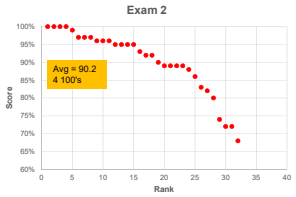
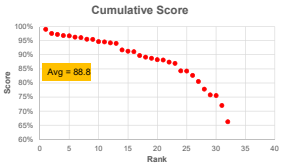
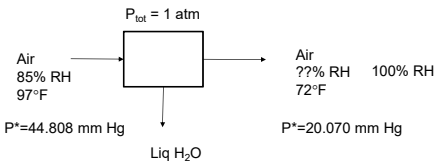




Humidity Problem on Practice Exam 2



$$y_{H_2O,in} = \frac{(0.85)(44.808)}{760} = 0.0501 \qquad y_{H_2O,out} = \frac{(1.0)(22.070)}{760} = 0.0264$$

Basis: 1 mole of dry air

$n_{dry} = n_{tot}(1-y_{H2O})$

$$n_{tot,in} = \frac{n_{dry}}{1-y_{H_2O,in}} = \frac{1}{1-0.0501} = 1.0527\ moles$$

$$n_{tot,out} = \frac{n_{dry}}{1-y_{H_2O,out}} = \frac{1}{1-0.0264} = 1.0271\ moles$$

$n_{liq} = n_{in} - n_{out} = 1.0527 - 1.0271$

= 0.0256 moles liq H_2O

Dr. Fletcher's Sanity Rules

- Wait 24 hours to come see me about points
- Please come see me if you think it was graded wrong or unfairly
  - Don't be afraid to come see me (please!)

Professional Program Application

- Due Apr. 15 to ChE Office
- Must meet with your ChE Faculty Advisor
- Must update the course planning Excel Spreadsheet
- Must take a shot at your electives
- This is not a contract!
- Allows you to take Fluids (ChE 374) in F'17

Exam 3

(In case you were wondering)

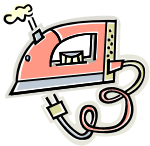
- Closed Book
- Closed Notes
- 3 hrs
- One 8x10 page with equations and notes (both sides)
- All tables and data will be provided

Homework Hints

(from web page)

- 7-18 (7-16 in 3rd Ed.)
  - Since an equation is given for the enthalpy, you cannot use the steam tables
  - You may use the ideal gas law here to calculate the number of moles.
- 7-32 (7-28 in 3rd Ed.)
  - Assume that the local atmospheric pressure is 1 bar

These hints are on the web page

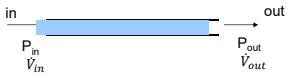


Enthalpy & Steam Tables

Class 25

Shaft Work vs Flow Work

- W_s = shaft work
  - Work done by moving parts
  - Axle, turbine, pump
- W_{fl} = flow work
  - Work by fluid to push through the system



  - $W_{fl} = P_{in}\dot{V}_{in} - P_{out}\dot{V}_{out}$ *(positive when W added to system)*
    $= -\Delta(P\dot{V})$ since the Δ means out minus in
  - Cannot be ignored (friction happens!)

Enthalpy

- An energy term made up for convenience

$$H = U + PV$$
$$\hat{H} = \hat{U} + P\hat{V}$$ (per kg or kgmole)

- Commonly used for open systems
  - For those of us who hate converting pressure units to energy units!!!

Open System Energy Balance

- At Steady State:

$$\Delta\dot{H} + \Delta\dot{E}_K + \Delta\dot{E}_P = \dot{Q} + \dot{W}_s$$

Units: Btu/hr or J/s or kW

where

$$\Delta\dot{H} = \dot{m}\Delta\hat{H} = \dot{m}(\hat{H}_{out} - \hat{H}_{in})$$

Compare with Closed System Energy Balance

$$\Delta\dot{H} + \Delta\dot{E}_K + \Delta\dot{E}_P = \dot{Q} + \dot{W}_s$$
$$\Delta U + \Delta E_K + \Delta E_P = Q + W$$

- What are the differences?
- Where did H come from?

$W = W_s + W_{fl}$
$= W_s - \Delta(PV)$
$\Delta U + \Delta(PV) = \Delta H$

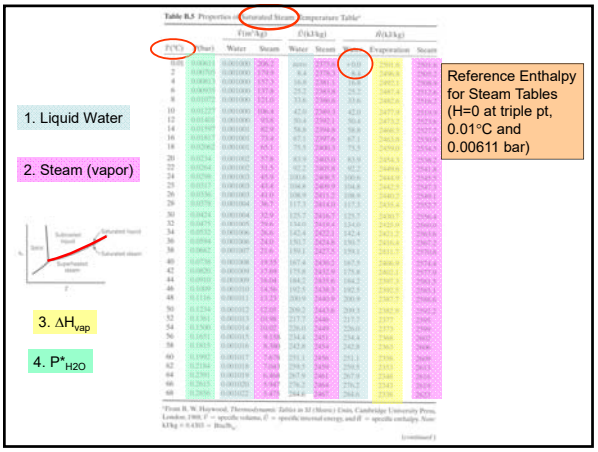
Enthalpy is your friend

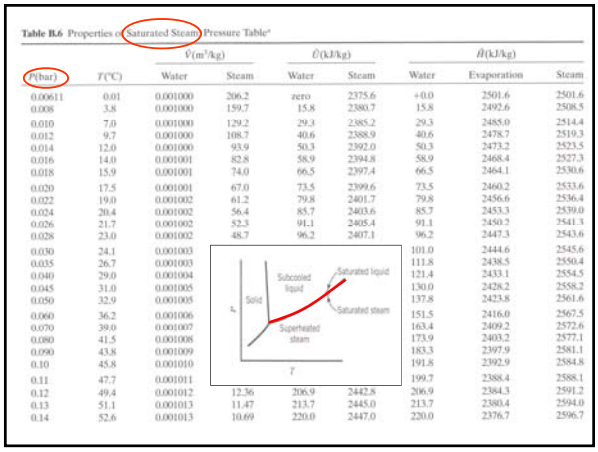
How Do You Calculate Enthalpy?

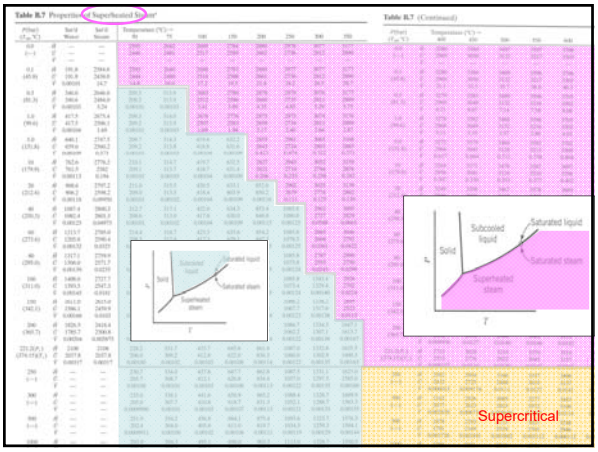
1. Tables
2. Equations
3. Graphs

Steam Tables

- Tables are always with respect to some reference state
- ΔH from reference state is the value in the table
- If you use data from different tables, you will need to adjust for the reference state
  - This can cause huge errors
- Enthalpy is a state property
  - Does not depend on path







Energy Equation Information Sheet

What they say…	What they mean…
Well insulated	$Q = 0$, but $\Delta T \neq 0$
Adiabatic	$Q = 0$, but $\Delta T \neq 0$
Isothermal	$\Delta T = 0$, but $Q \neq 0$
Rigid Container	Volume doesn't change $W_{PV} = 0$
Isochoric	Constant Volume $W_{PV} = 0$
No mechanical parts, or no moving parts	$W_S = 0$

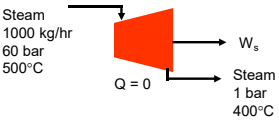
1. What is ΔH_{vap} at 30 bar?
2. What is P^*_{H2O} at 311°C?
3. What is $\hat{V}_{water}$ at 84°C?
4. What is $\hat{H}_{water}$ at 200 bar and 100°C?
5. What is $\hat{H}_{steam}$ at 80 bar and 600°C?
6. What is the dew point temperature (T_{dp}) for question #5?
7. What is the temperature and enthalpy of saturated steam at 80 bar?
8. What is the enthalpy of 10% quality steam at 30 atm? (Quality is defined as the wt% steam in a steam-water system).

1. What is ΔH_{vap} at 30 bar? 1793.9 kJ/kg (Table B.6)
2. What is P^*_{H2O} at 311°C? 100 bar (Table B.6)
3. What is $\hat{V}_{water}$ at 84°C? 0.001032 m³/kg (Table B.5)
4. What is $\hat{H}_{water}$ at 200 bar and 100°C? 434.0 kJ/kg (Table B.7)
5. What is $\hat{H}_{steam}$ at 80 bar and 600°C? 3640 kJ/kg (Table B.7)
6. What is the dew point temperature (T_{dp}) for question #5? 295.0°C (Table B.7)
7. What is the temperature and enthalpy of saturated steam at 80 bar? 295.0°C, 2759.9 kJ/kg (Table B.6)
8. What is the enthalpy of 10% quality steam at 30 atm? (Quality is defined as the wt% steam in a steam-water system).

0.9*1008.4 + 0.1*2802.3 = 1187.8 kJ/kg (Table B.6)

Examples

Example: Steam Turbine



Find the work done by the fluid on the turbine blades.

$$\Delta\dot{H} + \Delta\dot{E}_K + \Delta\dot{E}_P = \dot{Q} + \dot{W}_s$$

$\hat{H}_{in}$ = 3422 kJ/kg $\hat{H}_{out}$ = 3278 kJ/kg

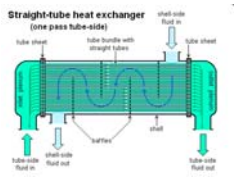
(1000 kg/hr)(3278 kJ/kg – 3422 kJ/kg) = W_s = 1.44 × 10^5 kJ/hr

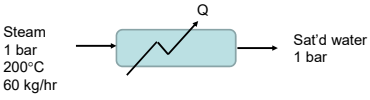
= 40 kJ/s = 40 kW

W_s = 40 kW

Work done by fluid on the turbine blades

Example: Condenser
(Heat Exchanger)





Find Q

$\hat{H}_{in} = 2875\ kJ/kg$ $\hat{H}_{out} = 417.5\ kJ/kg$

$$\Delta\dot{H} + \Delta\dot{E}_K + \Delta\dot{E}_P = \dot{Q} + \dot{W}_s$$

Q = (60 kg/hr)(417.5 kJ/kg – 2875 kJ/kg)(hr/3600 s) = - 40.96 kJ/s

Out - In

Q = -41 kW

(Heat removed)