_o K_M N i}{\mu_o}$

   $= 5200 \times 60 \times 10^2 \times 0.15$

   $= 4.68 \times 10^6 A/m$

6. Permanent magnets are those magnets which even show its magnetism in absense of magnetic field or current. Its has high retentivity, high coercivity and high permeability. The magnetisation of permanent magnet is not easily destroyed even if it is handled roughly or exposed in stray reverse magnetic field, e.g. steel.

7. Para and ferromagnetic materials.

8. i. The coil is free to move in vertical plane, it means that there is no horizontal component of the magnetic field of the earth, so the horizontal component of the earth's magnetic field is zero (B_H=0)

   ii. As B_H = Bcosδ = 0, so angle of dip δ = 90^o

9. When the magnetic moment of the magnetic dipole is antiparallel to the magnetic field $(\theta = 180^\circ)$, its potential energy is maximum.

10. Each piece is a magnet with reduced pole strength and reduced magnetic moment.
    i. Pole strength becomes half of original
    ii. Magnetic moment (M = M . 2 l) becomes t_1 times of original

11. It moves from stronger to weaker part of the magnetic field.

12. i. Outside the magnet, the magnetic lines starts from North pole and enter into the South pole whereas inside the magnet, the field lines travel from South pole to North pole. As monopoles do not exist, so, north and south pole always occur together so magnetic lines of force always form a closed loop.

    ii. Due to different rotations of electrons, the diamagnetic materials is magnetized in direction opposite to external field, therefore lines of force are repelled by a diamagnetic material.

13. $\because$ Horizontal component of earth's magnetic field,

$H = B\cos\theta = 0.4\cos 60^\circ = 0.4 \times (1/2) = 0.2G$

$\therefore\ magnetic\ field, B = 0.2 \times 10^{-4}\text{T} \quad [\cos 60^\circ = 1/2]$

This component is parallel to the plane of the wheel.

The wheel is rotating in a plane normal to the horizontal component, so it will cut the horizontal component only, vertical component of earth will contribute nothing in emf.

Thus, the emf induced between the axle and the rim is given as

$e = \frac{1}{2}Bl^2\omega$

where, $\omega = 2\pi(N/t)$ = $\frac{2\pi\times120}{60}$ radian/sec

l = length of the spoke = 50cm = 0.5m

$\therefore \quad e = \frac{1}{2} \times 0.2 \times 10^{-4} \times (0.5)^2 \times \frac{2\times314\times120}{60}$

$\therefore e = 314 \times 10^{-5}\text{V}$

The value of emf induced is independent of the number of spokes as the 8 spokes are connected in parallel to each other in between the axle and the rim and emf's across the spokes are in parallel. So, the emf will be unaffected with the increase in the number of spokes.

Hence, the required value of the induced emf = 3.14 mV

14. a. Magnetic moment

M = N I A $= 2000 \times 4 \times 1.6 \times 10^{-4}$

= 1.28 Am^2

The direction of $\overrightarrow{M}$ is along the axis of the solenoid in the direction related to the sense of current via the right handed screw rule.

b. The magnetic field is given to be uniform. So, the force on the solenoid is zero.

Torque, $\tau = MB\ \sin\theta = 1.28 \times 7.5 \times 10^{-2}\sin 30^\circ$

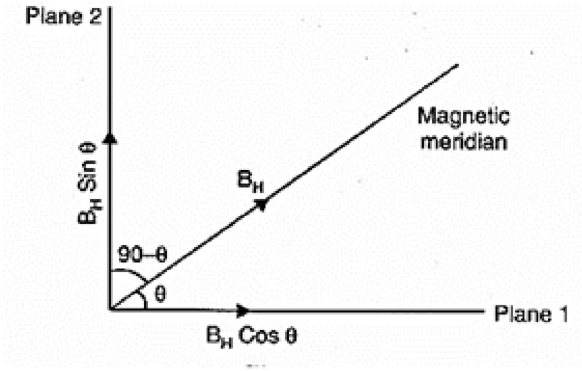
$= 1.28 \times 7.5 \times 10^{-2} \times \frac{1}{2}J = 0.048\ J$

The direction of the torque is such that the solenoid tends to align the axis of the solenoid (magnetic moment vector) along $\overrightarrow{B}$.

15. It horizontal and vertical components of earth's magnetic field are represented by B_H

and B_V respectively, then

$\tan \delta = \frac{B_V}{B_H}$



Let δ_1 be the (apparent) dip in a plane which makes angle θ with the magnetic meridian. In this plane, the vertical component will be B_V only but the effective horizontal component will be $B_H \cos \theta$.

$\tan \delta_1 = \frac{B_V}{B_H \cos \theta}$

or $\tan \delta_1 = \frac{\tan \delta}{\cos \theta} \because B_V = B_H \tan \delta$

or $\cos \theta = \frac{\tan \delta}{\tan \delta_1} = \tan \delta \cot \delta_1$....(i)

Let δ_2 be the (apparent) dip in the second plane. The angle made by this plane with the magnetic meridian will be $(90^\circ - \theta)$

Effective horizontal component in this plane is $B_H \cos(90^\circ - \theta)$ i.e. $B_H \sin \theta$. The vertical component will be B_V only.

$\tan \delta_2 = \frac{B_V}{B_H \sin \theta} = \frac{\tan \delta}{\sin \theta}$

Or $\sin \theta = \frac{\tan \delta}{\tan \delta_2} = \tan \delta \cot \delta_2$ ....(ii)

Squaring and adding equation (i) and (ii) we get

$\cot^2 \theta + \sin^2 \theta = \tan^2 \delta \cot^2 \delta_1 + \tan^2 \delta \cot^2 \delta_2$

or $1 = \tan^2 \delta (\cot^2 \delta_1 + \cot^2 \delta_2)$

$\cot^2 \delta = (\cot^2 \delta_1 + \cot^2 \delta_2)$