Intro to Thermodynamic Properties of Matter

An ideal gas.

A gas where there are no intermolecular forces that cause nonlinearities, – strong forces between molecules do not play a large role in screwing things up.

$$\boxed{P\underline{V} = RT} \equiv PV = nRT$$

$$\underline{V} = \frac{\text{Volume}}{n}$$

intrinsic ?
extrinsic ?

Heat capacity.

$$\frac{Q}{N} = C \, \Delta T$$

The change in temperature was noted to somehow be proportionate to Q or energy added to system.

- only true for very small amounts of Q.

C is a parameter

ΔT is small change in Temp.

Q is heat added.

N: number of moles or amount

$$\boxed{\begin{aligned} C_v(T, V) &= \left(\frac{\partial U}{\partial T}\right)_V \\ C_p(T, P) &= \left(\frac{\partial H}{\partial T}\right)_P \end{aligned}}$$

For ideal gas

$$C_p^*(T) = \frac{d\underline{H}}{dT} \qquad C_v^*(T) = \frac{d\underline{U}}{dT}$$

You - Relate C_p^* to C_v^*

using $\underline{H} = \underline{U} + P\underline{V}$

$$C_p^* = \frac{d\underline{H}}{dT} = \frac{d(\underline{U} + P\underline{V})}{dT} = \frac{d(\underline{U} + RT)}{dT}$$

$$= \frac{d\underline{U}}{dT} + R$$

$$\boxed{C_p^* = C_v^* + R}$$

for solids, liquids

$$\boxed{C_p^* \simeq C_v^*}$$

We are interested in energy flow problems.

Looking at differences between two states.

- For most problems here - there's really no "total" energy - everything is done with respect to a reference state.

$$\frac{d\underline{H}}{dT} = C_p$$

$$dH = C_p \, dT$$

$$\int dH = \int_{T_R}^{T} C_p \, dT$$

$$\boxed{\underline{H}^{IG}(T) = \int_{T_R}^{T} C_p \, dT}$$

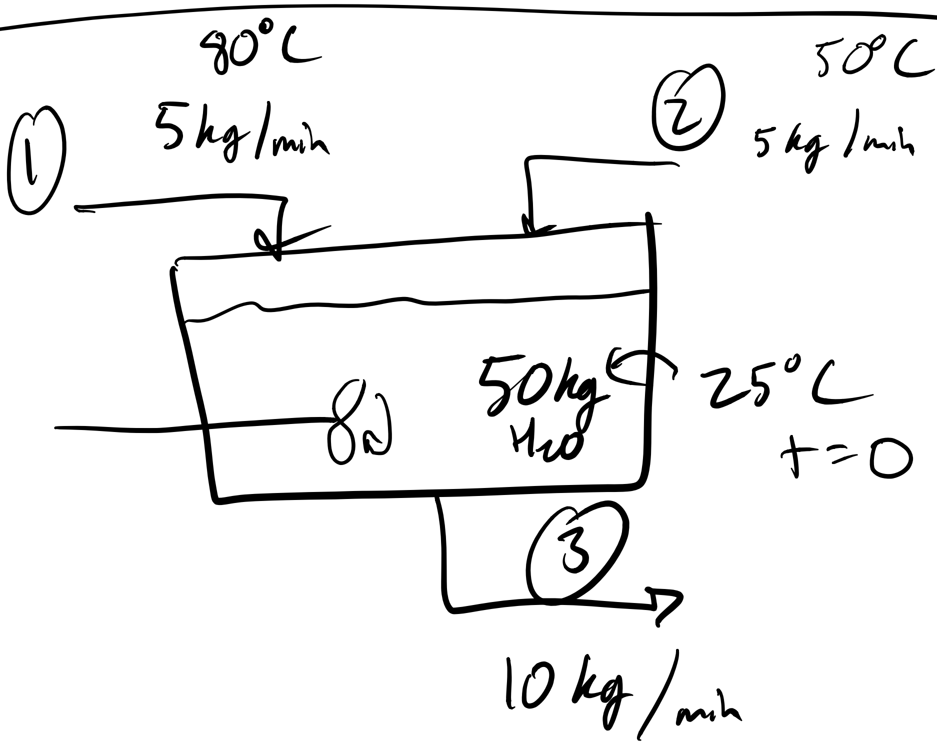
Frequent choices → $0°C$

A known state close to your current state

$$\underline{H}^{IG}(T) = C_p (T - T_R)$$

if T_R is 0 K.

$$\boxed{\begin{aligned} \underline{H}^{IG}(T) &= C_p^* T \\ \underline{U}^{IG}(T) &= C_v^* T \end{aligned}}$$



a) Develop final steady-state mass + energy balances for this system.

b) Determine final steady-state temp in tank.

c) Develop expression for $T(t)$ in the tank.

a) $\frac{dM}{dt} = 0 = ?$

START W/ FULL EQUATIONS — CROSS STUFF OFF

$$\frac{dM}{dt} = 0 = \dot{M}_1 + \dot{M}_2 + \dot{M}_3$$

$$\dot{M}_3 = -(\dot{M}_1 + \dot{M}_2) = -10 \frac{kg}{min}$$

$$\frac{d}{dt}\left\{\cancel{U + M\left(\frac{v^2}{2} + \Psi\right)}\right\} = \sum_{k=1}^{K} \dot{M}_k \left(\hat{U} + \cancel{\frac{v^2}{2} + \Psi}\right)_k + \cancel{\dot{Q}}$$

$$+ \cancel{\dot{W}_s} - \cancel{\rho\frac{dV}{dt}} + \sum_{k=1}^{K} \dot{M}_k (\rho\hat{V})_k$$

W

$$\boxed{\frac{dU}{dt} = \dot{M}_1 \hat{H}_1 + \dot{M}_2 \hat{H}_2 + \dot{M}_3 \hat{H}_3}$$

@ S.S. $0 = \dot{M}_1 \hat{H}_1 + \dot{M}_2 \hat{H}_2 + M_3 \hat{H}_3$

use $\hat{H} = C_p (T - T_R)$

$$0 = \dot{M}_1 C_p (80 - T_R) + \dot{M}_2 C_p (50 - T_R)$$

$$+ \dot{M}_3 C_p (T - T_R)$$

$$\dot{M}_3 = -(\dot{M}_1 + \dot{M}_2)$$

$$0 = 5\cancel{C_p}(80-\cancel{T_R}) + 5\cancel{C_p}(50-\cancel{T_R}) - 10\cancel{C_p}(T-\cancel{T_R})$$

$$\boxed{T = \frac{5T_1 + 5T_2}{10} = \frac{50+80}{2} = 65\,^\circ C}$$

$$\frac{dU}{dt} = \frac{d}{dt}(M\hat{u}) = M\frac{d\hat{u}}{dt} = M C_v \frac{dT}{dt}$$

$$= M C_p \frac{dT}{dt}$$

Total M of system

$C_p \approx C_v$ for liquid.

$$M \cancel{C_p} \frac{dT}{dt} = 5 \cancel{C_p} T_1 + 5 \cancel{C_p} T_2 - 10 \cancel{C_p} T$$

$$10 \frac{dT}{dt} = \underbrace{T_1 + T_2}_{\substack{\text{constants} \\ C}} - 2T$$

Rearrange + integrate.

$$10 \int_{T_0}^{T(t)} \frac{dT}{C - 2T} = \int_{t=0}^{t} dt$$

$$\boxed{T = A e^{-t/5} + C_1}$$ t in minutes.

$t \to \infty$

$T_{ss} = 65 \rightarrow C_1 = 65^\circ$

$t = 0$

$T = 25$

$$T = 25 = A + 65$$

$$A = -40$$

$$T(t) = 65 - 40\exp(-t/5)$$