Thermal Physics, Autumn 2016 CMI

Problem set 9

Due by the beginning of lecture on Monday Nov 14, 2016

van der Waals gas

1. $\langle \mathbf{7} \rangle$ Consider n moles of a vdW gas satisfying the equation of state

$$(p + \frac{n^2 a}{V^2})(V - nb) = nRT. \tag{1}$$

Suppose we measure p, V, T in units of their critical values

$$p_c = \frac{a}{27b^2}, \quad V_c = 3nb \quad \text{and} \quad T_c = \frac{8a}{27Rb}, \tag{2}$$

by defining $\mathcal{P} = p/p_c$, $\mathcal{V} = V/V_c$ and $\mathcal{T} = T/T_c$. Show that the EOS takes a universal form, i.e. the same form irrespective of the values of the material parameters a and b. Find this universal EOS.

2. $\langle \mathbf{7} \rangle$ Find an expression for the entropy of a vdW gas as a function of T and V, assuming the heat capacity C_V is independent of temperature. Hint: Use the caloric condition.