CBSE Test Paper-03

Class - 12 Physics (Magnetism & Matter)

1. If $\vec{H}$ = magnetic intensity,χ = susceptibility, magnetic moment per unit volume $\vec{M}$ equals
   a. $\pi\chi\vec{H}$
   b. $\chi^2\vec{H}$
   c. $\chi\vec{H}$
   d. $2\chi\vec{H}$
2. Assuming one unpaired electron spin per atom, saturation magnetization in a long cylinder of iron is(n for iron is 8.6×10^{28} atoms/m^3,Bohr magneton $= 9.27 \times 10^{-24}\mathrm{J/T}$
   a. $9.0 \times 10^5\,\mathrm{A/m}$
   b. $7.0 \times 10^5\,\mathrm{A/m}$
   c. $6.0 \times 10^5\,\mathrm{A/m}$
   d. $8.0 \times 10^5\,\mathrm{A/m}$
3. Magnetic dipole moment is a vector quantity directed from:
   a. east to west
   b. south to north
   c. west to east
   d. north to south
4. According to the dipole analogy $1/\varepsilon_0$ corresponds to
   a. $1/\mu_0$
   b. $\pi\mu_0$
   c. μ_0
   d. $2\mu_0 a$
5. A toroidal solenoid with 500 turns is wound on a ceramic 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, (Consider relative permeability of ceramic to be same as that of vacuum i.e. 1).
   a. 121.5 A
   b. 101.5 mA

c. 121.5 mA
d. 101.5 A

6. The horizontal component of the earth's magnetic field at a place is B and angle of dip is 60°. What is the value of vertical component of the earth's magnetic field?
7. Relative permeability of a material μ_r =0.5. Identify the nature of the magnetic material and write its relation of magnetic susceptibility.
8. What is the characteristic property of a diamagnetic material?
9. A vector needs three quantities for its specification. Name the three independent quantities conventionally used to specify the earth's magnetic field.
10. The relative magnetic permeability of a magnetic material is 800. Identify the nature of magnetic material and state its two properties.
11. The vertical component of earth's magnetic field at a place is $\sqrt{3}$ times the horizontal component. What is the value of angle of dip at this place?
12. The true value of dip at a place is 30°. The vertical plane carrying the needle is turned through 45° from the magnetic meridian. Calculate the apparent value of dip.
13. A long straight horizontal cable carries a current of 2.5 A in the direction 10° south of west to 10° north of east. The magnetic meridian of the place happens to be 10° west of the geographic meridian. The earth's magnetic field at the location is 0.33 G, and the angle of dip is zero. Locate the line of neutral points.
14. Interstellar space has an extremely weak magnetic field of the order of 10^{-12}T. Can such a weak field be of any significant consequence ? Explain.
15. A short bar magnet is placed in a horizontal plane with its axis in the magnetic meridian. Null points are found on its equatorial line (i.e. its normal bisector) at 12.5 cm from the centre of the magnet. The earth's magnetic field at the place is 0.38 gauss, and the angle of dip is zero.
    a. What is the total magnetic field at points on the axis of the magnet located at the same distance (12.5 cm) as the null points from the centre?
    b. Locate the null points when the bar is turned around by 180°. Assume that the length of the magnet is negligible compared to the distance of the null points from the centre of the magnet.

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Answers

1. c. $\chi\vec{H}$

   Explanation: Magnetic moment per unit volume is called magnetization and it is given by$\chi\vec{H}$

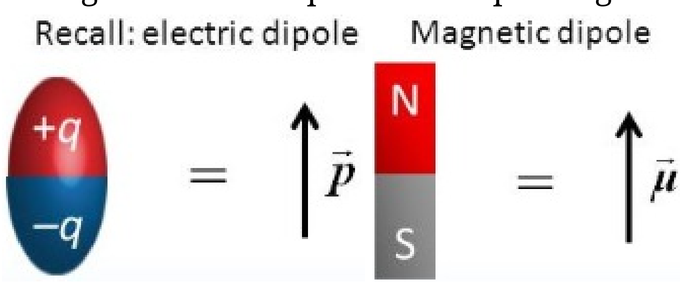
2. d. $8.0 \times 10^5 \mathrm{A/m}$

   Explanation: Saturation magnetization = n × Bohr magneton = 7.97 × 10^5 A/m = 8 × 10^5 A/m (approx)

3. b. south to north

   Explanation: Magnetic dipole & dipole moment

   A magnetic N and S pole make up a magnetic dipole



   Magnetic dipole moment is analogous to an electric dipole moment.

   Direction Vector from S to N pole (by convention).

4. c. μ_0

   Explanation: μ_0 in magnetisim is analogous to $1/\varepsilon_0$ in electricity.

5. d. 101.5 A

   Explanation: $i = \frac{B \times 2\pi r}{\mu_o \mu_r N} = \frac{0.35 \times 2 \times \pi \times 2.9 \times 10^{-2}}{4\pi \times 10^{-7} \times 1 \times 500} = 101.5A$

6. Horizontal component of earth's magnetic field,

   $H = B_e \cos 60^\circ = B$ (given θ = 60^0)

   $\Rightarrow \quad B_e \times \frac{1}{2} = B \quad \Rightarrow \quad B_e = 2B$

   Vertical component of earth's magnetic field,

   $V = B_e \sin 60^\circ \Rightarrow V = 2B \times (\sqrt{3}/2)$ (putting the value of B_e = 2B)

   $\Rightarrow \quad V = \sqrt{3}B$

7. The material is of diamagnetic nature. The required relation is
$\mu_r = 1 + \chi_m$

8. Diamagnetic material is very less magnetised in the opposite direction of the external magnetic field when they are placed in that field. These materials are repelled by magnets.

9. The three independent quantities conventionally used to specify the earth's magnetic field are - Magnetic declination, angle of dip and horizontal component of earth's magnetic field.

10. Ferromagnetic substances are those substances which have very high relative magnetic permeability. i.e. $\mu_r >> 1$ for ferromagnetic materials. Here in this question $\mu_r = 800$, so the material is a ferromagnetic one.
Properties
    i. High retentivity
    ii. High susceptibility $(\chi_m > 1000)$

11. $\tan\delta = \frac{B_V}{B_H} = \frac{\sqrt{3}B_H}{B_H} = \sqrt{3}$
$\tan\delta = \sqrt{3}$
$\delta = 60^\circ$ →(angle of dip)

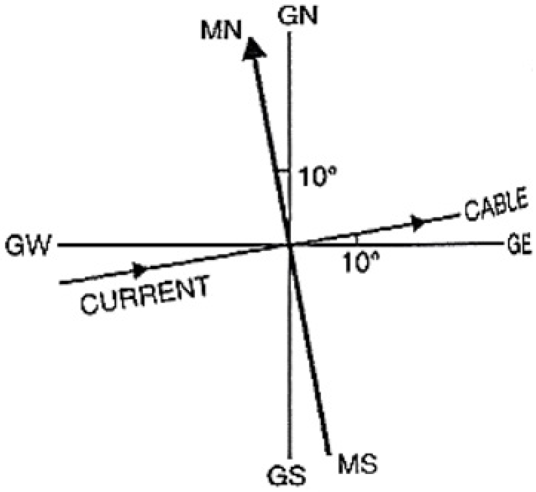
12. Given, $\delta = 30^\circ \theta = 45^\circ, \delta' = ?$
$\tan\delta = \frac{B_V}{B_H}$
$\tan\delta' = \frac{B_V}{B'_H} = \frac{B_V}{H\cos 45^\circ}$
$\tan\delta' = \frac{\tan\delta}{\cos 45^\circ} = \frac{\tan 30^\circ}{\cos 45^\circ}$
$\tan\delta' = \frac{\sqrt{2}}{\sqrt{3}} = 0.8164$
$\delta' = 39^\circ 14'$

13. Here, I = 2.5 amp
R = 0.33 G$= 0.33 \times 10^{-4}\ T$
$\delta = 0^\circ$
Horizontal component of earth's field
$H = R\cos\delta = 0.33 \times 10^{-4}\cos 0^\circ$
$= 0.33 \times 10^{-4}$tesla

Let the neutral points lie at a distance r from the cable.

Strength of magnetic field on this line due to current in the cable

$= \frac{\mu_0 I}{2\pi r}$



At neutral point,

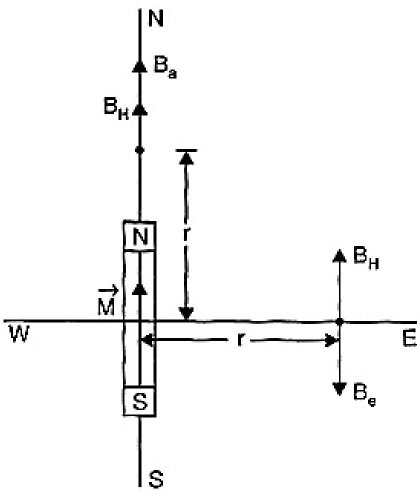
$\frac{\mu_0 I}{2\pi r} = H$

$r = \frac{\mu_0 I}{2\pi H} = \frac{4\pi\times10^{-7}\times2.5}{2\pi\times0.33\times10^{-4}} = 1.5 \times 10^{-2}m = 1.5cm$

Hence neutral points lie on a straight line parallel to the cable at a perpendicular distance of 1.5 cm above the plane of the paper.

14. From the relation $R = \frac{mv}{eB}\left[\because \frac{mv^2}{R} = qvB\right]$ we find that an extremely minute field bends charged particles in a circle of very large radius. Over a small distance, the deflection due to the circular orbit of such large R may not be noticeable, but over the gigantic interstellar distances, the deflection can significantly affect the passage of charged particles e.g. cosmic rays.

15. a. From figure (a) it is clear that null points are obtained on the normal bisector when the magnet's north and south poles face magnetic north and south respectively. Magnetic field on the normal bisector at a distance r from the centre is given by $\overrightarrow{B_e} = -\frac{\mu_0}{4\pi}\frac{\overrightarrow{M}}{r^3}$, provided r is much greater than the length of the magnet. [The above equation is strictly true only for a point dipole]. At a null point, this field is balanced by the earth's field.

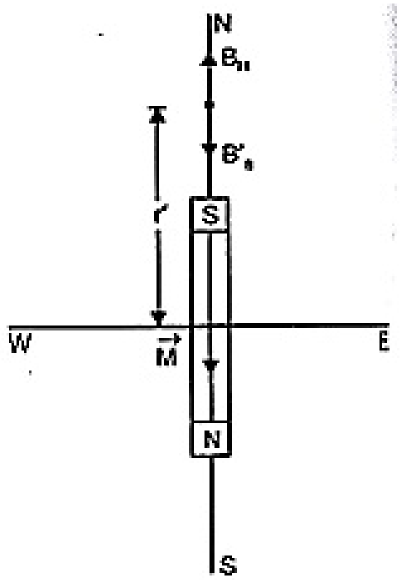


So, $B_e = B_H$

$\frac{\mu_0}{4\pi}\frac{M}{r^3} = 0.38 \times 10^{-4}$ ....(i)

(since the dip angle (s) is zero, therefore, $B_V = 0$ and the horizontal component of the earth's field equals the field itself)

Next, magnetic field due to a magnet on its axis at point distant r from the centre is given by



$B_a = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$ ....(ii)

provided r is much greater than the length of the magnet.

From figure (a) it is clear that on the axis, this field adds up to the earth's field.

Thus, the total field at a point on the axis has a magnitude equal to $B_a + B_H$

i.e. $\frac{\mu_0}{4\pi}\frac{2M}{r^3} + 0.38 \times 10^{-4}$ ....(iii)

and direction along $\overrightarrow{M}$ [which is parallel to the earth's field in case (a)].

Thus, for the same distance on the axis as the distance of the null point, the total field, using equations (i) and (iii) is

$2 \times 0.38 \times 10^{-4} + 0.38 \times 10^{-4}$

i.e. $3 \times 0.38 \times 10^{-4}$

i.e. $1.14 \times 10^{-4} tesla$

This field is directed along $\overrightarrow{M}$.

b. When the bar is turned around by 180°, the magnet's north and south poles face magnetic south and north respectively i.e., in this case, $\overrightarrow{M}$ is antiparallel to the earth's field. From figure (b) it is clear that the null points now lie on the axis of the magnet at a distance r' given by $B_a' = B_H$

or $\frac{\mu_0}{4\pi} \frac{2M}{r'^3} = 0.38 \times 10^{-4}$ ....(iv)

Comparing equations (iv) and (i), we get

$\frac{2}{r'^3} = \frac{1}{r^3}$ or $r'^3 = 2r^3$ or $r' = (2)^{1/3}r$

For r = 12.5 cm, r' = 15.7 cm