

Chapter 11. Magnetic materials

MCQ'S (1 Mark Each)

1) The magnetic susceptibility is given by

a) $\chi = \frac{1}{H}$ b) $\chi = \frac{B}{H}$ c) $\chi = \frac{M_{net}}{V}$ d) $\chi = \frac{M}{H}$

Ans : d) $\chi = \frac{M}{H}$

2) The relation between relative permeability and magnetic susceptibility is given by

a) $\chi = \mu_r + 1$ b) $\chi = -\mu_r - 1$ c) $\mu_r = 1 - \chi$ d) $\mu_r = 1 + \chi$

Ans : d) $\mu_r = 1 + \chi$

3) If an electron of charge (-e) and mass m_e revolves around the nucleus of an atom having orbital magnetic moment m_o , then angular momentum of electron is

a) $L = \frac{m_o e}{2m_e}$ b) $L = \frac{e}{2m_o m_e}$ c) $L = \frac{2m_o m_e}{e}$ d) $L = \frac{2e}{m_o m_e}$

Ans : c) $L = \frac{2m_o m_e}{e}$

4) If m_o and L denote the orbital angular moment and the angular momentum of the electron due to its orbital motion, then the gyromagnetic ratio is given by

a) $\frac{L}{m_o}$ b) $\frac{m_o}{L}$ c) Lm_o d) $\sqrt{\frac{m_o}{L}}$

Ans : b) $\frac{m_o}{L}$

5) Relative permeability of iron 5500, then its magnetic susceptibility will be

a) 5500×10^7 b) 5501 c) 5499 d) 5500×10^{-7}

Ans : c) 5499 , hint : $\chi = \mu_r - 1$

6) What is magnetization of a bar magnet having length 6 cm and area of cross section 5 cm^2 ?

$$(m_{net} = 1)$$

a) 1.2×10^{-4} A/m b) 3.3×10^4 A/m c) 1.25×10^{-4} A/m d) 3.3×10^{-4} A/m

Ans : b) 3.3×10^4 A/m , $M = \frac{m_{net}}{V} = \frac{m_{net}}{AL}$

- 7) A magnetic material of susceptibility 3×10^{-4} , and magnetic intensity is $4 \times 10^{-4} \text{ Am}^{-1}$. Then

The magnetization in the units of Am^{-1} is

a) 12×10^8 b) 1.33×10^8 c) 0.75×10^{-8} d) 14×10^{-8}

Ans : a) 12×10^8 , $M = \chi H$

Very Short Answer (VSA) (1 MARK Each)

1. Give gyro magnetic ratio.
2. What is stated in term of Bohr magneton.
3. Define magnetization.
4. What does the ratio of magnetization to magnetic intensity indicate?
5. What is diamagnetism?
6. State the formula for the periodic time of angular oscillations of the bar magnet, in terms of moment of inertia.
7. The relative permeability of a medium is 0.075. What is its magnetic susceptibility?

(Ans: 0.925 , hint : $\chi = \mu_r - 1$)

8. The moment of a magnet ($15 \text{ cm} \times 2 \text{ cm} \times 1 \text{ cm}$) is 1.2 A-m^2 . What is its intensity of magnetization? (Ans : $M = 4 \times 10^4 \text{ Am}^{-1}$)

9. The electron in hydrogen atom is moving with a speed of 2.5×10^6 m/s in an orbit of radius 0.5 \AA . What is the Magnetic moment of the revolving electron? (Ans: $m_o = \frac{evr}{2} = 10^{-23} \text{ Am}^2$).

Short Answer I (SA1) (2 MARKS Each)

1. Show that the orbital magnetic dipole moment of a revolving electron is $\frac{evr}{2}$.
2. Derive the quantity for Bohr magneton and also state its value.
3. Define magnetization. State its SI unit and dimensions.
4. What is a magnetic hysteresis?
5. Define: 1) retentivity 2) coercivity.
6. Explain magnetic shielding.
7. Calculate the gyro magnetic ratio of electron.

(given $e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg)

Ans.: hint: gyromagnetic ratio $= \frac{e}{2m_e} = 8.8 \times 10^{10} \text{ C kg}^{-1}$

8. An iron rod of area of cross-section 0.1 m^2 is subjected to a magnetizing field of 1000 A/m. Calculate the magnetic permeability of the iron rod.

(χ for iron = 599, $\mu_0 = 4\pi \times 10^{-7}$ SI unit)

Ans.: 7.54×10^{-4} , hint: $\mu_r = \chi + 1$, $\mu = \mu_r \mu_0$

9. A solenoid has core of a material with relative permeability 500 and its windings carry current of 1 A. The number of turns of the solenoid is 500 per meter. Calculate the magnetization of the material.

Ans.: $2.495 \times 10^5 \text{ Am}^{-1}$, $H = Ni$, $\chi = \mu_r - 1$, $M = \chi H = (\mu_r - 1)H$

Short Answer II (SA2) (3 MARKS Each

- 1) Define magnetic intensity. Explain magnetization of a material.

- 2) Obtain an expression for the orbital magnetic moment of an electron rotating about the nucleus in an atom.
- 3) Define gyromagnetic ratio. Find relation for Bohr magneton.
- 4) What is a paramagnetic material? Give two examples.
- 5) State any four properties of a paramagnetic material.
- 6) State Curie's law of Paramagnetic material.
- 7) What is a ferromagnetic material? Give two examples.
- 8) Explain magnetic hysteresis in a ferromagnetic material.
- 9) When a plate of magnetic material of size $10\text{ cm} \times 0.5\text{ cm} \times 0.2\text{ cm}$ (length, breadth and thickness respectively) is located in magnetizing field of $0.5 \times 10^4\text{ Am}^{-1}$ then magnetic moment of 5 Am^2 is induced in it. Find out magnetic induction in the plate.
(Ans : $M = 5 \times 10^6\text{ Am}^{-1}$, $B = 6.29\text{ T}$)
- 10) A magnet of magnetic moment 3 Am^2 weighs 75 g. The density of the material of the magnet is 7500 kg/m^3 What is the magnetization.? (Ans: $M = 3 \times 10^5\text{ A/m}$)
- 11) Find the relative permeability, if the permeability of a metal is 0.1256 TmA^{-1}
(Ans: 10^5)

Long Answer (LA) (4 marks Each)

- 1) Define magnetization. State its SI unit and dimensions. Derive the relation between magnetic field intensity(H) and magnetization (M) for a magnetic material placed in a magnetic field.
- 2) Explain the origin of magnetism in material, hence find the magnetic moment of an electron revolving around the nucleus of an atom.
- 3) Derive an expression for a torque acting on a magnetic dipole in a region of uniform magnetic induction. Express it in vector form.
- 4) State any four properties of a diamagnetic material.
- 5) An electron in an atom is revolving round the nucleus in a circular orbit of radius $5.3 \times 10^{-11}\text{ m}$, with a speed of $2 \times 10^6\text{ ms}^{-1}$. Find resultant orbital magnet moment and angular momentum of electron.
($e = 1.6 \times 10^{-19}\text{ C}$, $m = 9.1 \times 10^{-31}\text{ kg}$)

(Ans: $m_o = 8.48 \times 10^{-24}\text{ Am}^2$, $L = 9.646 \times 10^{-35}\text{ kg.m}^2/\text{s}$)