Physics 3410 Homework #6

5 problems

Due by March 14 (after break)

▷ **1.**

Calculate the chemical potential of an ideal gas, given the Sackur-Tetrode equation.

▷ **2.**

Consider an Einstein solid in the low-temperature limit $N \gg q \gg 1$, which as you'll recall has the multiplicity

$$\Omega = \left(\frac{eN}{q}\right)^q$$

(a) Find a formula for the temperature of an Einstein solid in the limit $q \ll N$. Let $U = q\varepsilon$ where ε is the energy per quantum.
(b) Solve for the energy as a function of temperature to obtain $U = N\varepsilon e^{-\varepsilon/kT}$.

▷ **3.**

Consider a $V = 1\,\mathrm{m}^3$ solid block of lead at standard temperature and pressure. The coefficient of volume expansion for lead is $\beta = 70 \times 10^{-6}\,/\mathrm{K}$, where

$$\beta V = \left(\frac{\partial V}{\partial T}\right)_{P,N}$$

Assume that the metal has $f = 6$ degrees of freedom per atom, and it obeys the equipartition theorem.
(a) If the block's temperature increases by $2\,\mathrm{K}$ at constant pressure, what is its increase in enthalpy? *(Hint: use β to find the change in volume.)*
(b) What is the block's heat capacity C_P at constant pressure, given this data?

▷ **4.**

During a particular quasistatic chemical reaction at constant temperature and pressure, the thermal potentials undergo the following changes:

$$\Delta U = +40\,\mathrm{kJ} \qquad \Delta H = +10\,\mathrm{kJ} \qquad \Delta F = +50\,\mathrm{kJ} \qquad \Delta G = +20\,\mathrm{kJ}$$

Answer the following questions:
(a) How much heat flows into or out of the system?
(b) What is the total work done on the system by the environment (or vice versa)?
(c) How much of that work is not due to the compression or expansion of the system?
(d) Does the system expand or contract?

▷ **5.**

At constant temperature and pressure, explain why

$$\Delta H + \Delta F = \Delta U + \Delta G$$