Today

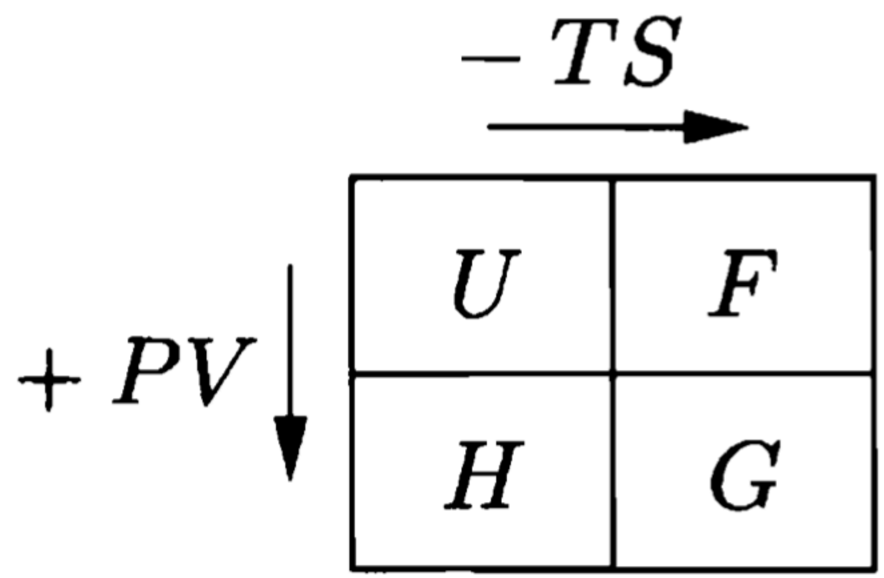
I. Our Stamina Breaks for the Semester: We will take Friday Oct 23rd off, Wed Nov 25th, and Fri Nov 27th.
II. Last Time
III. Nathalie's Guest Lecture on Thermodynamic `Potentials'
IV. Fuel Cells

II. We talked briefly about refrigerators

$$\mathrm{COP} = \frac{Q_c}{W} \leq \frac{T_c}{T_h - T_c}.$$

Very briefly touched the Otto cycle, which is ta more realistic model for internal combustion engines.

IV. We can summarize the various thermodynamic potentials I a little chart: all of the potentials arise in a patterned way. This process of changing variables in the potential is called a Legendr transformation.



Recall $U = U(S, V, N)$. What is F a function of?

$$\Delta F = \Delta U - \Delta(TS) = \Delta U - T\Delta S - S\Delta T = T\Delta S - P\Delta V + \mu dN - T\Delta S - S\Delta T$$
$$= -P\Delta V - S\Delta T + \mu dN$$

Then $F = F(T, V, N)$: $\left(\frac{\partial F}{\partial T}\right)_{V,N} = -S$; $\left(\frac{\partial F}{\partial V}\right)_{T,N} = -P$; $\left(\frac{\partial F}{\partial N}\right)_{V,T} = \mu$

IV. Let's explore the Gibbs free energy in the context of a hydrogen fuel cell. These are both analogous and very different from our heat engines. For an internal combustion we get something like 20-40%, while hydrogen fuel cells are in the range 40-80%. They are expensive and the high end of this range turns out to be more theoretical than practical. They nicely illustrate the usefulness of the Gibbs free energy. Electrolysis is the process of breaking water up into its constituent oxygen and hydrogen $2H_2O \rightarrow 2H_2 + O_2$

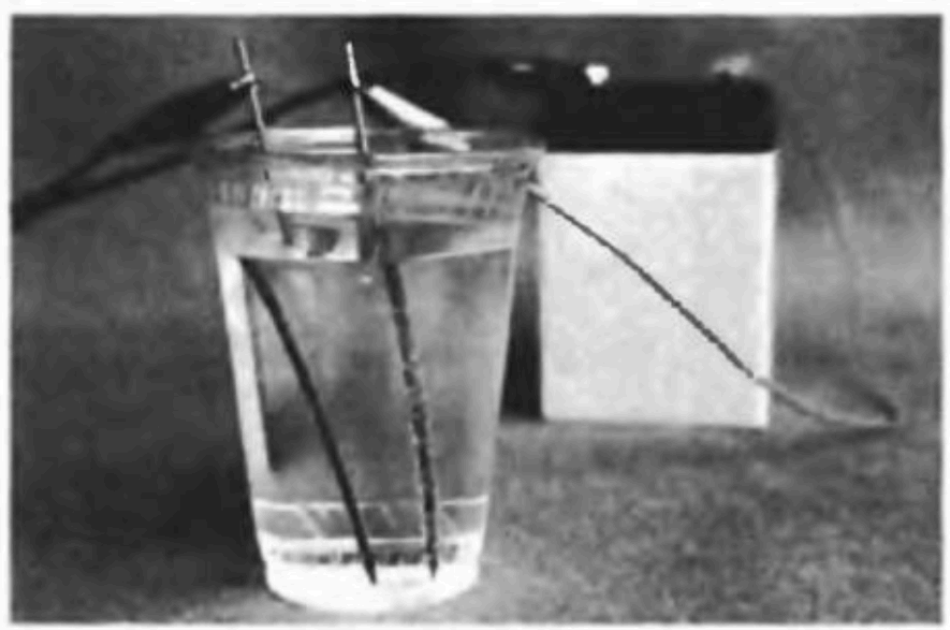


Figure 5.3. To separate water into hydrogen and oxygen, just run an electric current through it. In this home experiment the electrodes are mechanical pencil leads (graphite). Bubbles of hydrogen (too small to see) form at the negative electrode (left) while bubbles of oxygen form at the positive electrode (right).