

1ª. Lista de Exercícios
Introdução ao Magnetismo e Materiais Magnéticos
1º. Semestre de 2025
Respostas

- 1 (a) $\mu = 4,85 \times 10^{-6} \text{ H/m}$ e $\mu_r = \mu/\mu_0 = 3,86$.
(b) $\chi = 2,86$.
(c) Ferromagnetismo ou ferrimagnetismo fracos. A permeabilidade e susceptibilidade são pequenas, a susceptibilidade é positiva, mas é aproximadamente 3 ordens de grandeza maior que um típico paramagneto.
- 2) (a) $\chi = 3820$; $\mu_r = \mu/\mu_0 = 3821$; $\mu = 4,80 \times 10^{-3} \text{ H/m}$
(b) $B = 2,40 \text{ T}$
(d) Ferromagnetismo forte e material macio, pois a indução magnética é alta (a do Fe é 2,2T) e a susceptibilidade é positiva e é cerca de 6 ordens de grandeza maior que de um paramagneto.
- 3) $d_{\text{Co}} = 8,9 \text{ g/cm}^3$, $m_{\text{at.}} = 59 \text{ g/mol}$
(a) $n = (6,02 \times 10^{23} \text{ at.} \times 8900 \text{ kg/m}^3) / 59 \times 10^{-3} \text{ kg} = 9,08 \times 10^{28} \text{ at/m}^3$
 $\rightarrow M_s = n \times 1,72 \times \mu_B = 1,448 \times 10^6 \text{ A/m}$
(b) $B_s \approx \mu_0 M_s = 1,82 \text{ T}$
- 4) Ferro metálico é CCC e tem 2 átomos por célula unitária. A célula é cúbica então $V = (2,8660 \text{ \AA})^3 = 23,54 \times 10^{-30} \text{ m}^3$. $M_s = 1,70 \times 10^6 \text{ A/m}$ e $a = 2,8660 \text{ \AA}$.
 $n = 2 / 23,54 \times 10^{-30} = 8,50 \times 10^{28} \text{ at/m}^3$
 $N = M_s / (n \times \mu_B) = 1,70 \times 10^6 / (8,50 \times 10^{28} \times 9,27 \cdot 10^{-24}) = 2,16$

5)

(a) The saturation magnetization of nickel ferrite is computed in the same manner as Example Problem 21.2, and from the expression

$$M_s = \frac{n_B \mu_B}{a^3}$$

Now, n_B is just the number of Bohr magnetons per unit cell. The net magnetic moment arises from the Ni^{2+} ions, of which there are eight per unit cell, each of which has a net magnetic moment of two Bohr magnetons (Table 21.4). Thus, n_B is sixteen. Therefore,

$$\begin{aligned} M_s &= \frac{(16 \text{ BM/unit cell})(9.27 \times 10^{-24} \text{ A}\cdot\text{m}^2/\text{BM})}{(0.8337 \times 10^{-9} \text{ m})^3/\text{unit cell}} \\ &= 2.56 \times 10^5 \text{ A/m} \end{aligned}$$

(b) This portion of the problem calls for us to compute the saturation flux density. From Equation (21.8)

$$\begin{aligned} B_s &= \mu_0 M_s \\ &= (1.257 \times 10^{-6} \text{ H/m})(2.56 \times 10^5 \text{ A/m}) = 0.32 \text{ tesla} \end{aligned}$$

6)

We want to compute the number of Bohr magnetons per Mn^{2+} ion in $(\text{MnFe}_2\text{O}_4)_8$. Let n represent the number of Bohr magnetons per Mn^{2+} ion; then, using the expression

$$M_s = nN\mu_B$$

in which N is the number of Mn^{2+} ions per cubic meter of material. But, from Equation (4.2)

$$N = \frac{N_A \rho}{A}$$

in which A is the molecular weight of MnFe_2O_4 (230.64 g/mol). Thus,

$$M_s = \frac{nN_A \rho \mu_B}{A}$$

or

$$\begin{aligned} n &= \frac{M_s A}{N_A \rho \mu_B} \\ &= \frac{(5.6 \times 10^5 \text{ A/m})(230.64 \text{ g/mol})}{(6.023 \times 10^{23} \text{ ions/mol})(5.0 \times 10^6 \text{ g/m}^3)(9.27 \times 10^{-24} \text{ A}\cdot\text{m}^2/\text{BM})} \\ &= 4.6 \text{ Bohr magnetons}/\text{Mn}^{2+} \text{ ion} \end{aligned}$$