Magnetism

SHORT-ANSWER QUESTIONS (1 MARK)

CONCEPTUAL QUESTIONS

1. What are magnetic poles?

Ans. When a megnet is freely suspended in the earth's field, it orients itself approximately in the geographic North-Sourth direction. A particular end always points towards the geographical North. It is called the **north (N) pole.** The other, which points towards the geographical South, is called the **south (S) pole.**

The property of a magnet to attract certain materials is concentrated at the poles.

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2. Define magnetic moment of a dipole and give its S.I. unit.

Ans. **Magnetic moment** of a dipole is the torque acting on the dipole when it is placed at right angels to a magnetic field of unit strength. S.I. unit of magnetic moment is Am^2 or JT^{-1}.

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3. Is magnetic moment a scalar or a vector quantity?

Ans. Magnetic moment is a vector whose direction is along the axis of the magnet directed from its S-pole to the N-pole.

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4. A bar magnet of magnetic moment M is placed in a uniform magnetic field B such that the axis of the magnet makes an angle θ with the direction of B. What is the torque experienced by the dipole?

Ans. Torque $\boxed{\tau = MB \sin \theta}$

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5. A bar magnet placed with its axis making an angle θ with a uniform external field B experiences a torque τ. What is the magnetic moment of the magnet?

Ans. Magnetic moment $M = \dfrac{\tau}{M \sin \theta}$

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6. What is meant by pole strength? Express magnetic moment of a magnet in terms of its pole strength and length.
What is S.I. unit of pole strength?

Ans. In the study of bar magnets it is sometimes useful to introduce a quantity called magnetic **pole strength** (q_m) which is analogous to charge in electrostatics. The magnetic moment of a bar magnet of length $2l$ and pole strength q_m is written as

$$\boxed{M = 2l\, q_m}$$

The S.I. unit of pole strength is A-m.

7. A bar magnet is suspended freely with its axis horizontal in a uniform horizontal magnetic field. If it is rotated slightly about a vertical axis passing through its centre and then released, what type of motion it will execute?

Ans. It will execute approximately simple harmonic motion.

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8. Write the expression for the time period of small oscillation of a magnet of magnetic moment M in a uniform field B.

Ans. Time Period $\boxed{T = 2\pi\sqrt{\frac{I}{MB}}}$,

where I is the moment of inertia of the magnet.

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9. How much work must an external agent do to rotate a magnet of magnetic moment M in a magnetic field B from a position in which its axis makes an angle θ_1 with the field direction to a position in which the axis makes an angle θ_2 with the field direction?

Ans. Work $\boxed{W = MB\,(\cos\theta_1 - \cos\theta_2)}$

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10. What is the potential energy of a magnet of magnetic moment M placed in an external field B, with its axis making an angle θ with the direction of the field?

Ans. Potential Energy $\boxed{U = -MB\cos\theta = -\mathbf{M.B}}$

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11. A magnetic dipole of magnetic moment M is placed in a uniform magnetic field B with its axis parallel to the magnetic field. What is its potential energy? What amount of work will be done if this dipole is rotated through 180° ?

Ans. Potential energy $= -MB$

Work done $= 2MB$

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12. Write an expression for the work done in rotating a bar magnet of magnetic moment M through an angle θ from the equilibrium position in a magnetic field B.

Ans. $W = MB\,(1 - \cos\theta)$

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13. A magnetic needle of magnetic moment M is broken into two pieces at the middle. What is the magnetic moment of each piece?

Ans. $M/2$.

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14. Does a magnetic monopole exist?

Ans. No, the most elementary magneitc entity is a dipole.

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15. What is a magnetic line of force?

Ans. A magnetic **line of force** is a curve drawn in a magnetic field such that the tangent to it any point gives the direction of the field at that point.

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16. Can two magnetic lines of force intersect? Why?

Ans. No. If two lines of force intersect, then at the point of intersection there will be two directions of the magnetic field, which is not possible.

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17. What is the basic difference between magnetic and electric lines of force?

Ans. An electric line of force starts at one point (positive charge) and end

at some other point. (negative change) A magnetic line of force has no begining and end. It forms closed loop.

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18. Give the position of a magnetic dipole, held in a magnetic field, where its potential energy is minimum.

Ans. The potential energy of a magnetic dipole is minimum when the dipole moment is directed along the magnetic field.

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19. Two iron bars *A* and *B* are given, one of which is definitely known to be magnetized, but which one we do not know. How would you ascertain whether or not both are magnetized? If only one is magnetized, how does one ascertain which one? Use only the two bars *A* and *B*.

Ans. Bring different ends of the bars closer. A repulsive force in some situations shows that both are magnetized. If the force is always attractive then only one bar is magnetized. To see which one, pick up one, say *A*, and lower one of its ends first on one of the ends of *B*, and then on the middle of *B*. If you find that in the middle of *B*, *A* experiences no force, then *B* is magnetized. If you do not find any change from the end to the middle of *B*, then *A* is magnetized.

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20. Write the expression for the magnetic field due to a magnet at a distant point along the axis (end-on position).

Ans.

$$\boxed{\mathbf{B} = \frac{\mu_0}{4\pi}\frac{2\mathbf{M}}{x^3}}$$

The symbols have their usual meanings.

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21. Write the expression for the magnetic field due to a magnet at a distant point along the perpendicular bisector (broad-side-on position).

Ans.

$$\boxed{\mathbf{B} = \frac{\mu_0}{4\pi}\frac{\mathbf{M}}{x^3}}$$

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22. What is the approximate form of the earth's magnetic field?

Ans. The earth's field is approximately like that of a fictitious huge bar magnet located deep inside the earth with its N-pole nearly towards the geographic south and the S-pole nearly towards the geographic north.

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23. What is **geographic meridian**?

Ans. It is the vertical plane passing through the axis of rotation of the earth.

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24. What is **magnetic meridian**?

Ans. It is the vertical plane passing through the axis of a freely suspended magnet?

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25. What is **declination**?

Ans. It is the angle between the geographic meridian and the magnetic meridian at a place.

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26. What is **dip**?

Ans. It is the angle between the earth's magnetic field and the horizontal direction at a place.

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27. How does dip vary as one moves from the magnetic equator to the poles?

Ans. The angle of dip is zero at the magnetic equator and becomes 90° at the poles, varying gradually as one moves from the equator to the poles.

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28. Give the relation between the angle of dip, and the horizontal and vertical components of the earth's magnetic field.

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

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29. State tangent law.

Ans. Suppose a magnet is suspended in a region where there are two fields B_1 and B_2 at right angles. If θ is the angle made by the magnet with field B_1 in equilibrium, then

$$B_2 = B_1 \tan \theta$$

This is called the **tangent law**.

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30. A small magnet is pivoted to move freely in the magnetic meridian. Where on the earth will it be vertical?

Ans. It will be vertical at earth's **magnetic poles**.

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31. What is magnetic equator?

Ans. A plane perpendicular to the line joining the two magnetic poles of the earth and passing through the centre of the earth intersects the earth's surface in a circle. This circle is called the **magnetic equator**.

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32. Enumerate the factors on which the time period of vibrations depends in a vibration magnetometer. **[1995]**

Ans. The time period of vibrations in a vibration magnetometer depends on

(*i*) the moment of inertia of the magnet (I);

(*ii*) the magnetic moment of the magnet (M);

(*iii*) the horizontal component of the earth's magnetic field (B_H).

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33. How can paramagnetic and diamagnetic materials be distinguished by studing their behaviour in a magnetic field? **[1994]**

Ans. When placed in a non-uniform magnetic field, a paramagneitc material tends to move from weaker to stronger parts of the field whereas a diamagnetic material tends to move from stronger to weaker parts of the field.

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34. How can paramagnetic and diamagnetic material rods be distinguished in a magnetic field?

Ans. If a paramagnetic rod is suspended in a magnetic field, it aligns itself parallel to the field.

If a diamagnetic rod is suspended in a magnetic field, it aligns itself perpendicular to the field.

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35. Define magnetic permeability. **[1998]**

Ans. **Permeability** of a material is the ratio of the magnetic flux density (B) in the material to the external magnetic intensity (H):

$$\mu = \frac{B}{H}$$

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36. What is the S.I. unit of permeability?

Ans. The S.I. unit of permeability is TmA^{-1} or $Wb\ A^{-1}\ m^{-1}$ or Hm^{-1}.

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37. Define relative permeability.

Ans. **Relative permeability** of a material is the ratio of the permeability of the material to the permeability of vacuum:

$$\mu_r = \frac{\mu}{\mu_0}$$

38. Define **magnetic susceptibility**.

Ans. It is the ratio of the magnetization (magnetic moment per unit volume) M of the material to the applied magnetic intensity H:

$$\chi = \frac{M}{H}$$

39. What are the S.I. units of M and H ?

Ans. Both have the S.I. unit Am^{-1}.

40. What is the relation between χ and μ_r?

Ans.

$$\mu_r = 1 + \chi$$

41. How does magnetic susceptibility depend on temperature?

Ans. Diamagnetic susceptibility is nearly independent of temperature whereas paramagnetic susceptibility varies inversely with temperature.

42. What is the origin of the magnetic behaviour of materials?

Ans. In all materials, the magnetic behaviour is due to the orbital motion of electrons around the nucleus and due to the spin of electrons. Each electron is like a tiny magnetic dipole having a certain magnetic moment. The resultant magnetic moment of the atom is the vector sum of the magnetic moments of individual electrons.

43. Which of the three effects—diamagnetism, paramagnetism and ferromagnetism—is universal?

Ans. Diamagnetism. It is present in all materials.

44. Which of the two effects—diamagnetism and paramagnetism—is weaker?

Ans. Diamagnetism.

45. State **Curie law**.

Ans. The paramagnetic susceptibility is inversely proportional to the absolute temperature:

$$\chi = \frac{C}{T}$$

46. What is **Curie temperature**?

Ans. It is that temperature above which a ferromagnetic material loses its ferromagnetism and becomes paramagnetic.

47. Does an iron bar retain its magnetization when melted?

Ans. No, the melting point of iron is higher than its Curie temperature.

48. What is magnetic hysteresis?

Ans. When a ferromagnetic material is magnetized and then demagnetized, the flux density B lags behind the external magnetic intensity H. This behaviour is called **hysteresis**.