Problem 5.31 Iron contains 8.5×10^{28} atoms/m^3. At saturation, the alignment of the electrons' spin magnetic moments in iron can contribute 1.5 T to the total magnetic flux density **B**. If the spin magnetic moment of a single electron is 9.27×10^{-24} (A·m^2), how many electrons per atom contribute to the saturated field?

Solution: From the first paragraph of Section 5-6.2, the magnetic flux density of a magnetized material is $\mathbf{B}_m = \mu_0 \mathbf{M}$, where $\mathbf{M}$ is the vector sum of the microscopic magnetic dipoles within the material: $\mathbf{M} = N_e \mathbf{m}_s$, where $\mathbf{m}_s$ is the magnitude of the spin magnetic moment of an electron in the direction of the mean magnetization, and N_e is net number of electrons per unit volume contributing to the bulk magnetization. If the number of electrons per atom contributing to the bulk magnetization is n_e, then $N_e = n_e N_{\text{atoms}}$ where $N_{\text{atoms}} = 8.5 \times 10^{28}$ atoms/m^3 is the number density of atoms for iron. Therefore,

$$n_e = \frac{N_e}{N_{\text{atoms}}} = \frac{M}{m_s N_{\text{atoms}}} = \frac{B}{\mu_0 m_s N_{\text{atoms}}} = \frac{1.5}{4\pi \times 10^{-7} \times 9.27 \times 10^{-24} \times 8.5 \times 10^{28}}$$
$$= 1.5 \quad \text{(electrons/atom)}.$$