QUEEN MARY, UNIVERSITY OF LONDON
SCHOOL OF PHYSICS AND ASTRONOMY

Structure and Properties of Functional Materials

Homework Set 8

Due Wednesday, 27 March, 2013 by 4 p.m.

Problem 1: Terms and definitions (8 marks)

Explain the following terms or concepts, giving an example of their significance in condensed matter physics:

(a) Magnetic susceptibility (4)

(b) Exchange interaction (4)

Problem 2: Hund's rules (14 marks)

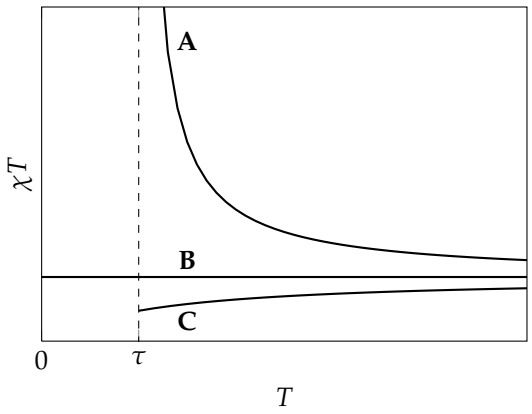
(a) Complete the following table to predict the magnetic ground state of these two magnetic ions. (10)

Ion	Config.	S	L	J	g_J	$\mu_{\text{eff}}/\mu_{\text{B}}$	$\mu_{\text{eff}}^{\text{experimental}}/\mu_{\text{B}}$
Tm^{3+}	$4f^{12}$						7.61
Mn^{3+}	$3d^4$						4.90

(b) Why is the agreement with experiment so much better for the thulium than for the manganese ion? Name the phenomenon responsible for this difference. Suggest an alternative way of calculating μ_{eff} that agrees better with experiment. (4)

Problem 3: Types of magnetic ordering (8 marks)

Consider the following sketch, showing the variation of χT with T for three different materials.



(a) What type of magnetism does each material display? (3)

(b) What happens at $T = \tau$ to material **A**? Explain why the susceptibility of this material diverges to infinity as T decreases towards τ. (5)

Data:

Electronic charge	$e = 1.6022 \times 10^{-19}\,\mathrm{C}$
Planck constant	$h = 6.626 \times 10^{-34}\,\mathrm{J\,s}$
	$\hbar = h/2\pi = 1.055 \times 10^{-34}\,\mathrm{J\,s}$
Boltzmann constant	$k_\mathrm{B} = 1.3807 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
Electron mass	$m = 9.109 \times 10^{-31}\,\mathrm{kg}$
Avogadro number	$N_\mathrm{A} = 6.022 \times 10^{23}\,\mathrm{mol^{-1}}$
Bohr magneton	$\mu_\mathrm{B} = 9.274 \times 10^{-24}\,\mathrm{A\,m^2}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{7}\,\mathrm{H\,m^{-1}}$