Indian Institute of Technology, Delhi
Department of Physics
Minor I

PYL422/EPL446 Spintronics

Total marks: 15 Time: 45 min

1. A system of electrons with spin angular momentum 5 ħ/2 along z axis is exposed to a magnetic field of 2 T applied along the same direction. What is the Zeeman splitting of the system? [3]

2. Explain qualitatively how Hund's rules support minimization of Coulomb repulsion. [2]

3. Explain with a diagram to show how the magnetic susceptibility for an antiferromagnet and ferromagnet vary with temperature. Indicate the corresponding transition temperatures in the diagram. [2]

4. In Fe (at. no. 26), d electrons contribute to the magnetic moment of the atoms. The magnetic moments per Fe atom is ~ 2.2 μ_B. Assume that the exchange constant in Fe can be estimated by setting equal to $k_B T_c$ where T_c (Curie Temperature) = 1043 K.
Estimate the ratio of the exchange and dipolar coupling of two adjacent Fe atoms in metallic Fe. [3]

5. For a ferromagnet, it can be shown that

$$3k_B T_c = g_J \mu_B (J+1) \lambda M_s.$$

Estimate the Weiss molecular field for Gd (T_c= 292 K, J=S=7/2). [2]

6. In a cubic crystal, the magnetocrystalline anisotropy energy is given by

$$E = K_1(\alpha_1^2 \alpha_2^2 + \alpha_2^2 \alpha_3^2 + \alpha_1^2 \alpha_3^2) + K_2 \alpha_1^2 \alpha_2^2 \alpha_3^2 + \ldots..$$

where k's are anisotropy constants and α's are the direction cosines.

Estimate the value for E for [100] and [111] directions. [1+2]

$\hbar = 1.054 \times 10^{-34}$ Js, $k_B = 1.38 \times 10^{-23}$ J/K, $\mu_B = 9.274 \times 10^{-24}$ J/T, $\mu_0 = 4\pi \times 10^{-7}$ Tm/A

Note: All parameters used in the questions have their usual meanings.