Extremal Thermodynamic Functions S, U, H, A & G for different Experimental conditions

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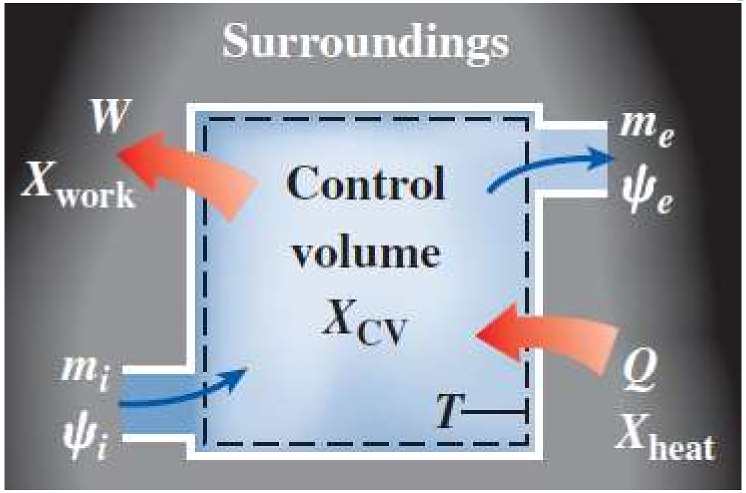
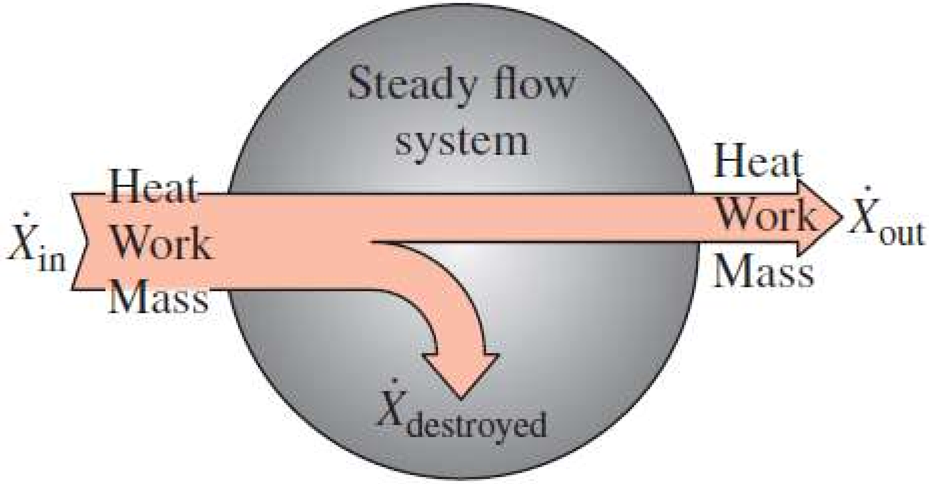
Previously: Exergy Balances





$$X_{\text{heat}} - X_{\text{work}} + X_{\text{mass,in}} - X_{\text{mass,out}} - X_{\text{destroyed}} = (X_2 - X_1)_{\text{CV}}$$

$$\sum\left(1 - \frac{T_0}{T_k}\right)\dot{Q}_k - \left(\dot{W} - P_0\frac{dV_{\text{CV}}}{dt}\right) + \sum_{\text{in}}\dot{m}\psi - \sum_{\text{out}}\dot{m}\psi - \dot{X}_{\text{destroyed}} = \frac{dX_{\text{CV}}}{dt}$$

Single-stream: $$\sum\left(1 - \frac{T_0}{T_k}\right)\dot{Q}_k - \dot{W} + \dot{m}(\psi_1 - \psi_2) - \dot{X}_{\text{destroyed}} = 0$$

$$\eta_{\text{II}} = \frac{\dot{W}_{\text{out}}}{\dot{W}_{\text{rev,out}}}$$

$$\dot{X}_{\text{destroyed}} = \dot{W}_{\text{rev,out}} - \dot{W}_{\text{out}}$$

$$\eta_{\text{II,mix}} = 1 - \frac{T_0\dot{S}_{\text{gen}}}{\dot{m}_1\psi_1 + \dot{m}_2\psi_2}$$

Figs-TD: Cengel & Boles

Flashback & flashforward: Extremum principles

$$\Delta S_{\text{isolated}} \geq 0$$

$-TS$ $\longrightarrow$

$+PV$ $\downarrow$

U (or E)	A (or F) $= \mathrm{U} - \mathrm{TS}$
H $= \mathrm{U} + \mathrm{PV}$	G $= \mathrm{U} + \mathrm{PV} - \mathrm{TS}$

- Differences in experimental conditions lead to representation of extremum conditions via different thermodynamic potentials/functions

What is controlled in experiments determines the relevant TD extremum fxn-1

$-TS$ →

$+PV$ ↓

U (or E)	A (or F) $= U - TS$
H $= U + PV$	G $= U + PV - TS$

$$\Delta S_{\text{isolated}} \geq 0$$

	Constant V	Constant P
Constant S	U	H
Constant T	F	G

$$\boxed{dU = TdS - PdV}$$

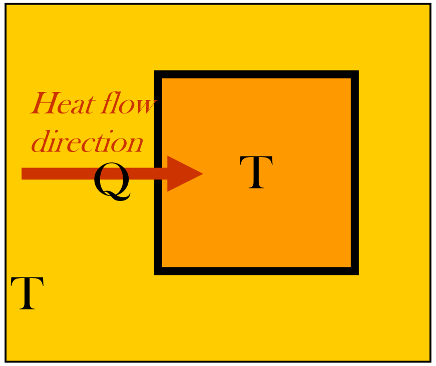
$$\boxed{dH = TdS + VdP}$$

$$\boxed{dA = -SdT - PdV}$$

$$\boxed{dG = -SdT + VdP}$$

- **δS (U,V,N)≥ 0; δU (S,V,N) ≤ 0; δH (S,P,N) ≤ 0;**
- **δA (T,V,N) ≤ 0; δG (T,P,N) ≤ 0;**

What is controlled in experiments determines the relevant TD extremum fxn-2



Combined (bath+system) is Isolated: $\Delta U_{bath} + \Delta U_{system} = 0$

$$\boxed{\Delta S - \frac{Q_{rev}}{T} \geq 0}$$

$$\boxed{\Delta S - \frac{\Delta U}{T} \geq 0} \quad \boxed{T\Delta S - \Delta U \geq 0} \quad \textit{or equivalently} \quad \boxed{\Delta U - T\Delta S \leq 0}$$

Zero at constant T

$$\boxed{A = U - TS} \quad \boxed{\Delta A = \Delta U - (T\Delta S + S\cancel{\Delta T})}$$

$$\boxed{\Delta A = \Delta U - (T\Delta S) \leq 0}$$

- **δS (U,V,N)≥ 0; δU (S,V,N) ≤ 0; δH (S,P,N) ≤ 0;**
- **δA (T,V,N) ≤ 0; δG (T,P,N) ≤ 0;**

What's next?

- Maxwell relations & Clapeyron equation