

$$\begin{aligned}
 \therefore B &= \mu_0 \mu_r H && \text{(from Eqn. 11.4)} \\
 \text{and } B &= \mu_0 (M + H) && \text{(from Eq. 11.5)} \\
 \therefore \mu_0 \mu_r H &= \mu_0 (M + H) && (i) \\
 \text{Knowing that } M &= \chi H && \text{(from Eq. 11.6)} \\
 \text{We can write Eq. (i) as} \\
 \mu_0 \mu_r H &= \mu_0 (\chi H + H) \\
 &= \mu_0 \chi H + \mu_0 H \\
 \text{or } \mu_0 \mu_r H - \mu_0 H &= \mu_0 \chi H \\
 \text{i.e. } (\mu_0 \mu_r - \mu_0) H &= \mu_0 \chi H \\
 \text{hence } \mu_0 (\mu_r - 1) &= \mu_0 \chi \\
 \text{or } \mu_r - 1 &= \chi \\
 \text{Thus } \mu_r &= 1 + \chi && (11.10)
 \end{aligned}$$

Example 11.1 A magnetic field of 2400 A/m is applied to a material having a susceptibility of 1500. Determine (a) its relative permeability, (b) intensity of magnetization, and (c) the remanance.

Solution. (a) From Eq. 11.10, we find

$$\mu_r = 1 + \chi = 1 + 1500 = 1501$$

(b) Since $\chi = \frac{M}{H}$

$$\begin{aligned}
 \therefore M &= \chi H = 1500 \times 2400 \\
 &= 3.6 \times 10^6 \text{ A/m}
 \end{aligned}$$

(c) As $B = \mu_0 \mu_r H$

$$\begin{aligned}
 \therefore B &= (4\pi \times 10^{-7}) \times 1501 \times 2400 \\
 &= 4.52 \text{ T} \quad (T \text{ stands for tesla})
 \end{aligned}$$

Example 11.2 Relative permeability of ‘supermalloy’ is 200 000. It has a magnetization of 6000 A/m. Determine the strength of the magnet thus produced. Take $\mu_0 = 4\pi \times 10^{-7}$ henry/metre.

Solution. Given are: $\mu_r = 200\,000$, and $M = 6000$ A/m.

Since the strength of the magnet is expressed in Tesla (or Wb/m²) for which we have to determine magnetic flux density B , hence using Eqns. 11.6 and 11.10, we write

$$M = \chi H$$

$$= (\mu_r - 1)H$$

So $6000 = (200\,000 - 1)H$

or $H = \frac{6000}{199999} = 0.03$

Now on using Eqn. 11.4, we find as

$$B = \mu_0 \mu_r H$$

$$= (4\pi \times 10^{-7}) \times 200\,000 \times 0.03$$

$$= 7.539 \times 10^{-3} \text{ Wb/m}^2 = 0.007 \text{ tesla}$$

Example 11.3 Nickel has a magnetic moment of 0.6 times of Bohr magneton per atom. If its lattice constant is 0.35 nm, find the saturation magnetization.

Solution. Given are: $M = 0.6 \beta$, β (Bohr magneton) $= 9.27 \times 10^{-24} \text{ Am}^2$,

and $a = 0.35 \text{ nm} = 0.35 \times 10^{-9} \text{ m}$.

The structure of Ni unit cell is FCC, and effective number of atoms/unit cell $N_e = 4$. Therefore

$$M_s = \frac{N_e M}{a^3}$$

$$= \frac{4}{(0.35 \times 10^{-9})^3} \times 0.6 \times 9.27 \times 10^{-24} \text{ A/m}$$

$$= 0.51 \times 10^6 \text{ A/m}$$

11.3 Classification of Magnetic Materials

The magnetic materials are classified into following types based on the arrangement of their magnetic moments.

1. Diamagnetic materials,
2. Paramagnetic materials,