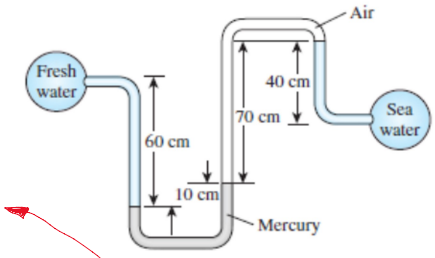
Homework 2

Saturday, February 20, 2021 1:00 PM

"I pledge my honor I have abided by the Stevens Honor system."
- Alex Jaskins

1. Freshwater and sea water are flowing in parallel pipes. The pipes are connected by a double U-tube manometer (see figure). What is the pressure difference between the pipes? Take the density of seawater to be 1035 kg/m³. You may neglect the pressure due to the air in the tube. Why is this? [15]



$P_{above} = P_{below} + \rho g h$

$P_{above} - P_{below} = \sum \rho g h$

$\Delta P = P_{mercury} g h_1 + P_{air} g h_2 - P_{saltwater} g h_3 - P_{Freshwater} g h_4$

$\Delta P = (9.8)(13600(.1) - 1035(.4) - 1000(.6))$

$\Delta P = 3390.8 \text{ Pa}$

Air Pressure and its height is so miniscule in this case, its involvement is negligible.

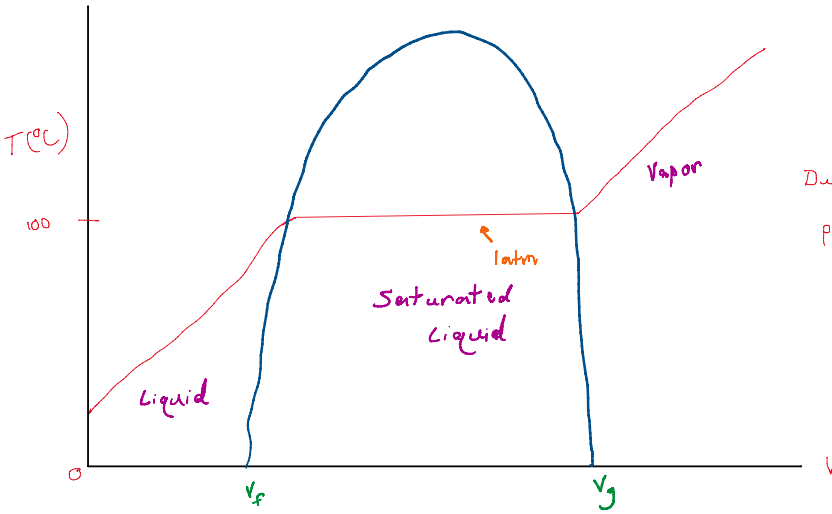
2. Is it possible to have water vapor at -8°C? [2]

Yes. Boiling point of water is dependent on both temperature and pressure. If pressure is low enough, water can boil at -8 °C.

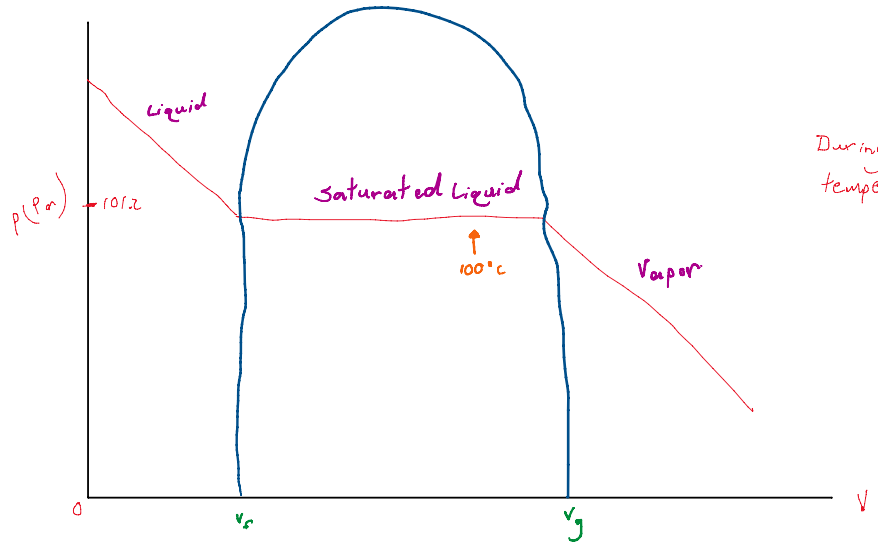
3. You are cooking a stew at home. You have three different pots, one without a lid, one with a light lid and one with a heavy lid. Which pot should you use to cook the stew in the least time? Why? [3]

Heavy lid, because it would contain the highest pressure. Higher pressure means a lower boiling point, which would allow the stew to cook (to a higher temperature) faster.

4. Draw a T-v diagram for water boiling at 1 atm pressure. Label all the states of the water on the diagram and show the saturation line. Draw and label another curve for water boiling at a higher pressure. Draw a P-v diagram for water boiling. What is the main difference between this and the T-v diagram you just drew? [10]



During the phase change, pressure remains constant.



During the phase change, temperature remains constant.

5. Complete the following table for water (show your work) [20]:

T [°C]	P [kPa]	h [kJ/kg]	x (quality)	Phase Description
120.21	200	1389.7	0.7	Saturated Liquid
140	361.53	1800	.87	Saturated Liquid
177.66	950	752.74	0.0	Liquid
80	500	461.42	N/A	Compressed Liquid
350	800	3162.2	N/A	Superheated Vapor

$h = x h_g - h_f$

$h = .7(2706.3) - (504.71)$

$h = 1389.7$

$x = \frac{(1800 + 589.16)}{2733.5}$

$x = .87$

6. Complete the following table for Refrigerant-134a (show your work) [20]:

	T [°F]	P [psia]	h [Btu/lbm]	x (quality)	Phase Description
	66.2	80	78	1.0	Vapor
a	15	29.83	46.27	0.6	Saturated Liquid
	10	70	15.43	N/A	Compressed Liquid
b	117.57	180	129.46	1.53	Saturated Vapor
c	110	161.06	68.56	1.0	Vapor

b

h_g: $\frac{276.17 - 273.92}{1400 - 1200} = \frac{276.17 - x}{1400 - 1241.06}$

$x = 274.38$ kJ/kg

h_f: $\frac{127.25 - 117.79}{1400 - 1200} = \frac{127.25 - x}{1400 - 1241.06}$

$x = 119.73$ kJ/kg

$301.12 = x(274.38) - 119.73$

$x = 1.53$

T: $\frac{52.40 - 46.29}{} = \frac{52.40 - x}{}$

a	15	27.83	T6.17	0.6	Saturated Liquid
	10	70	15.43	N/A	Compressed Liquid
b	117.57	180	129.46	1.53	Saturated Vapor
c	110	161.06	68.56	1.0	Vapor

a

$\frac{117.08 - 200.74}{-8 - (-10)} = \frac{117.08 - x}{-8 - (-9.4)}$

$x = 205.642 \text{ kPa} = 29.83 \text{ psia}$

$h_{fg} = .6(249.90) - 39.32$

$h_{fg} = 107.62 \text{ kJ/kg} = 46.27 \text{ Btu/lbm}$

h_g: $\frac{247.31 - 244.50}{-5.38 - (-10.09)} = \frac{247.31 - x}{-5.38 - (-9.4)}$

$x = 244.90 \text{ kJ/kg}$

h_f: $\frac{44.64 - 38.41}{-5.38 - (-10.09)} = \frac{44.64 - x}{-5.38 - (-9.4)}$

$x = 39.32 \text{ kJ/kg}$

b

$301.12 = x$ (illegible)

$x = 1.53$

T: $\frac{52.40 - 46.29}{1400 - 1200} = \frac{52.40 - x}{1400 - 1291.06}$

$x = 47.59°C = 117.57°F$

c

P: $\frac{1130.7 - 1072.8}{44 - 42} = \frac{1130.7 - x}{44 - 43.3}$

$x = 1110.44 \text{ kPa} = 161.06 \text{ psia}$

h_{fg}: $\frac{158.70 - 160.89}{44 - 42} = \frac{158.70 - x}{44 - 43.3}$

$x = 159.47 \text{ kJ/kg} = 68.56 \text{ Btu/lbm}$

7. What is the enthalpy of the R-134a in the container shown? [15]

V = 9 m³

m = 900 kg

T = 10°C

$v_s = \frac{9}{900} = .01 \text{ m}^3/\text{kg}$

$.01 = (1 - x)(.0007930) + x(.049403)$

$x = .189$

$h = (1 - .189)(65.42) + (.189)(256.22)$

$h = 101.54 \text{ kJ/kg}$

8. A piston-cylinder device contains water at 600°F. If the volume of the system is 2.4264 ft³ and the mass of the water is 1 lbm, determine the final pressure and volume if the water is then cooled to 200°F at constant pressure. Draw this process on a P-V diagram. [15]

$v_s = v = 2.4264 \text{ ft}^3/\text{lbm}$

$P = 250 \text{ psia}$ at $600°F$

$v_f = .01663 \text{ ft}^3/\text{lbm}$