

CBSE Test Paper-02
Class - 12 Physics (Magnetism and Matter)

1. A bar magnet of magnetic moment 1.5 J/T lies aligned with the direction of a uniform magnetic field of 0.22 T. What is the amount of work required by an external torque to turn the magnet so as to align its magnetic moment opposite to the field direction?
 - a. 0.66J
 - b. 0.86J
 - c. 0.56J
 - d. 0.76J nC
2. Correct unit of Bohr magneton is
 - a. T/J
 - b. T
 - c. J
 - d. J/T
3. A toroidal solenoid with 500 turns is wound on a ring with a mean radius of 2.90 cm. Find the current in the winding that is required to set up a magnetic field of 0.350 T in the ring if the ring is made of silicon steel of relative permeability, $\mu_r = 5200$
 - a. 19.5mA
 - b. 21.5mA
 - c. 23.5mA
 - d. 22.5mA
4. Permeability of a paramagnetic material is expected to decrease with increasing temperature because
 - a. random thermal motion reduces magnetic moment alignment
 - b. random thermal motion increases magnetic moment alignment
 - c. electrons stop moving
 - d. electrons go into forbidden gap
5. A bar magnet of magnetic moment M , is placed in a magnetic field B . The torque exerted on it is:
 - a. $\vec{M} \times \vec{B}$
 - b. $\vec{M} \cdot \vec{B}$

c. $-\vec{B} \cdot \vec{M}$

d. $-\vec{M} \cdot \vec{B}$

6. Does the earth's magnetic field at a point vary with time? Is this variation appreciable?
7. The susceptibility of a magnetic material is 1.9×10^{-5} . Name the type of magnetic material, it represents.
8. In what way is the behaviour of a diamagnetic material different from that of a paramagnetic, when kept in an external magnetic field?
9. A short bar magnet placed with its axis at 30° with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to $4.5 \times 10^{-2} J$. What is the magnitude of magnetic moment of the magnet?
10. If you made a map of magnetic field lines at Melbourne in Australia, would the lines seem to go into the ground or come out of the ground?
11. A small compass needle of magnetic moment M and moment of inertia I is free to oscillate in a magnetic field B . It is slightly disturbed from its equilibrium position and then released. Show that it executes simple harmonic motion. Hence, write the expression for its time period.
12. Define magnetic dipole moment of a magnet and write its unit by taking into consideration the torque acting on it, when placed in magnetic field. Is it a vector or a scalar?
13. What do you understand by the terms magnetic length and geometric length of the magnet? How are the two related to each other?
14. Explain the sense in which the solenoid acts like a bar magnet. What is its associated magnetic moment?
15. A short bar magnet of magnetic moment $5.25 \times 10^{-2} JT^{-1}$ is placed with its axis perpendicular to earth's field direction. At what distance from the centre of the magnet, is the resultant field inclined at 45° with earth's field on
 - i. its normal bisector.
 - ii. its axis? Magnitude of earth's field at the place 0.42 G. Ignore the length of the magnet in comparison to the distances involved.

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Answers

1. a. 0.66J

Explanation: $W = mB[\cos\theta_1 - \cos\theta_2] = mB[\cos 0 - \cos\pi]$
 $= 2mB = 2 \times 1.5 \times 0.22 = 0.66J$

2. d. J/T

Explanation: J/T

3. a. 19.5mA

Explanation: $i = \frac{B \times 2\pi r}{\mu_o \mu_r N} = \frac{0.35 \times 0.29 \times 10^{-2}}{4\pi \times 10^{-7} \times 5200 \times 500}$
 $= 19.5 \times 10^{-3}A$

4. a. random thermal motion reduces magnetic moment alignment

Explanation: Due to temperature thermal velocity of atoms which are in random directions increases hence the alignment of their magnetic moment decreases.

5. a. $\vec{M} \times \vec{B}$

Explanation: Since torque is cross product of magnetic moment vector and magnetic field, hence it is given by

6. Yes. The variation may be appreciable over a very large interval of time.

7. **Paramagnetic substance.**

The susceptibility of paramagnetic substance is small and positive (1.9×10^{-5}).
Ex. Aluminium, Sodium etc.

8. When paramagnetic materials are placed in external magnetic field, these are feebly magnetised in the direction of the applied external magnetic field whereas in case of diamagnetic materials, these are feebly magnetised opposite to the direction of the applied external magnetic field.

9. Given, $\theta = 30^\circ$, $B = 0.25 \text{ T}$, $\tau = 4.5 \times 10^{-2}J$

Using formula

$$\tau = M \cdot B \sin \theta$$

$$\therefore M = 2 \text{ m l [m = pole strength]}$$

$$\therefore M = \frac{\tau}{B \sin \theta} = \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30^\circ}$$

$$m = 0.36 \text{ JT}^{-1}$$

10. Field lines of \vec{B} due to the earth's magnetism would seem to come out of the ground.

11. When compass needle of magnetic moment M and moment of inertia I is slightly disturbed by an angle θ from the mean position of equilibrium. Then, restoring torque begins to act on the needle which try to bring the needle back to its mean position which is given by

$$\vec{\tau} = -\vec{M} \times \vec{B}$$

$$\Rightarrow \tau = -MB \sin \theta \text{ (taking only magnitude), } B \text{ being magnetic field intensity.}$$

Since, θ is small

$$\text{So, } \sin \theta = \theta$$

$$\tau = -MB\theta \dots\dots (i)$$

$$\text{But } \tau = I\alpha \dots\dots (ii)$$

where, α = angular acceleration, I = moment of inertia of the needle and

M = magnetic moment of dipole

On comparing Eqs. (i) and (ii),

$$\Rightarrow I\alpha = -MB\theta \Rightarrow \alpha = -(MB/I)\theta \dots\dots (iii), \alpha \propto -\theta$$

\Rightarrow Angular acceleration α - angular displacement

Therefore, the needle will execute SHM. Comparing equation (iii) with the general

form of SHM, $\alpha = -\omega^2 \theta$ we get $\omega = \sqrt{\frac{MB}{I}}$.

Hence, the time period,

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

This is the required expression.

12. We know that $\tau = MB \sin \theta$

If $B = 1$ and $\theta = 90^\circ$ then $M = \tau$

Magnetic dipole moment is numerically equally equal to the torque experienced by the magnet when placed perpendicular to a uniform magnetic field of unit strength.

Now, $M = \frac{\tau}{B \sin \theta}$ So, SI unit of M is N mT^{-1}

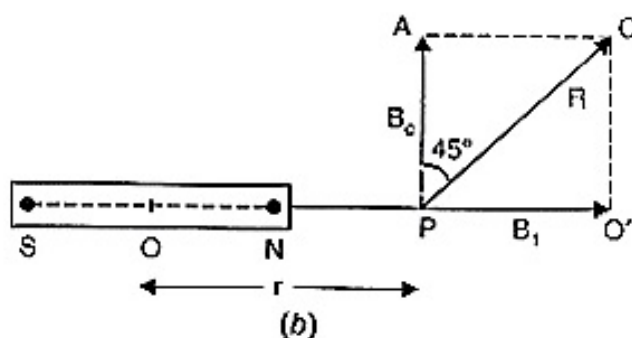
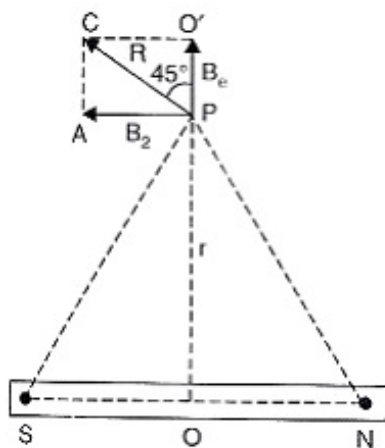
Magnetic dipole moment is a vector.

13. The actual length of a magnet is called the geometric length of the magnet. The distance between the poles of a magnet is called the magnetic length of the magnet. The geometric length of the magnet is nearly $8/7$ times the magnetic length of the magnet.
14. It is along the axis of the solenoid. The direction is determined by the sense of flow of the current. Solenoid acts like a bar magnet.
15. Here, $M = 5.25 \times 10^{-2} JT^{-1}$ $r = ?$

Earth's field = $\vec{B}_e = 0.42 G = 0.42 \times 10^{-4} T$

- i. At a point P distant r on normal bisector,

Figure (a) field due to the magnet is



Magnetic field B_2 due to magnet at equatorial line

$$\vec{B}_2 = \frac{\mu_0}{4\pi} \frac{M}{r^3} \text{ along PA || NS}$$

The resultant field \vec{R} will be inclined at 45° to the earth's field along PQ', only when

$$\begin{aligned} \left| \vec{B}_2 \right| &= \left| \vec{B}_e \right| \\ \frac{\mu_0}{4\pi} \frac{M}{r^3} &= 0.42 \times 10^{-4} \\ \frac{10^{-7} \times 5.25 \times 10^{-2}}{r^3} &= 0.42 \times 10^{-4} \end{aligned}$$

Which gives, $r = 0.05 \text{ m} = 5 \text{ cm}$

- ii. When the point P lies on axis of the magnet such that $OP = r$, field due to magnet fig. (b) is

$$\vec{B}_1 = \frac{\mu_0}{4\pi} \frac{2M}{r^3} \text{ along PO}$$

Earth's field \vec{B}_e is along \vec{PA} .

The resultant field \vec{R} will be inclined at 45° to earth's field only when

$$\begin{aligned} \left| \vec{B}_1 \right| &= \left| \vec{B}_e \right| \\ \therefore \frac{\mu_0}{4\pi} \frac{2}{r^3} &= 0.42 \times 10^{-4} \end{aligned}$$

Which gives $r = 6.3 \times 10^{-2} \text{ m} = 6.3 \text{ cm}$