1. Problem 20–14 in McQuarrie & Simon:

   Show that
$$\Delta\overline{S} = \overline{C}_V \ln\frac{T_2}{T_1} + R\ln\frac{V_2}{V_1}$$
   if one mole of an ideal gas is take from T_1, V_1 to T_2, V_2, assuming that $\overline{C}_V$ is independent of temperature. Calculate the value of $\Delta\overline{S}$ if one mole of N_2(g) is expanded from 20.0 dm^3 at 273 K to 300 dm^3 at 400 K. Take $\overline{C}_P = 29.4\,\mathrm{J\,K^{-1}\,mol^{-1}}$.

2. Problem 20–17 in McQuarrie & Simon:

   Show that
$$\Delta S \geq \frac{q}{T}$$
   for an isothermal process. What does this equation say about the sign of ΔS? Can ΔS decrease in a reversible isothermal process? Calculate the entropy change when one mole of an ideal gas is compressed reversibly and isothermally from a volume of 100 dm^3 to 50.0 dm^3 at 300 K.

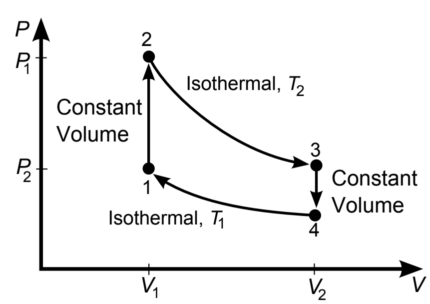
3. Problem 20–18 in McQuarrie & Simon:

   Vaporization at the normal boiling point (T_{vap}) of a substance (the boiling point at one atm) can be regarded as a reversible process because if the temperature is decreased infinitesimally below T_{vap}, all the vapor will condense to liquid, whereas if it is increased infinitesimally above T_{vap}, all the liquid will vaporize. Calculate the entropy change when two moles of water vaporize at 100.0 °C. The value of $\Delta_{\mathrm{vap}}\overline{H}$ is 40.65 kJ mol^{-1}. Comment on the sign of $\Delta_{\mathrm{vap}}S$.

4. Problem 20–19 in McQuarrie & Simon:

   Melting at the normal boiling point (T_{fus}) of a substance (the melting point at one atm) can be regarded as a reversible process because if the temperature is changed infinitesimally from exactly T_{fus}, then the substance will either melt or freeze. Calculate the change in entropy when two moles of water melt at 0 °C. The value of $\Delta_{\mathrm{fus}}\overline{H}$ is 6.01 kJ mol^{-1}. Compare your answer with the one you obtained in Problem 3. Why is $\Delta_{\mathrm{vap}}S$ much larger than $\Delta_{\mathrm{fus}}S$?

5. A Stirling engine has the PV cycle shown in the figure below and uses an ideal gas working fluid. The steps are quasi static.



(a) How much work is done in the constant-volume segments w_{12} and w_{34}?

(b) What is the energy change around the cycle, $\Delta U_{\text{tot}} = \Delta U_{12} + \Delta U_{23} + \Delta U_{34} + \Delta U_{41}$?

(c) What is the total work performed around the cycle, $w_{\text{tot}} = w_{12} + w_{23} + w_{34} + w_{41}$?

(d) If $T_2 = 2000\,\text{K}$, $T_1 = 300\,\text{K}$, $V_2 = 1\,\text{L}$, $V_1 = 0.01\,\text{L}$, and $n = 0.1\,\text{mol}$ of ideal gas, compute w_{tot}.

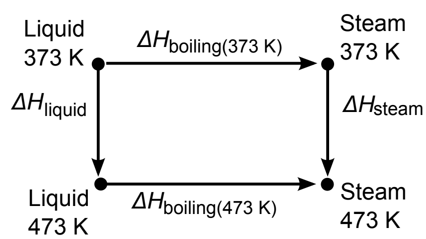
6. Suppose the compression ratio in your car engine is $V_2/V_1 = 8$. For a diatomic gas, $C_V = (5/2)Nk$ and for ethane, $C_V \approx 5Nk$.

   (a) What is the efficiency of your engine if the working fluid is a diatomic gas?

   (b) Which is more efficient: a diatomic gas or ethane?

   (c) Would your engine be more or less efficient with a higher compression ratio?

7. Suppose you want to know how much heat it would take to boil water at 473 K, rather than 373 K. At $T = 373\,\text{K}$, $\Delta H_{\text{boiling}(100\,°\text{C})} = 40.7\,\text{kJ mol}^{-1}$ is the enthalpy of vaporization. Assuming that the heat capacities of the liquid $\left(C_{p,\text{liquid}} = 75\,\text{J K}^{-1}\,\text{mol}^{-1}\right)$ and the vapor $\left(C_{p,\text{vapor}} = 3.5\,\text{J K}^{-1}\,\text{mol}^{-1}\right)$ are constant over this tempearture range, calculate the enthalpy of vaporization at 473 K using the thermodynamic cycle shown below.



8. 10 points extra credit: Maximum Entropy in Las Vegas

   You play a slot machine in Las Vegas. For every \$1 coin you insert there are three outcomes:

   (a) you lose \$1.

   (b) you win \$1, so your profit is \$0.

   (c) you win \$5, so your profit is \$4.

   Suppose you find that your average expected profit over many trials is \$0 (i.e. you play slots at a casino owned by someone exceedingly generous or stupid). Find the maximum entropy distribution for the probabilities p_1, p_2 and p_3 of observing each of these three outcomes.