

✓ Exercises

$$\begin{aligned} \text{Q1)} \quad & \rho = 7873 \text{ kg m}^{-3} \\ & M_A = 55.847 \\ & T_c = 1043 \text{ K} \\ & \text{moment/atom} = 2.2 \mu_B \end{aligned}$$

$$B_{\text{mf}} = \frac{3 k_B T_c}{g_J \mu_B (1+J)}$$

It is given that $g_J (1+J) \approx 2.2$

$$B_{\text{mf}} = \frac{3 k_B T_c}{2.2 \mu_B} \approx \frac{3 \times 1.38 \times 10^{-23} \times 1043}{2.2 \times 9.27 \times 10^{-24}} = \boxed{2.12 \times 10^3 \text{ T}}$$

$$\rightarrow M_{\text{sat}} = n (2.2 \mu_B)$$

$$\underline{n} = ?$$

55.847 g has 6.02×10^{23} atoms.

$$\begin{aligned} 55.847 \text{ g has a volume of } & \frac{55.847}{7.873} = 7.09 \text{ cm}^3 \\ & = 7.09 \times 10^{-6} \text{ m}^3 \end{aligned}$$

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$$\cancel{N} = 6.02 \times 10^{23} \text{ atoms} \equiv 7.09 \times 10^{-6} \text{ m}^3$$

$$n = \frac{6.02 \times 10^{23}}{7.09 \times 10^{-6}} = 0.84 \times 10^{29} \text{ m}^{-3} = 8.4 \times 10^{28} \text{ m}^{-3}$$

$$M_{\text{sat}} \approx 8.4 \times 10^{28} \times 2.2 \times 9.27 \times 10^{-24} = 1.71 \times 10^6 \text{ A m}^{-1}$$

$$B_{\text{sat}} = \mu_0 M = 2.2 \text{ T}$$

$$B_{\text{mf}} \gg B_{\text{sat}}$$

The molecular field is 3 orders of magnitude larger than what is required to saturate the spins.

HW ✓
Q2

$$M_+ = m_s \frac{g_J \mu_B J}{k_B T} (B + |\alpha| M_+ - |\lambda| M_-) \left(\frac{J+1}{3J} \right)$$

closer to
a real
antiferromagnet

$$M_- = m_s \frac{g_J \mu_B J}{k_B T} (B + |\alpha| M_- - |\lambda| M_+) \left(\frac{J+1}{3J} \right)$$

$$M_+ + M_- = m_s \frac{g_J \mu_B J}{k_B T} \left(\frac{J+1}{3J} \right) (2B + |\alpha| (M_+ + M_-) - |\lambda| (M_+ + M_-))$$

$$M = \frac{m_s g_J \mu_B J}{k_B T} \left(\frac{J+1}{3J} \right) (2B) + \frac{m_s g_J \mu_B J}{k_B T} \alpha \left(\frac{J+1}{3J} \right) M - |\lambda| \frac{m_s g_J \mu_B J}{k_B T} \left(\frac{J+1}{3J} \right) M$$

$$M \left(1 - \alpha \left(\frac{J+1}{3J} \right) \frac{m_s g_J \mu_B J}{k_B T} + |\lambda| \left(\frac{J+1}{3J} \right) \frac{m_s g_J \mu_B J}{k_B T} \right) = \frac{m_s g_J \mu_B J}{k_B T} (2B) \left(\frac{J+1}{3J} \right)$$

$$\text{Now } T_N = \frac{m_s (J+1) g_J \mu_B \lambda}{3k_B}$$

$$M \left(1 - \alpha \frac{T_N}{T} + \frac{T_N}{T} \right) = 2B \frac{T_N}{T}$$

$$\chi = \frac{2 \mu_0 T_N / T}{1 + \left(\frac{T_N}{T} \left(-\frac{\alpha}{\lambda} + 1 \right) \right)} = \frac{2 \mu_0 T_N}{T + \left(-\frac{\alpha}{\lambda} + 1 \right) T_N}$$

