Hints for exam 2013-04-05

1 Movable plate with unknown mass

To solve this one needs three equations:

1. Initial energy = final energy.
2. The total force on the plate sums to zero.
3. The partitions have the same temperature.

I then get

$$M = \frac{12}{7} N n k_B T_i \frac{A}{V}.$$

2 Entropy increase

Use the Sackeur-Tetrode equation for the entropy. Note that energy per particle is $\propto T$ and that the final energy is $U_f = U_1 + U_2$, where $U_f = (3/2)2Nk_BT_f$, $U_1 = (3/2)Nk_BT_1$, and $U_2 = (3/2)Nk_BT_2$.

I find that the increase in entropy is

$$\Delta S = Nk_B \ln \left[\frac{4}{3} \left(\frac{4}{3} \right)^{3/2} \right].$$

3 Chemical potential in the Debye model

Use the same methods as in probl. 3 of 2013-01-13.

4 Efficiency of an engine cycle

Determine the heat flows associated with step 2 and 3. (No heat flow in the adiabatic process!) These give Q_c and Q_h which are used to determine the efficiency.

5 Change in Gibbs free energy

Hint: Note that

$$dF = -SdT - pdV + \mu dN,$$

implies

$$\left(\frac{\partial F}{\partial V}\right)_{TN} = -p.$$

Therefore, first calculate

$$\Delta F = \int_{V_1}^{V_2} (-p) dV,$$

and then use $\Delta G = \Delta F + \Delta(pV)$.

I get

$$\Delta G = -Nk_B \ln 2 - \frac{Nk_BT}{8} + \frac{28}{25 \cdot 27} \frac{AN}{b^2}.$$