15. MAGNETISM

1. A circular coil of 300 turns and diameter 14 cm carries a current of 15 A. What is the magnitude of magnetic moment associated with the coil ?

Given :

n = 300

d = 14 cm

r = 7 cm = 7×10^{-2} m

I = 15 A

To Find :

M = ?

Formula :

M = nIA

Solution :

From formula

$M = nI\pi r^2$

$= 300 \times 15 \times \pi \times (7 \times 10^{-2})^2$

$\therefore$ M = 69.27 Am^2

2. An electron in an atom revolves around the nucleus in an orbit of radius 0.5 Å. Calculate the equivalent magnetic moment, if the frequency of revolution of electron is 10^{10} MHz.

Given :

r = 0.5 Å

$= 0.5 \times 10^{-10}$ m

f = 10^{10} MHz

$= 10^{10} \times 10^6 = 10^{16}$ Hz

To Find :

M = ?

Formula :

M = IA

Solution :

Since,

$I = \frac{1}{T}.e = f.e$

$\therefore$ M = IA becomes,

$M = feA = fe\pi r^2$

$= 10^{16} \times 1.6 \times 10^{-19} \times \pi \times (0.5 \times 10^{-10})^2$

$= 1.6 \times \pi \times 0.25 \times 10^{-23}$

$\therefore$ M = 1.256×10^{-23} Am^2

3. Find the percent increase in the magnetic field B when the space within a current-carrying toroid is filled with aluminium. The susceptibility of aluminium is 2.1×10^{-5}.

Solution :

The magnetic field inside the toroid in the absence of aluminium = $B_0 = \mu_o H$

When filled with aluminium,

$B = \mu_o (1 + \chi)H$

The increase in the field = $B - B_0 = \mu_0 \chi H$

The percent increase in the magnetic field

$$= \frac{B - B_0}{B_0} \times 100$$

$$= \frac{\mu_0 H + \mu_0 \chi H - \mu_0 H}{\mu_0 H} \times 100$$

$$= \frac{\mu_0 \chi H}{\mu_0 H}$$

$= \chi \times 100$

$= 2.1 \times 10^{-5} \times 100$

$\therefore$ % increase in B = 2.1×10^{-3}.

4. A bar magnet made of steel has magnetic moment of 2.5 Am^2 and a mass of 6.6×10^{-3} kg. If the density of steel is 7.9×10^3 kg/m^3, find the intensity of magnetization of the magnet

Given :

M_{net} = 2.5 Am^2

m = 6.6×10^{-3} kg

ρ = 7.9×10^3 kg/m^3

To Find :

M_z = ?

Formula :

$$M_z = \frac{M_{net}}{V}$$

Solution :

Since,

$$\rho = \frac{m}{V}$$

$$\therefore V = \frac{m}{\rho} = \frac{6.6 \times 10^{-3}}{7.9 \times 10^{3}}$$

$$= 8.354 \times 10^{-7}$$

$\therefore M_z = \frac{M_{net}}{V}$ becomes,

$$M_z = \frac{2.5}{8.354 \times 10^{-7}}$$

$$\therefore M_z = 3 \times 10^{6} \text{ A/m}$$

5. A susceptibility of annealed iron at saturation is 5500. Find the permeability of annealed iron at saturation.

Given :

$\chi = 5500$

To Find :

$\mu = ?$

Formula :

$\mu = \mu_0 (1 + \chi)$

Solution :

$\mu = \mu_0 (1 + \chi)$

$\mu = 4\pi \times 10^{-7} (1 + 5500)$

$\therefore \mu = 6.98 \times 10^{-3}$ T m/A

6. The susceptibility of magnesium at 300 K is 1.2×10^{-5}. At what temperature will the susceptibility increase to 1.8×10^{-5} ?

Given :

$\chi_1 = 1.2 \times 10^{-5}$

$T_1 = 300$ K

$\chi_2 = 1.8 \times 10^{-5}$

To Find :

$T_2 = ?$

Formula :

$\chi T = \text{constant}$

Solution :

From formula

$$\chi_1 T_1 = \chi_2 T_2$$

$$\therefore T_2 = \frac{\chi_1 T_1}{\chi_2}$$

$$= \frac{1.2 \times 10^{-5} \times 300}{1.8 \times 10^{-5}}$$

$$\therefore T_2 = 200 \text{ K}$$

7. The magnetic field B and the magnetic intensity H in a material are found to be 1.6 T and 1000 A/m respectively. Calculate the relative permeability 'μ_r' and the susceptibility 'χ' of the material ?

Given :

B = 1.6 T

H = 1000 A/m

To Find :

$\mu_r = ?$

$\chi = ?$

Formula :

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

ii) $\mu_r = 1 + \chi$

Solution :

Since,

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

$$\mu = \frac{1.6}{1000}$$

$$= 1.6 \times 10^{-3} \text{ T m/A}$$

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

$$\mu_r = \frac{1.6 \times 10^{-3}}{4\pi \times 10^{-7}}$$

$$\therefore \mu_r = 1.27 \times 10^{3}$$

$$\mu_r = 1 + \chi$$

$$\chi = \mu_r - 1$$

$$= 1.273 \times 10^{3} - 1$$

$$\chi = 1.272 \times 10^{3}$$