Magnetism And Matter

Previous Years' CBSE Board Questions

5.2 The Bar Magnet

MCQ

1. A bar magnet has magnetic dipole moment $\vec{M}$. Its initial position is parallel to the direction of uniform magnetic $\vec{B}$. In this position, the magnitudes of torque and force acting on it respectively are
   (a) 0 and MB (b) MB and MB
   (c) 0 and 0 (d) $|\vec{M}\times\vec{B}|$ and 0
   (Term I 2021-22)

2. Which of the following statements is correct?
   (a) Magnetic field lines do not form closed loops.
   (b) Magnetic field lines start from north pole and end at south pole of a magnet.
   (c) The tangent at a point on a magnetic field line represents the direction of the magnetic field at that point.
   (d) Two magnetic field lines may intersect each other. *(Term I 2021-22)* U

Question No. 3 is Assertion (A) and Reason (R) type questions. Given below are the two statements labelled as Assertion (A) and Reason (R). Select the most appropriate answer from the options given below.

3. **Assertion (A) :** The poles of a bar magnet cannot be separated.
   Reason (R) : Magnetic monopoles do not exist.
   (a) Both (A) and (R) are true and (R) is correct

hold the magnet in equilibrium at an angle of 30° with the field.
Calculate the value of F.
How will the equilibrium be effected if F is withdrawn? *(AI 2020)*

7. (a) Show that a current carrying solenoid behaves like a small bar magnet. Obtain the expression for the magnetic field at an external point lying on its axis.
   (b) A steady current of 2 A flows through a circular coil having 5 turns of radius 7 cm. The coil lies in X-Y plane with its centre at the origin. Find the magnitude and direction of the magnetic dipole moment of the coil. *(AI 2020)* Ev

5.3 Magnetism and Gauss's Law

SA II (3 marks)

8. State Gauss's law for magnetism. Explain its significance. *(1/3, Delhi 2019)* R

5.5 Magnetic Properties of Materials

MCQ

9. Which of the following has its permeability less than that of free space?
   (a) Copper (b) Aluminium
   (c) Copper chloride (d) Nickel *(2023)* R

explanation of (A).
(b) Both (A) and (R) are true, and (R) is not correct explanation of (A).
(c) (A) is true, but (R) is false.
(d) (A) is false and (R) is also false. *(Term I 2021-22)*

SA II (3 marks)

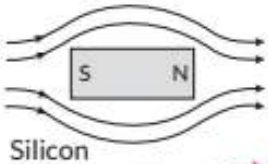
4. Write the four important properties of the magnetic field lines due to a bar magnet. *(2/3, Delhi 2019)* R

5. A bar magnet of magnetic moment 6 J T^{-1} is aligned at 60° with a uniform external magnetic field of 0.44 T. Calculate (a) the work done in turning the magnet to align its magnetic moment (i) normal to the magnetic field, (ii) opposite to the magnetic field, and (b) the torque on the magnet in the final orientation in case (ii). *(2018)* Ap

LA (5 marks)

6. (a) Derive the expression for the force acting between two long parallel current carrying conductors. Hence, define 1 A current.
(b) A bar magnet of dipole moment 3 Am^2 rests with its centre on a frictionless pivot. A force *F* is applied at right angles to the axis of the magnet, 10 cm from the pivot. It is observed that an external magnetic field of 0.25 T is required to

10. Which of the following cannot modify an external magnetic field as shown in the figure?



(a) Nickel (b) Silicon
(c) Sodium Chloride (d) Copper *(2023)* U

11. Which one of the following has relative magnetic permeability between 0 and 1?
(a) Aluminium (b) Alnico
(c) Water (d) Sodium *(2023)* R

12. Above Curies temperature, a
(a) ferromagnetic material become diamagnetic
(b) ferromagnetic material become paramagnetic
(c) paramagnetic material become ferromagntic
(d) paramagnetic material become diamagnetic
(AI 2020) U

VSA (1 mark)

13. The magnetic field lines are _____ by a diamagnetic substance. *(AI 2020)*

14. The magnetic susceptibility of magnesium at 300 K is 1.2×10^5. At what temperature will its magnetic susceptibility become 1.44×10^5 ?
(AI 2019)

15. The magnetic susceptibility χ of a given material is – 0.5. Identify the magnetic material. *(AI 2019)*

16. Write one important property of a paramagnetic material. *(AI 2019)*

17. Do the diamagnetic substances have resultant magnetic moment in an atom in the absence of external magnetic field? *(AI 2019)*

18. In what way is the behaviour of a diamagnetic material different from that of a paramagnetic, when kept in an external magnetic field? *(AI 2016)*

19. Depict the behaviour of magnetic field lines in the presence of a diamagnetic material. *(Foreign 2016)*

20. Relative permeability of a material $\mu_r = 0.5$. Identify the nature of the magnetic material and write its relation to magnetic susceptibility. *(Delhi 2014C)* U

SA I (2 marks)

21. Two identical bars, one of paramagnetic material and other of diamagnetic material are kept in a uniform external magnetic field parallel to it. Draw diagrammatically the modifications in the magnetic field pattern in each case. *(AI 2020)*

22. Give two points to distinguish between a paramagnetic and a diamagnetic substance.
(Foreign 2014)

SA II (3 marks)

23. Write three points of differences between para-, dia- and ferro- magnetic materials giving one example for each. *(Delhi 2019)*

24. The susceptibility of a magnetic material is 0.9853. Identify the type of magnetic material. Draw the modification of the field pattern on keeping a piece of this material in a uniform magnetic field.
(AI 2018) Ap

25. 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. *(AI 2014)*

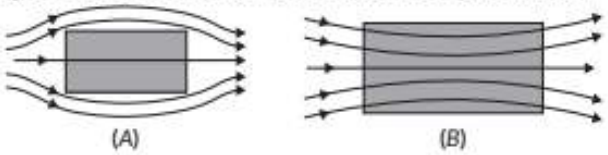
CBSE Sample Questions

5.5 Magnetic Properties of Materials

MCQ

1. If the magnetizing field on a ferromagnetic material is increased, its permeability
   (a) decreases
   (b) increases
   (c) remains unchanged
   (d) first decreases and then increases *(2022-23)*

2. A uniform magnetic field gets modified as shown in figure when two specimens *A* and *B* are placed in it.



   (i) Identify the specimen *A* and *B*.
   (ii) How is the magnetic susceptibility of specimen *A* different from that of specimen *B*? *(2022-23)*

Detailed SOLUTIONS

Previous Years' CBSE Board Questions

1. (c): Given that Magnetic moment $\vec{M}$ is parallel to Magnetic field $\vec{B}$ *i.e.*, $\vec{M} \| \vec{B}$.

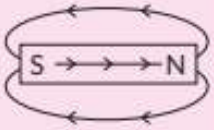
Torque, $\vec{\tau} = |\vec{M} \times \vec{B}| = MB\sin\theta = MB\sin 0° = 0$

Net force = 0, as two forces are equal and opposite.

2. (c): The direction of magnetic field at any point is given by the direction of tangent at that point on the magnetic field line.

Commonly Made Mistake

Generally student consider magnetic field lines starting from north pole and end at south pole these lines are discontinuous. But this is not so, magnetic field lines are continuous, as inside the magnet, the field lines travel from south to north pole.



(iii) Magnetic poles always exist in pairs *i.e.*, an isolated magnetic pole does not exist.

(iv) Like poles repel each other and unlike poles attract each other.

5. Here, $m = 6\ \text{J T}^{-1}$, $\theta_1 = 60°$, $B = 0.44\ \text{T}$

(a) Work done in turning the magnet,
$W = -mB(\cos\theta_2 - \cos\theta_1)$

(i) When the bar magnet is turned normal to the magnetic field, the final angle made by the axis of the bar magnet with the magnetic field is, $\theta_2 = 90°$ and $\theta_1 = 60°$

$\therefore \quad W = -6 \times 0.44(\cos 90° - \cos 60°)$

$$= -6 \times 0.44\left(0 - \frac{1}{2}\right) = 1.32\ \text{J}$$

3. (a): Magnetic poles cannot be separated as monopoles of a magnet does not exists.

Gauss's law in magnetism :

$\phi = \sum_{\text{all area elements}} \vec{B} \cdot \Delta\vec{S} = 0$, this indicates monopole does no exist.

4. Properties of magnets :

(i) Attractive property : When a magnet is dipped into iron filings, it is found that the concentration of iron filings is maximum at the ends. It means attracting power of the magnet is maximum at two points near the ends and minimum at the centre. The places in a magnet where its attracting power is maximum are known as poles while the place of minimum attracting power is known as the neutral region.

(ii) Directive property : When a magnet is suspended, its length becomes parallel to N-S direction. The pole at the end pointing north is known as north pole while the other pointing south is known as south pole.

Therefore, magnetic field at point *P* due to this circular element.

$$dB = \frac{\mu_0 ndx.ia^2}{2\left[(r-x)^2 + a^2\right]^{3/2}};\ B = \frac{\mu_0 nia^2}{2}\int_{-l}^{l} \frac{dx}{2\left[(r-x)^2 + a^2\right]^{3/2}}$$

for point *P*, $r >> a$ and $r >> l$

$$B = \frac{\mu_0 nia^2}{2r^3}\int_{-l}^{l} dx = \frac{\mu_0 ni2la^2}{2r^3};\ B = \frac{\mu_0}{4\pi}\cdot\frac{2m}{r^3}$$

(b) $M = Ni\pi a^2 = 5 \times 2 \times \frac{22}{7} \times 49 \times 10^{-4}$

$M = 154 \times 10^{-3} = 0.154\ \text{Am}^2$

$\vec{M}$ will be perpendicular to *x* - *y* plane or parallel to *z*-axis.

8. Gauss's law for magnetism : Gauss's law for magnetism states that the net magnetic flux through any closed surface is zero.

(ii) When the bar magnet is turned opposite to the magnetic field, the final angle made by the axis of the bar magnet with the magnetic field is $\theta_2 = 180°$ and $\theta_1 = 60°$

$\therefore \quad W = -6 \times 0.44(\cos 180° - \cos 60°)$

$$= -6 \times 0.44\left(-1-\frac{1}{2}\right) = 3.96\ \text{J}$$

(b) $\tau = mB \sin\theta = mB \sin 180° = 0$

6. (a) Consider two parallel wires A and B placed at a distance d apart. Current in wire A and B is i_a and i_b respectively.

The magnetic field due to the current i_a flowing in conductor A at any point on conductor B is

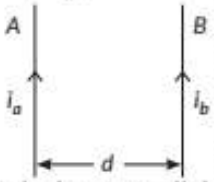
$$B_A = \frac{\mu_0 i_a}{2\pi d} \ldots\text{(i)} \quad \text{(acting perpendicular inwards)}$$

So, the force on conductor B due to the field B_a

$$\vec{F} = i_b\left(\vec{i} \times \vec{B}_a\right)$$

$$F = i_b \times i \times \frac{\mu_0 i_a}{2\pi d} \qquad \text{from (i)}$$

$$F = \frac{\mu_0}{2\pi}\frac{i_a i_b i}{d}\ ;\ \frac{F}{l} = \frac{\mu_0 I_a I_b}{d}$$



Definition of 1A : Two straight infinitely long parallel conductors are said to carry 1 A current each when they interact each other with a force of 2×10^{-7} N/m, when kept 1 m apart in vacuum.

(b) $m = 3\ \text{A m}^2, r = 10\ \text{cm}, B = 0.25\ \text{T}, \theta = 30°$

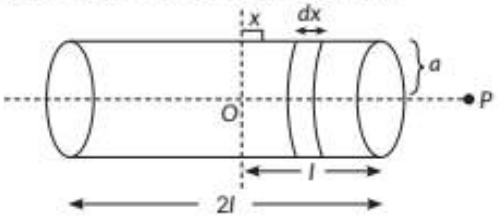
In equilibrium,

Restoring torque = Deflecting torque , $F \times r = mB\sin\theta$

$F \times 10 \times 10^{-2} = 3 \times 0.25 \times \sin 30°, F = 3.75\ \text{N}$

The magnet oscillates for sometime but finally aligns along the original direction of the external magnetic field.

7. (a) A solenoid may be regarded as a combination of large number of identical circular current loops in which each behaves like a magnetic dipole. Hence, the current carrying solenoid will behave like a small bar magnet. Figure shows a solenoid consisting of n turns per unit length. Consider a circular element of thickness dx at a distance x from the centre of the solenoid. **(1/2)**



$$\phi = \sum_{\substack{\text{all area}\\ \text{elements}}} \vec{B}\cdot\Delta\vec{S} = 0$$

Physical significance : This law establishes that isolated magnetic poles do not exist.

9. (a): Copper has less than one relative permeability.

Copper relative permeability, $\mu_r = \frac{\mu}{\mu_0} = 0.999994$

10. (d): As copper is diamagnet, so the magnetic field lines do not pass through it.

11. (c): Water has relative magnetic permeability between 0 and 1 as it is a diamagnetic material.

12. (b)

13. Magnetic field lines are repelled by diamagnetic substances.

14. $\chi_m \propto \frac{1}{T}$ so, $T_2 = \frac{\chi_{m_1}}{\chi_{m_2}} \times T_1\ ;\ T_2 = \frac{1.2\times10^5}{1.44\times10^5} \times 300 = 250\,\text{K}$

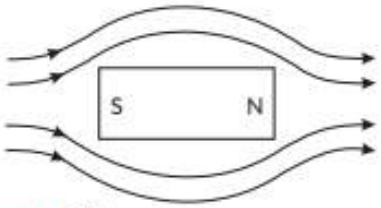
15. For diamagnetic materials, the magnetic susceptibility in negative.

16. The paramagnetic materials attracts field lines weakly and they moves from weaker to stronger field regions.

17. No, diamagnetic substances do not have magnetic moment.

18. A diamagnetic specimen would tend to move towards the region of weaker magnetic field while a paramagnetic specimen would tend to move towards the region of stronger magnetic field.

19. Behaviour of magnetic field lines when a diamagnetic substance is placed in an external field.



Concept Applied

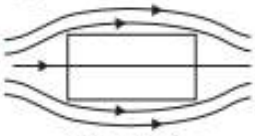
A diamagnetic material tends to move from stronger to weaker regions of the magnetic field and hence decreases the number of magnetic field lines passing through it.

20. The relative permeability is an intrinsic property of a magnetic material. A related quantity is the magnetic susceptibility, denoted by χ_m.

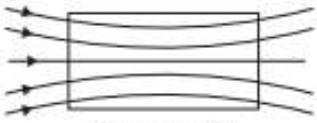
$\mu_r = 1 + \chi_m$ $[\because \mu_r = 0.5]$

Here, $\mu_r < 1$ (χ_m negative), so the material is termed as diamagnetic.

21.



Diamagnetic material



Paramagnetic material

22.

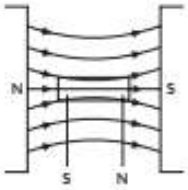
S.No.	Paramagnetic substance	Diamagnetic substance
1.	A paramagnetic substance is feebly attracted by a magnet.	A diamagnetic substance is feebly repelled by a magnet.
2.	For a paramagnetic substance, the intensity of magnetisation has a small positive value.	For a diamagnetic substance, the intensity of magnetisation has a small negative value.

23.

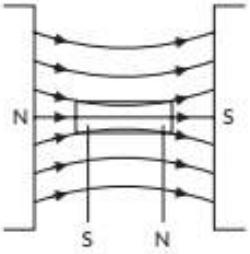
S.No.	Paramagnetic	Diamagnetic	Ferromagnetic
1.	Substances are feebly attracted by the magnet. Na, K, Mg, Mn, Al, Cr, Sn and liquid oxygen are paramagnetic.	Substances are feebly repelled by the magnet. Bi, Cu, Ag, Hg, Pb, water, hydrogen, He, Ne, etc., are diamagnetic.	Substances are strongly attracted by the magnet. Fe, Co, Ni and their alloys are ferromagnetic.
2.	χ_m is small, positive and varies inversely with temperature, *i.e.*, $\chi_m \propto (1/T)$.	Susceptibility χ_m is small, negative and temperature independent.	χ_m is very large, positive and temperature dependent.
3.	μ_r is slightly greater than unity, *i.e.*, $\mu > \mu_0$.	Relative permeability μ_r is slightly lesser than unity, *i.e.*, $\mu < \mu_0$	μ_r is much greater than unity, *i.e.*, $\mu >> \mu_0$.

24. As $\chi = 0.9853$, so material is paramagnetic.

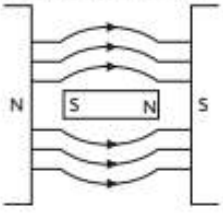
The behaviour of magnetic field lines in the presence of a paramagnetic substance is shown :



25. (i) The behaviour of magnetic field lines in the presence of a paramagnetic substance is shown :



(ii) The behaviour of magnetic field lines in the presence of a diamagnetic substance is shown :



This distinguishing feature is because of the difference in their relative permeabilities. The relative permeability of the diamagnetic substance is negative; so, the magnetic lines of force do not prefer passing through the substance. The relative permeability of a paramagnetic substance is greater than 1; so, the magnetic lines of force prefer passing through the substance.

Concept Applied

➲ Relative permeability of the diamagnetic substance is negative.

CBSE Sample Questions

1. (a) : The magnetic permeability of a substance is given by $\mu = \frac{B}{H}$. Here, B is magnetic field inside the material, H is applied external magnetic field. When external applied magnetic field H is increased, the internal magnetic field for a ferromagnetic material remains the same. Thus, the magnetic permeability decreases. **(1)**

2. (i) Specimen *A* - diamagnetic, **(1)**
Specimen *B* - paramagnetic
(ii) The magnetic susceptibility of *A* is small negative and that of *B* is small positive. **(1)**