CHAPTER – 37
MAGNETIC PROPERTIES OF MATTER

1. $B = \mu_0 ni$, $\quad H = \dfrac{B}{\mu_0}$

$\Rightarrow H = ni$

$\Rightarrow 1500$ A/m $= n \times 2$

$\Rightarrow n = 750$ turns/meter

$\Rightarrow n = 7.5$ turns/cm

2. (a) H = 1500 A/m

As the solenoid and the rod are long and we are interested in the magnetic intensity at the centre, the end effects may be neglected. There is no effect of the rod on the magnetic intensity at the centre.

(b) $I = 0.12$ A/m

We know $\vec{I} = X\vec{H}$ $\quad$ X = Susceptibility

$\Rightarrow X = \dfrac{I}{H} = \dfrac{0.12}{1500} = 0.00008 = 8 \times 10^{-5}$

(c) The material is paramagnetic

3. $B_1 = 2.5 \times 10^{-3}$, $\quad B_2 = 2.5$

$A = 4 \times 10^{-4}\ m^2$, $\quad$ n = 50 turns/cm = 5000 turns/m

(a) $B = \mu_0 ni$,

$\Rightarrow 2.5 \times 10^{-3} = 4\pi \times 10^{-7} \times 5000 \times i$

$\Rightarrow i = \dfrac{2.5 \times 10^{-3}}{4\pi \times 10^{-7} \times 5000} = 0.398\ A \approx 0.4\ A$

(b) $I = \dfrac{B_2}{\mu_0} - H = \dfrac{2.5}{4\pi \times 10^{-7}} - (B_2 - B_1) = \dfrac{2.5}{4\pi \times 10^{-7}} - 2.497 = 1.99 \times 10^6 \approx 2 \times 10^6$

(c) $I = \dfrac{M}{V} \Rightarrow I = \dfrac{m\ell}{A\ell} = \dfrac{m}{A}$

$\Rightarrow m = IA = 2 \times 10^6 \times 4 \times 10^{-4} = 800$ A-m

4. (a) Given $\quad d = 15$ cm $= 0.15$ m

$\ell = 1$ cm $= 0.01$ m

$A = 1.0\ cm^2 = 1 \times 10^{-4}\ m^2$

$B = 1.5 \times 10^{-4}$ T

M = ?

We Know $\vec{B} = \dfrac{\mu_0}{4\pi} \times \dfrac{2Md}{(d^2 - \ell^2)^2}$

$\Rightarrow 1.5 \times 10^{-4} = \dfrac{10^{-7} \times 2 \times M \times 0.15}{(0.0225 - 0.0001)^2} = \dfrac{3 \times 10^{-8} M}{5.01 \times 10^{-4}}$

$\Rightarrow M = \dfrac{1.5 \times 10^{-4} \times 5.01 \times 10^{-4}}{3 \times 10^{-8}} = 2.5$ A

(b) Magnetisation $I = \dfrac{M}{V} = \dfrac{2.5}{10^{-4} \times 10^{-2}} = 2.5 \times 10^6$ A/m

(c) $H = \dfrac{m}{4\pi d^2} = \dfrac{M}{4\pi I d^2} = \dfrac{2.5}{4 \times 3.14 \times 0.01 \times (0.15)^2}$

net $H = H_N + H_{'} = 2 \times 884.6 = 8.846 \times 10^2$

$\vec{B} = \mu_0 (-H + I) = 4\pi \times 10^{-7} (2.5 \times 10^6 - 2 \times 884.6) \approx 3{,}14$ T

5. Permiability (μ) = $\mu_0(1 + x)$
Given susceptibility = 5500
$\mu = 4 \times 10^{-7} (1 + 5500)$
$= 4 \times 3.14 \times 10^{-7} \times 5501\ 6909.56 \times 10^{-7} \approx 6.9 \times 10^{-3}$

6. B = 1.6 T,   H = 1000 A/m
μ = Permeability of material
$\mu = \frac{B}{H} = \frac{1.6}{1000} = 1.6 \times 10^{-3}$
$\mu r = \frac{\mu}{\mu_0} = \frac{1.6 \times 10^{-3}}{4\pi \times 10^{-7}} = 0.127 \times 10^4 \approx 1.3 \times 10^3$
$\mu = \mu_0 (1 + x)$
$\Rightarrow x = \frac{\mu}{\mu_0} - 1$
$= \mu_r - 1 = 1.3 \times 10^3 - 1 = 1300 - 1 = 1299 \approx 1.3 \times 10^3$

7. $x = \frac{C}{T} = \Rightarrow \frac{x_1}{x_2} = \frac{T_2}{T_1}$
$\Rightarrow \frac{1.2 \times 10^{-5}}{1.8 \times 10^{-5}} = \frac{T_2}{300}$
$\Rightarrow T_2 = \frac{12}{18} \times 300 = 200$ K.

8. $f = 8.52 \times 10^{28}$ atoms/m^3
For maximum 'I', Let us consider the no. of atoms present in 1 m^3 of volume.
Given: m per atom = $2 \times 9.27 \times 10^{-24}$ A–m^2
$I = \frac{\text{net m}}{V} = 2 \times 9.27 \times 10^{-24} \times 8.52 \times 10^{28} \approx 1.58 \times 10^6$ A/m
$B = \mu_0 (H + I) = \mu_0 I$ [$\because$ H = 0 in this case]
$= 4\pi \times 10^{-7} \times 1.58 \times 10^6 = 1.98 \times 10^{-1} \approx 2.0$ T

9. $B = \mu_0 ni$, $H = \frac{B}{\mu_0}$
Given n = 40 turn/cm = 4000 turns/m
$\Rightarrow H = ni$
$H = 4 \times 10^4$ A/m
$\Rightarrow i = \frac{H}{n} = \frac{4 \times 10^4}{4000} = 10$ A.

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