Last Class: Refrigerator

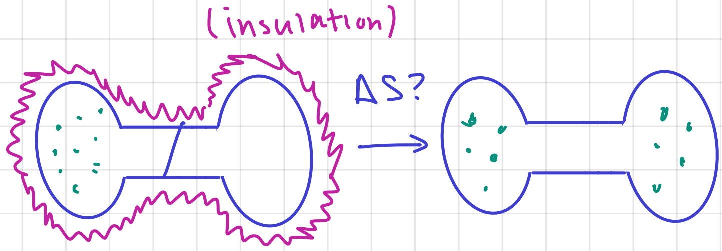
Another formulation of 2nd law due to Clausius: no process is possible whose sole result is the transfer of heat from a colder to hotter body

energy in form of heat is not same as energy in form of work

Finish today

Ch 20: Entropy

fig. 20.1 ΔS?



$q = 0$, $w = 0$ } $\Delta U = 0$

for ideal gas, if $\Delta U = 0$, then $\Delta T = 0$

$U = \frac{3}{2} nRT$

Option 1 assume monoatomic ideal gas

absolute → $S = \frac{3}{2} nR \ln T + nR \ln V + c$

$\Delta S = nR(\ln V_f - \ln V_i) = nR \ln\left(\frac{V_f}{V_i}\right)$ if $V_f = 2V_i$ ↓ $\Delta S = R \ln 2$

the higher the temp or volume, the higher the S

Option 2 $dS = \frac{\delta q_{rev}}{T}$ which uses us to use reversible path.

Reversible isothermal expansion → has to absorb energy from surroundings

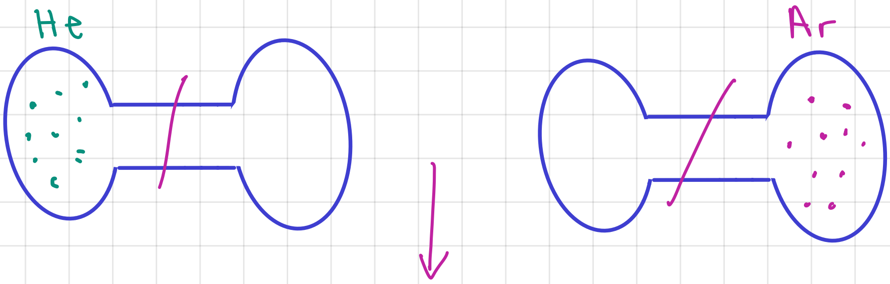
$\Delta U = 0 \Rightarrow q = -w$

$dS = \frac{\delta q}{T} = \frac{-\delta w_{rev}}{T} = \frac{+PdV}{T} = \frac{nRT}{V}\frac{dV}{T} = nR\frac{dV}{V}$

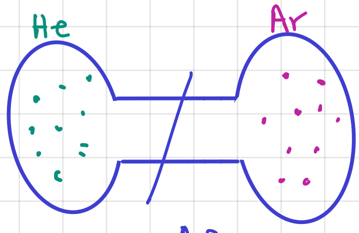
$\Delta S = \int_{V_i}^{V_f} nR \frac{dV}{V} = nR \ln\left(\frac{V_f}{V_i}\right)$

$\Delta S = \Delta S_{sys}$ ΔS_{surr}? Original Scenario: $\Delta S_{surr} = 0$

Option 2: rev conditions $\Delta S_{surr} =$



Is the He affected by presence of Ar ?

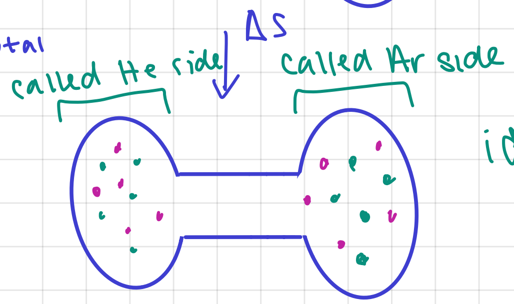


T, P constant

$PV = nRT$ (P, V, R, T: constants)

$V \propto n$

$\Delta S = n_{He} R \ln \frac{V_{He}}{V_{Total}} + n_{Ar} \ln \frac{V_{Ar}}{V_{Total}}$



ideal gasses ignore each other

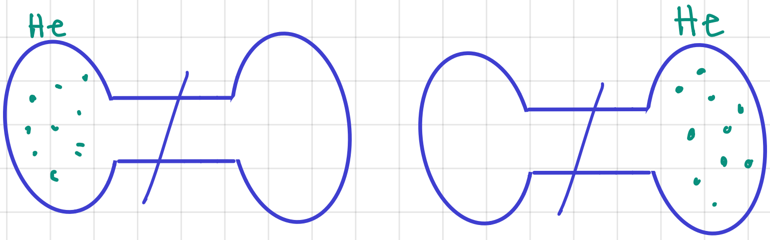
mol fraction

$\frac{\Delta S_{mix}}{n_{total}} = \frac{n_{He}}{n_{total}} R \ln \frac{n_{He}}{n_{total}} + \frac{n_{Ar}}{n_{total}} R \ln \frac{n_{Ar}}{n_{total}}$

$\frac{n_{He}}{n_{total}} \to X_{He}$, $\frac{n_{Ar}}{n_{total}} \to X_{Ar}$ mole fraction

$\Delta \bar{S}_{max} = X_{He} R \ln X_{He} + X_{Ar} R \ln X_{Ar}$

Switch Ar to He : $\Delta S_{mix} = \frac{1}{2} R \ln \frac{1}{2} + \frac{1}{2} R \ln \frac{1}{2} \Rightarrow R \ln 1/2 \neq 0$???



Still get non 0 entropy change

Gibbs mixing paradox ?
solved in grad course, not here
need to know QM

*done with Ch 20