Anna University Solved Problems

Unit - 3: Magnetic materials

1. **The magnetic field strength of copper is 10^6 ampere / metre. If the magnetic susceptibility of copper is – 0.8 x 10^{-5}, calculate the magnetic flux density and magnetization in copper (*May 2014*)**

Given data(s): (i) Magnetic field strength (H) = 10^6 Am^{-1}
(ii) Magnetic susceptibility (χ) = -0.8 x 10^{-5}
(iii) Permeability of free space (μ_0) = 4π x 10^{-7} H/m

Formula(s): (i) $I = \chi H$
(ii) $\mu_r = 1+\chi$
(iii) $B = \mu_0 \mu_r H$

Calculation(s): (i) **-0.8 x 10^{-5} x 10^6 = -8 Am^{-1}**
(ii) 1 - 0.8 x 10^{-5} = 0.999
(iii) 0.999 x 4π x 10^{-7} x 10^6 = 1.26 Wb m^{-2}

Answer(s):
(i) Magnetization in copper (I) = -8 Am^{-1}
(ii) Magnetic flux density (B) = 1.26 Wbm^{-2}

2. **A magnetic field of 1800 ampere / meter produces a magnetic flux of 3 x 10^{-5} weber in an iron bar of cross sectional area 0.2 cm^2. Calculate magnetic permeability (May *2015*).**

Given data(s):
Magnetizing field (H) = 1800 Am^{-1}
Magnetic flux (ϕ) = 3 x 10^{-5} weber

Formula(s): $B = \phi / A$
$\mu = B / H$

Calculations:

$$B = \frac{3\times10^{-5}}{0.2\times10^{-4}} = 1.5\,\text{Wb/m}^2$$

$$\mu = \frac{1.5}{1800} = 8.33\times10^{-4}\,\text{Hm}^{-1}$$

Result(s)
B = 1.5 Wb/m^2
μ = 8.33 x 10^{-4} Hm^{-1}

3. **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 (*December 2016*).**

Given data (s):

Magnetic induction (B) = 0.65 Wb m^{-2}
Density (ρ) = 8906 kg m^{-3}
Atomic weight (M) = 58.7
Permeability of free space (μ_0) = 4π x 10^{-7} H/m
Avagardo number (N) = 6.023 x 10^{26}
Bohr magneton (μ_B) = 9.27 x 10^{-24} Am^2

Formula (s):

(i) B = n μ_0 μ_m (or) $\mu_m = \frac{B}{n\mu_0}$

(ii) No. of atoms per unit volume $n = \frac{\rho N}{M}$

***Calculation(s)*:**

$$n = \frac{8906 \times 6.023 \times 10^{26}}{58.7} = 9.14 \times 10^{28} m^{-3}$$

$$\mu_m = \frac{0.65}{9.14 \times 10^{28} \times 4\pi \times 10^{-7}} = 5.66 \times 10^{-24}$$

$$\mu_m = \frac{5.66 \times 10^{-24}}{9.27 \times 10^{-24}} = 0.61 \mu_B$$

Results:

n **= 9.14 x 10^{28} atoms/m^3**

μ_m = 0.61 μ_B

4. A paramagnetic material has bcc structure with a cube edge of 2.5 Å. If the saturation value of magnetization is 1.8 x 10^6 ampere / meter. Calculate the average magnetization contributed per atom in Bohr magneton (*December 2016*).

Given data (s):
a = 2.5 Å = 2.5x 10^{-10}m
M = 1.8 x 10^6 Am^{-1}
e = 1.6 x 10^{-19} C
h = 6.626 x 10^{-34} Js

Formula (s):

No of atoms / unit volume = No. of atoms in an unit cell / volume of unit cell

Average magnetization = Magnetization / No. of atoms per unit volume

***Calculation(s)*:**

No. of atoms per unit volume = $\frac{2}{(2.5\times10^{-10})^3} = 1.28\times10^{29} m^3$

Average magnetization per atom = $\frac{1.8\times10^6}{1.28\times10^{29}} = 1.406\times10^{-23}$ **Am^{-1}**

Average magnetization per Bohr magneton = $\frac{1.406\times10^{-23}}{9.27\times10^{-24}} = 1.52\mu_B$

Results:

Average magnetization per Bohr magneton = 1.52 μ_B.

5. Prove that $\mu_r = 1 + \chi$.

Solution:

When the magnetic material is kept in an external magnetic field, then the flux density can be written as $B = \mu_0 (H+I)$ (1)

In the absence of magnetic field, we know that $B = \mu H$ (2)

Sub (1) in (2), we get

$\mu H = \mu_0 (H+I)$

(or) $\mu_0 \mu_r H = \mu_0 (H+I)$ (since $\mu = \mu_0 + \mu_r$)

(or) $\mu_r H = H[1+\frac{I}{H}]$

(or) $\mu_r = 1+\chi$

Hence proved.