Magnetic properties

1. Fill in the following table with values of $\vec{B}$

	Tesla (T)	Gauss (G)
Earth's field		
small bar magnet		
electromagnet		
MRI, NMR magnet		
at National High Magnetic Field Lab		

2. Draw the magnetic field lines for a loop of current, a solenoid, a bar magnet, and Earth. Add the magnetic dipole moment for each to your sketch.

3. The electron spin has an associated magnetic dipole moment of $\mu_B = e\hbar/2m$. μ_B is called the Bohr magneton.

   (a) What are the units of μ_B? Use SI

   (b) Calculate the value of μ_B.

   (c) Calculate the interaction energy, $\pm U$, of the electron spin magnetic dipole moment with a 1.0T field. Use eV.

   (d) Compare the interaction energies to the thermal energy at room temperature (300K). Is this a case of $k_BT \ll U$ or $k_BT \gg U$?

   (9.3×10^{-24}J/T, $\pm 58\mu$ eV, 2.6 eV)

4. Estimate the susceptibility in a Curie paramagnetic material with 2×10^{28} moments/m^3 at room temperature. Use $\mu = \mu_B$.

   (5.2×10^{-4})

5. The magnetic susceptibility due to delocalized electrons (Pauli paramagnetism) is given by

$$\chi = g(E_f)m_m^2\mu_0$$

   Substitute in the density of states at the Fermi energy to show that

$$\chi = \frac{3n\mu_b^2\mu_0}{2E_F}$$

   where n is the valence electron density.

6. Sodium has valence electron density of $2.7 \times 10^{28}m^{-3}$ and a Fermi energy of 3.22 eV.

   (a) Calculate the magnetic susceptibility due to Pauli paramagnetism.

   (b) The measured magnetic susceptibility is 7.2×10^{-6}. Given that $\chi = \chi_{para} + \chi_{dia}$, estimate the diamagnetic susceptibility of sodium.

   ($8.4 \times 10^{-6}, -1.2 \times 10^{-6}$)

7. Which electrons can participate in Pauli paramagnetism? All of them? All of the valence? Just a few? Explain and include a diagram.

8. How is Curie paramagnetism different from Pauli paramagnetism?