Good Morning

Entropy odds – let's shoot for 6 rings

Entropy – an additional balance equation

Goals – 1) Develop and use rate-of-change form of entropy balance.

2) Use the difference form of the entropy balance equation.

3) Apply these equations to Ideal single component systems.

Accumulation = ~~In~~ − ~~Out~~ + Gen − Consumption

Let's do a balance equation for a closed, isolated, constant volume system.

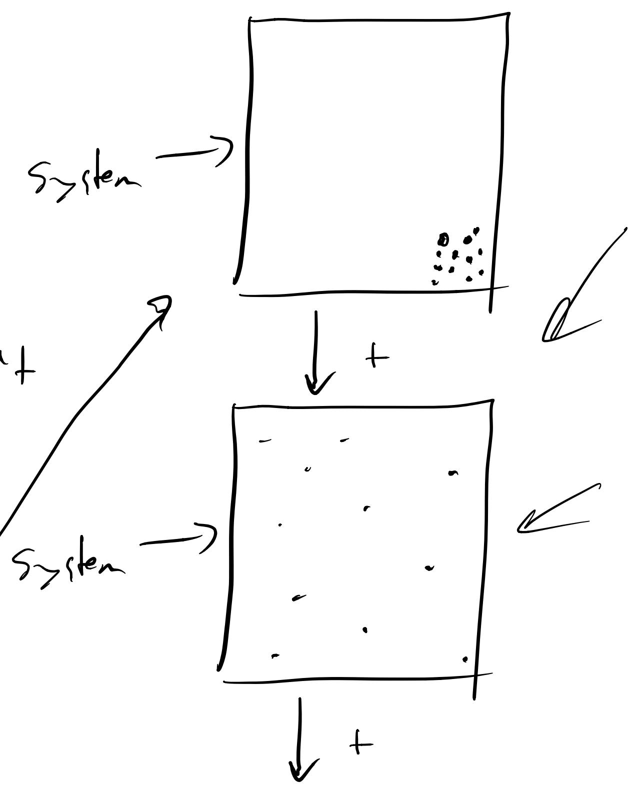
start w/ variable Θ

$\boxed{\text{Chapter 3 of Haynie}}$

$$\frac{d\Theta}{dt} = \dot{\Theta}_{gen}$$

for instance

we can have



Something happened here – what it is ain't exactly clear

There's a box with particles there but now they spread everywhere no way that mass or energy balances help

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$$\frac{d\Theta}{dt} = \dot{\Theta}_{gen}$$ — the rate of internal change of something

seems that @ equilibrium

$$\dot{\Theta}_{gen} = 0$$

but what happens before equilibrium?

Suppose we could identify a thermodynamic variable Θ where $\dot{\Theta}_{gen}$ was positive except @ equilibrium where $\dot{\Theta}_{gen} = 0$ $\rightarrow 0$

$$\frac{d\Theta}{dt} > 0$$ away from equilibrium

$$\frac{d\Theta}{dt} = 0$$ @ equilibrium.

$\rightarrow \Theta =$ constant.

$$\frac{dS}{dt} = \sum_{k=1}^{K} \dot{M}_k \hat{S}_k + \frac{\dot{Q}}{T} + \dot{S}_{gen}$$

$\sum_{k=1}^{K} \dot{M}_k \hat{S}_k$ = net rate of entropy flow due to flows of mass into or out of the system

In-n-Out

$\frac{\dot{Q}}{T}$ = rate of entropy generation due to flow of heat across the system boundary

$\dot{S}_{gen}$ = rate of internal generation of entropy within the system.

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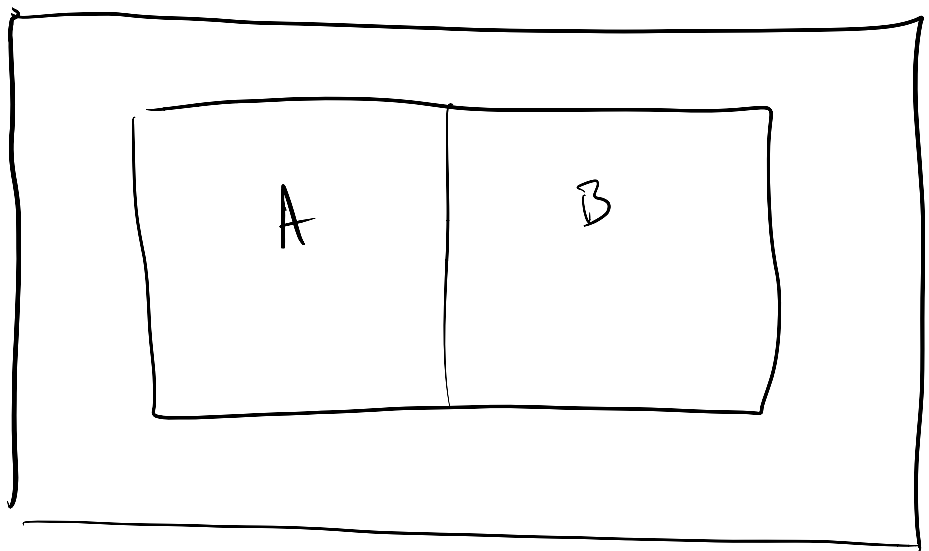
1) closed mass system.

2nd Law of Thermo

$$\boxed{\begin{gathered} \frac{dS}{dt} = \frac{\dot{Q}}{T} + \dot{S}_{gen} \\ \dot{S}_{gen} \geq 0 \\ \frac{dS}{dt} = 0 \text{ @ equilibrium} \end{gathered}}$$

Huh?

Examples



Systems A and B are free to interchange energy, but the composite system (A + B) is isolated from the environment.

In this system, heat transfer occurs between A and B and at any moment in time the internal state of A or B are in equilibrium. $\rightarrow$ $S_{gen} = 0$

$$\dot{Q}_A = -h(T_A - T_B)$$

$$\dot{Q}_B = h(T_A - T_B)$$

→ definitions of heat transfer for this system.

$$\frac{dS_A}{dt} = \frac{\dot{Q}_A}{T_A} = -h\left(\frac{T_A - T_B}{T_A}\right)$$

$$\frac{dS_B}{dt} = \frac{Q_B}{T_B} = h\left(\frac{T_A - T_B}{T_B}\right)$$

The composite system must be

$$\boxed{\frac{dS}{dt} = \dot{S}_{gen}}$$

but total $\boxed{S = S_A + S_B}$

Trying to figure out the thing we know nothing about - what is $\dot{S}_{gen}$?

$$\frac{dS}{dt} = \frac{d(S_A + S_B)}{dt} = \frac{dS_A}{dt} + \frac{dS_B}{dt} = \dot{S}_{gen}$$

$$\dot{S}_{gen} = -\frac{h(T_A - T_B)}{T_A} + \frac{h(T_A - T_B)}{T_B}$$

$$= -\frac{h\,T_B(T_A - T_B)}{T_A T_B} + \frac{h\,T_A(T_A - T_B)}{T_A T_B}$$

$$= \frac{h(T_A - T_B)^2}{T_A T_B} \qquad \frac{h\,\Delta T^2}{T_A T_B}$$