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Problem sheet 2: Atomic magnetism **6.11.2024**

You can use both the SI or CGS units, but you may find CGS easier whenever magnetic moments and magnetic susceptibilities are involved.

2.1. Ambiguity of the atomic states (5 P)

Compare two possible scenarios of the valence states in La_2CrFeO_6: i) Cr^{3+} and Fe^{3+}; ii) Cr^{2+} and Fe^{4+}

(a) Determine the spin quantum number (S) for each of the ions. Assume the high-spin state for both Co and Mn. Neglect the orbital moment.

(b) Determine the saturation magnetization (in units of μ_B) for the scenarios i) and ii)

(c) Determine the Curie constants and the corresponding paramagnetic effective moments μ_{eff} (in units of μ_B) for the scenarios i) and ii)

2.2. Entropy storage in paramagnets (6 P)

Consider the paramagnetic salt $KCr(SO_4)_2 \cdot 12H_2O$ (CPA = chromium potassium alum) used in adiabatic demagnetization refrigeration. This compound features Cr^{3+} in the octahedral coordination.

(a) Calculate the change in the molar entropy on magnetizing this salt from 0 T to 5 T at 2 K.

(b) Calculate the respective volume entropy density of CPA as the magnetic refrigerant.

2.3. Hund's rules in action (4 P)

Determine the saturation magnetization and paramagnetic effective moments for the following ions:

(a) Nd^{3+}

(b) Tb^{3+}

Express the result in units of μ_B.

2.4. High-spin or low-spin? (5 P)

Magnetization measurements on a 20 mg sample of $K_3Fe(CN)_6$ in the applied field of 1 T returned the following values of the magnetic moment:

10 K	0.02448 emu
50 K	0.00490 emu
100 K	0.00245 emu

Calculate the paramagnetic effective moment and determine whether Fe^{3+} is in the high-spin or low-spin state. Neglect the orbital moment.