

1. The saturation magnetic induction of nickel is 0.65 Wb/m^2 . If the density of Nickel is 8906 kg/m^3 and atomic weight is 58.7. Calculate the magnetic moment of the nickel atom in Bohr magneton.

Solution:

Given $B_s = 0.65 \text{ Wb/m}^2$

$\rho = 8906 \text{ kg/m}^3$

Atomic weight = 58.7

We know $B_s = N\mu_o\mu_m$ (or) $\mu_m = \frac{B_s}{N\mu_o}$

We know $\mu_o = 4\pi \times 10^{-7}$

$$N = \frac{\rho A}{\text{Atomic weight}}$$

Here N is the number atoms/ m^3 in 1 kg of substance

$$\therefore N = \frac{8906 \times 6.023 \times 10^{26}}{58.7}$$

$$\therefore N = 9.14 \times 10^{28} \text{ atoms/m}^3$$

$$\begin{aligned}\therefore \mu_m &= \frac{0.65}{9.14 \times 10^{28} \times 4\pi \times 10^{-7}} \\ &= 5.66 \times 10^{-24} \text{ Am}^2\end{aligned}$$

We know 1 Bohr Magnetron = $9.27 \times 10^{-24} \text{ Am}^2$

$$\begin{aligned}\therefore \mu_m &= \frac{5.66 \times 10^{-24}}{9.27 \times 10^{-24}} \text{ Bohr magneton} \\ &= 0.61 \text{ Bohr magneton}\end{aligned}$$

$$\therefore \mu_m = 0.61 \mu_B$$

Avogadro Number
 ~~6.022×10^{23}~~
 6.022×10^{26}
In kg
 6.022×10^{26}

2. The rare earth element gadolinium is ferromagnetic below 16°C with 7.1 Bohr magneton per atom. Calculate the magnetic moment per gram. What is the value of saturation magnetisation, given that the atomic weight of gadolinium is 157.26 and its density is $7.8 \times 10^3 \text{ kg/m}^3$.

Solution:

$$\begin{aligned}\text{Number of atoms per kg} &= \frac{6.025 \times 10^{26} \times 7.8 \times 10^3}{157.26} \\ &= 2.9883 \times 10^{28}\end{aligned}$$

$$\therefore \text{Number of atoms per gram} = 2.9883 \times 10^{25}$$

$$(i) \text{ Magnetic moment per gram} = 2.9883 \times 10^{25} \times 7.1 \text{ Bohr magneton}$$

$$\text{Since 1 Bohr magneton} = 9.27 \times 10^{-24} \text{ Am}^2$$

$$\text{Magnetic moment per gram} = 2.9883 \times 10^{25} \times 7.1 \times 9.27 \times 10^{-24} \text{ Am}^2$$

$$m = 1966.809 \text{ Am}^2$$

$$(ii) \text{ Saturation magnetisation } B_s = N \mu_o \mu_m$$

$$= 2.9883 \times 10^{28} \times 4\pi \times 10^{-7} \times 9.27 \times 10^{-24}$$

$$B_s = 0.3481 \text{ Wbm}^{-2}$$

April 2002, June 2012

3. A paramagnetic material has a magnetic field intensity of 10^4 A/m . If the susceptibility of the material at room temperature is 3.7×10^{-3} calculate the magnetization and flux density in the material.

Solution:

$$(i) \text{ We know susceptibility } \chi = \frac{I}{H}$$

$$\therefore \text{Intensity of magnetisation } I = \chi H$$

$$= 3.7 \times 10^{-3} \times 10^4$$

$$I = 37 \text{ Am}^{-1}$$

(ii) Flux density $B = \mu_o [H + I]$

$$B = 4\pi \times 10^{-7} [10^4 + 37]$$

$$B = 0.012612 \text{ Wb/m}^2$$

MAY 2005

4. A magnetic field strength of 2×10^5 amperes/m is applied to a paramagnetic material with a relative permeability of 1.01. Calculate the values of B and M .

Solution:

Given data: Magnetic field strength $(H) = 2 \times 10^5$ Amp/m

Relative permeability $(\mu_r) = 1.01$

Permeability in free space $(\mu_o) = 4\pi \times 10^{-7}$

Formula: (i) We know magnetic permeability $= \mu = \frac{B}{H}$

$$\text{(or)} \mu_o \mu_r = \frac{B}{H} \quad [\because \mu = \mu_o \mu_r]$$

$\therefore$ Magnetic flux density $B = \mu_o \mu_r H$

$$\therefore B = 4 \times 3.14 \times 10^{-7} \times 1.01 \times 2 \times 10^5$$

$$\therefore B = 0.2537 \text{ weber/m}^2$$

$$\therefore \text{Magnetic flux density } (B) = 0.2537 \text{ Wb/m}^2$$

(ii) We know magnetic susceptibility $\chi_m = \mu_r - 1$

$$\text{(or)} \frac{M}{H} = \mu_r - 1 \quad [\because \chi_m = \frac{M}{H}]$$

$\therefore$ Intensity of magnetisation $M = H (\mu_r - 1)$

$$\therefore M = 2 \times 10^5 (1.01 - 1)$$

$$\therefore M = 2000 \text{ Amp/m}$$

$$\therefore \text{Intensity of magnetisation } (M) = 2000 \text{ Amp/m}$$

Nov. 2005, June 2010

5. Magnetic field intensity of a paramagnetic material is 10^4 A/m. At room temperature, its susceptibility is 3.7×10^{-3} . Calculate the magnetization in the material.

Solution:

We know $\chi = \frac{I}{H}$

(or) $I = H \chi$

$$\therefore I = 3.7 \times 10^{-3} \times 10^4$$

$$\therefore I = 37 \text{ Am}^{-1}$$

$$\therefore \text{Magnetization in the material} = 37 \text{ Am}^{-1}$$

June 2009

6. A magnetic field of 2000 A/m is applied to a material which has a susceptibility of 1000. Calculate (i) Intensity of magnetization and (ii) Flux density.

Solution

Given Data: $H = 2000 \text{ A/m}$

$$\chi = 1000$$

$$I = ?$$

$$B = ?$$

Formulae:

(i) Intensity of Magnetisation $I = \chi_m H$

$$I = 1000 \times 2000$$

$$\therefore I = 2 \times 10^6 \text{ A/m}$$

$$\therefore \text{Intensity of magnetization } I = 2 \times 10^6 \text{ A/m}$$

(ii) Flux density

$$B = \mu H$$

$$\text{Here } \mu = 1 + \chi_m$$

$$\therefore \mu = 1 + 1000$$

$$\therefore \mu = 1001$$

$$\therefore B = 1001 \times 2000 \times 4\pi \times 10^{-7}$$

$$\therefore B = 2.5145 \text{ Wb/m}^2$$

$$\therefore \text{Flux density } B = 2.5145 \text{ Wb/m}^2$$

May 2011

7. The magnetic field strength of Silicon is 1500 A/m. If the magnetic susceptibility is -0.3×10^{-5} , calculate the magnetization and flux density in Silicon.

Solution

Given Data:

$$H = 1500 \text{ A/m}$$

$$\chi_m = -0.3 \times 10^{-5}$$

Formulae:

(i) Intensity of magnetization $I = \chi_m H$

$$\therefore I = -0.3 \times 10^{-5} \times 1500$$

$$\therefore I = -4.5 \times 10^{-3} \text{ A/m}$$

$$\therefore \text{Intensity of magnetization } I = -4.5 \times 10^{-3} \text{ A/m}$$

(ii) Flux density $B = \mu H$

$$\therefore B = (1 + \chi_m) H$$

$$\therefore B = (1 - 0.3 \times 10^{-5}) \times 1500$$

$$\therefore B = 0.999997 \times 1500$$

$$\therefore B = 1499.9 \text{ Wb/m}^2$$

$$\therefore \text{Magnetic flux density } B = 1499.9 \text{ Wb/m}^2$$

ADDITIONAL SOLVED PROBLEMS

1. The magnetic field strength in copper is 10^6 A/m. If the magnetic susceptibility of copper is -0.8×10^{-5} , calculate the flux density and magnetisation in copper.

Solution

$$\chi_m = \frac{I}{H}$$

$$I = \chi_m H = -0.8 \times 10^{-5} \times 10^6$$

$$I = -8 \text{ A/m}$$

$$\mu_r = 1 + \chi_m$$

$$= 1 - 0.8 \times 10^{-5}$$

$$\mu_r = 0.999992$$

$$B = \mu H = 0.999992 \times 4\pi \times 10^{-7} \times 10^6$$

$$B = 1.26 \text{ wb/m}^2$$

2. A piece of ferric oxide with magnetic field intensity 10^6 A/m and susceptibility is 1.5×10^{-3} . Find the magnetisation of the material.

Solution

$$I = \chi_m H = 1.5 \times 10^{-3} \times 10^6$$

$$I = 1500 \text{ A/m}$$

3. A magnetic material of flux density and magnetisation are 0.0044 Wb/m^2 and 3300 A/m respectively. Calculate the magnetising force and relative permeability of the material.

Solution

$$\chi_m = \frac{I}{H} \Rightarrow \chi_m = \frac{I\mu}{H\mu} = \frac{I\mu}{B}$$

$$\frac{I}{B} = \frac{\chi_m}{\mu} = \frac{\mu_r - 1}{\mu_0 \mu_r}$$

$$\frac{I}{B} = \frac{3300}{0.0044} = 750000$$

$$\frac{\mu_r - 1}{\mu_r} = 4\pi \times 10^{-7} \times 750000 = 0.94247$$

$$1 - \frac{1}{\mu_r} = 0.94247$$

$$\frac{1}{\mu_r} = 0.0575$$

$$\mu_r = 17.3$$

$$H = \frac{B}{\mu} = \frac{0.0044}{4\pi \times 10^{-7} \times 17.3} = 202.39 \text{ A/m}$$

$$\mu_r = 1 + \chi_m = 1 + 1.5 \times 10^{-3}$$

$$\mu_r = 1.0015$$

$$B = \mu H = 1.0015 \times 4\pi \times 10^{-7} \times 10^6$$

$$\therefore B = 1.259 \text{ Wb/m}^2$$

4. Calculate the magnetic moment per unit volume in copper when subjected to a field whose magnetic inside copper is 10^4 A/m . The magnetic susceptibility of copper is -0.5×10^{-5} .

Solution

Magnetic moment per unit volume $\equiv$ Intensity of Magnetisation (I)

$$\chi_m = \frac{I}{H}$$

$$I = \chi_m H = -0.5 \times 10^{-5} \times 10^4$$

$$\therefore I = -0.05 \text{ A/m}$$