

# Physics 4311: Thermal Physics - Homework 11

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due date: Tuesday, April 22, 2025, please upload your solution as a pdf on Canvas

## Problem 1: Curie law (10 points)

Consider a paramagnetic material whose magnetic susceptibility is governed by the Curie law  $m = aB/T$  where  $m$  is the magnetization,  $B$  is the magnetic field (induction), and  $a$  is the Curie constant .

- a) Does the magnetization of the material increase or decrease when the material is cooled from a temperature of 300 K to 100 K at constant nonzero magnetic field?
- b) By what factor does the magnetization change?

## Problem 2: Heat capacities of a paramagnet (30 points)

This problem is about the heat capacities of a magnetic material. It compares the heat capacity at constant field,  $C_B$  with heat capacity at constant magnetization,  $C_m$ .

- a) Show that for any magnetic material, the two heat capacities are related via

$$C_m - C_B = T \left( \frac{\partial m}{\partial T} \right)_B \left( \frac{\partial B}{\partial T} \right)_m .$$

Hint: Start from the total differential of the entropy as a function of  $B$  and  $T$  and take a derivative w.r.t.  $T$  at fixed  $m$ . Use a MAXwell relation to simplify the resulting expression.

- b) Show that for a paramagnet that fulfills the Curie law  $m = aB/T$ , the derivatives in the above relation can be computed, giving  $C_m - C_B = -aB^2/T^2$ .