ChE-304 Problem Set 4

Week 4

Problem 1

Massieu (a French mathematician and physicist) proposed alternate thermodynamic potentials based on entropy as a function of internal energy ($dS(U, V, N)$). We don't use them because they are less practical than the ones you are used to seeing. Can you write the 4 "Massieu thermodynamic potentials" with dS being the first and the 3 others obtained using Legendre transformations?

Hint: the goal of the Legendre transforms is to have the variables be functions of intensive variables (in this case T and P). They do not have to be as simple as the classical potentials you are used to.

Problem 2

The Petit Chêne in Lausanne goes up by about 60 m. Imagine you want to build a 1 ton car that can go up the Petit Chêne in one minute. Assuming the only thing the car has to deal with is climbing the hill (no friction, or other non ideal losses) and that the fuel cell is reversible, what are the minimum number of hydrogen fuel cells you will need and the minimum hydrogen consumption per time?

Assume a typical fuel cell current densities are on the order of 1 A/cm^2 with reasonably sized cell that can fit into a car (measuring 100 cm^2).

Faraday's constant: $F = 96485 \frac{C}{mol\, e^{-}}$

Problem 3

Can you re-derive the efficiency of a fuel cell using a simple energy balance for a reversible fuel cell? Assume reactants enter the fuel cell continuously and products (after full reaction) exit the fuel cell continuously. Draw all the incoming and exiting energy streams and write the energy balance.