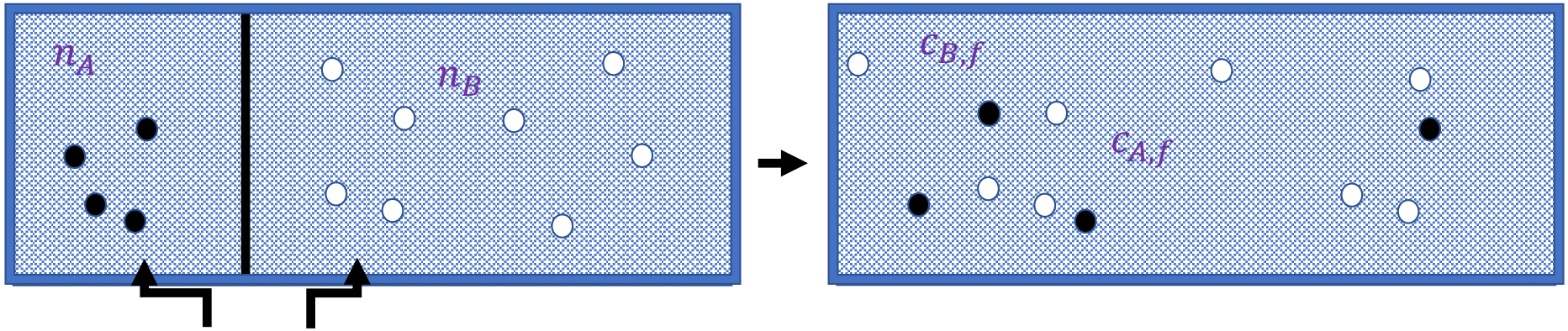
Blackboard: A derivation of the E-ICE equation for entropy of mixing



Same initial concentration "c_i"

$$\Delta S_{mix} = -n_A R ln\left(\frac{c_{A,f}}{c_i}\right) - n_B R ln\left(\frac{c_{B,f}}{c_i}\right)$$

$$\boldsymbol{\Delta S_{mix} = -n_{tot} R[\chi_A ln(\chi_A) + \chi_B ln(\chi_B)]}$$

Clues …

- Show that $\frac{c_{A,f}}{c_i} = \frac{c_{A,f}}{c_{A,f}+c_{B,f}} = \frac{n_A}{n_{tot}}$
- Use $\frac{n_A}{n_{tot}} = \chi_A$ couple of different ways
- Repeat for B, factor out n_{tot}

Blackboard: Deriving FE#1

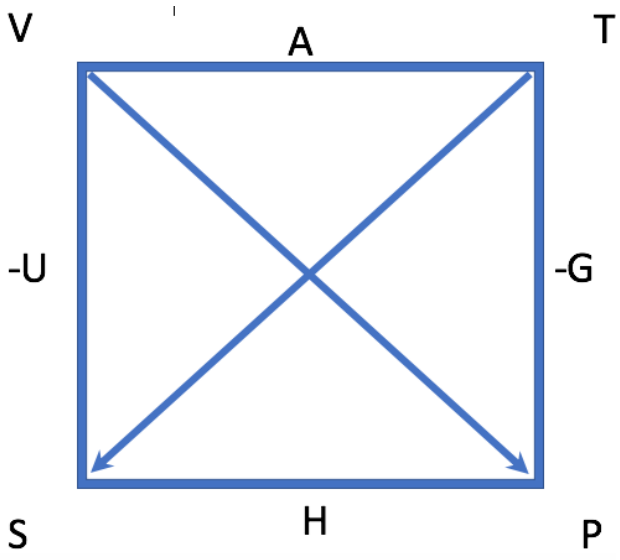
Claim: The differential equation of state for $\boldsymbol{U}$ can be written $\boldsymbol{dU = TdS - PdV}$, and the corresponding Maxwell relation is $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$. We can get that with the box, but how do we get there *without* the box?

Clues …

- The thermodynamic definition of entropy says $dS = \frac{dq_{rev}}{T}$.
- If a process is *reversible*, the 1st Law ($dU = dq + dw$) becomes

$$dU = dq_{rev} - PdV$$

  (you should explain this).
- Combining these, we get FE#1.
- Applying the cross-derivative rule gets us Maxwell.



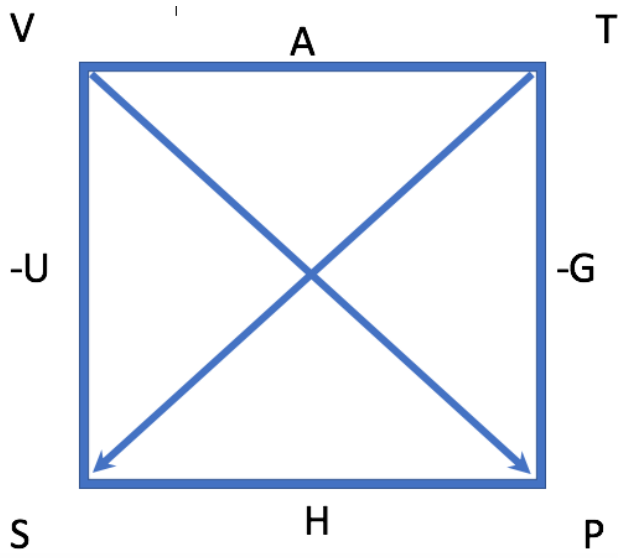
By the way: There are actually three other Fundamental Equations; but these others are basically restatements of the same idea**.**

Blackboard: Deriving FE#2

The ***Helmholtz energy*** is defined by $\boldsymbol{A \equiv U - TS}$. What's the differential equation of state for $\boldsymbol{A}$? What's the corresponding Maxwell relation?

Clues:

- Take the total differential of A, using the product rule for TS.
- Combine with FE#1.
- Use cross-derivative rule to get the corresponding Maxwell relation.

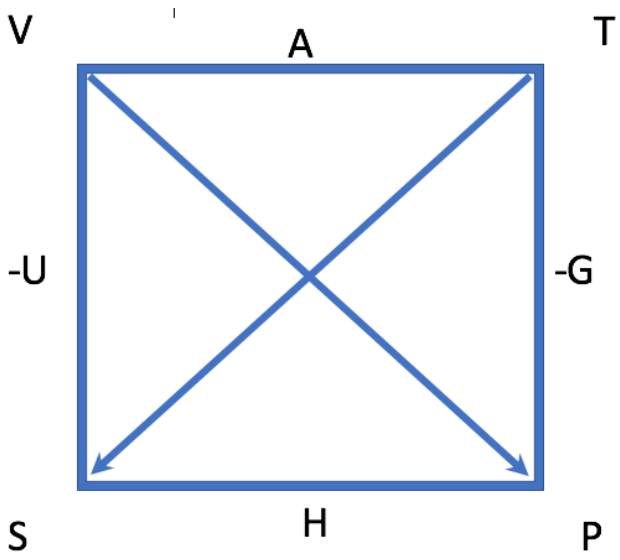


Blackboard: Deriving FE#3 & 4

The ***Enthalpy*** is defined by $\boldsymbol{H \equiv U + PV}$. What's the differential equation or state for $\boldsymbol{H}$? What's the corresponding Maxwell relation?

Clues:

- Take the total differential of A, using the product rule for PV.
- Combine with FE#1.



The ***Gibbs Energy*** is defined by $\boldsymbol{G \equiv H - TS}$. What's the differential equation or state for $\boldsymbol{G}$? What's the corresponding Maxwell relation?

Clues:

- Take the total differential of G, using the product rule for TS.
- Combine with FE#3.