Thermo Review 1/19

* Lectures on Prof. website *→

Sander, Chemical Engineering Thermo
First 4 chapters. [In library]

"Processes that take place in real life":

- Heating ? associated w/ heat
- Cooling ? exchangers
- Pressurizing = pumps, Compressors & opposite
- De-pressurizing = Valves, Expanders

- Mixing ? VLE, Dist column
- Separate ? Absorbance

- Reactions ? Exn thermodynamics

Never heat or pressurize/depressurize at the same time b/c it is cheaper to perform processes separately.

Small ΔT w/ heating and cooling
Small ΔP w/ pressurizing and depressurizing

\[ \Theta = U + M \left( \frac{v^2}{2} + g \right) \]  
from gravity

\[ \Theta = \text{Energy (not specific energy)} \]

\[ U = \text{internal energy "soul of mass"} \]

changes w/ Temp. and Pressure

Little molecules (bonds)

\[ \frac{v^2}{2} = \text{kinetic energy per unit mass} \]
Energy Conservation

1st law

\[ \frac{d}{dt} \left[ U + M \left( \frac{V^2}{2} + V \right) \right] = \sum M_i \left( U + \frac{V^2}{2} + V \right) + Q \]

\[ + \dot{W} - P \frac{dV}{dt} + \sum M_i (PV) \]

\textbf{Work} = PV = \text{associated with mass entering and leaving system}

\textbf{Work (Shaft)} \quad f = PA

\[ W = -P \frac{dV}{dt} \]

\cdot impellers

\cdot electricity

\cdot stirrers = make energy b/c move molecules

\textbf{Closed Systems}

\cdot No mass enters or leaves system

\begin{align*}
\text{Isolated System - No heat or mass exchanged} \\
\text{Adiabatic} \Rightarrow Q = 0
\end{align*}

\[ \Delta U = Q + W \]

\[ \Rightarrow \left( \dot{W} - \int P dV \right) \] \text{from Equation (Energy conservation)}

\textbf{Constant Pressure}

\[ W = \dot{W} + P \Delta V \]

\textbf{Constant Volume} \quad \text{b/c} \Delta V = 0

\[ W = \dot{W} \]

Batch reactors usually closed systems

\cdot Most plants are continuous w/ open systems
Steady State

- No fluctuations of pressure or temp w/ respect to time
  - In 1st law anything w/ dt is equal to zero

\[ \Delta U = Q - P \Delta V \]

\[ \Delta H = Q + W_g \]
  - used when pressure is constant

Entropy

- property that grows w/ every system does not change in equilibrium

\[ \frac{dS}{dt} = \frac{Q}{T} + S_{gen} \]

\[ \Delta S = \int \frac{Q}{T} \ dt + S_{gen} \]

2nd law of Thermo

\[ S_{gen} \geq 0 \]

- Possible TEST question + LIFE lesson-ish
  - Use 2nd law to evaluate situations and decide whether impossible or possible
  - If \( S_{gen} \) is negative IMPOSSIBLE!
  - Cannot calculate on own - must use formula to solve

\[ \Delta S \Rightarrow \text{comes from table!} \]

"No entropy Thermometer" measured through tiny steps w/ calorimeter
Reversible
does not generate any entropy
\[ S_{\text{gen}} = 0 \]

\[ \text{piston} \]

1 marble  All marbles
@ time @ once

* Example explained in book

Find Temperature

\[ \Delta S \text{ valve} \]
\[ \Rightarrow \Delta S \text{ compressor} \]

\[ \text{constant Temp horizontal lines} \]
\[ \text{constant entropy vertical lines} \]

Pressurizing system (compressor)
NOT isobaric
Volume changes.
Entropy is isotropic (in reversible systems)
\[ \Delta s = \int_{s_0}^{s_1} \frac{dQ}{T} \quad S_{\text{gen}} = 0 \quad \Rightarrow \quad \text{constant entropy} \]

Expander \Rightarrow compressor in reverse
\[ \Delta H = 0 \]
flow same before \& after

Valve \Rightarrow Pressure gets smaller velocity increases
Adiabatic / No \( W_b \) / only PV work \( \Delta H = \Delta E_{\text{kinetic}} \)
Carnot Cycle (TG diagram)

1. Expansion
2. Compression
3. Heating
4. Cooling

Most efficient cycle (closed cycle)

\[ \eta = \frac{Q}{W} \] efficiency

1. Heating
   - Adding heat
2. Compression
   - Adding work
3. Cooling
   - Heat leaves
4. Expansion
   - Work leaves

Engineering Rule:
"If you are heating, NO PRESSURE Δ" 

Intersting:
Plane Wings Vibrate to absorb surges
Avoid clouds because of density changes of density
Surge vibration small pressure changes

Mixture do not cool down or heat up at a constant temp use pure fluid

Cannot do this (Surge - Vibrate) too much. Damage compressor + expander

Can have vertical line outside 2 phase region.
Pick Refrigerant

- Pressure above atm
- Temp above ambient
- Want $\Delta h$ to be as small as possible
  $\Rightarrow$ Total amount of work needed (PT work)

Valve instead of Expander

Air conditioning system at your house

Only simple systems on test.

**Rankine cycle** $\Rightarrow$ produces work
Refrigerant cycle in reverse