**CHEN 3320: ChE Thermo Department of Chem & Bio Engineering Fall 2018**

**Assignment # 4** team assignment Due: Friday Sept 14, 2018 by 1:00 PM

This assignment must be done in teams, and only one set of solutions is to be turned in to Gradescope. Your team number will be posted on Canvas. Print the names of the team members at the top of the first page. You must also enter your team members into Gradescope when you submit the assignment.

All problems are worth 10 points unless indicated otherwise.

* Please use dark pencil or a pen so that the scanned version is readable. Write neatly so the TA can fairly grade your work. Also, leave margins and write large enough.
* Use a high-quality scanner or copier for your solutions and submit to the Gradescope website. Check the quality of the scanned version before uploading it. The assignment must be in one PDF file.
* The quality of scans are better if you use plain white paper instead of colored engineering paper. The grid on engineering paper seems to affect the scanning quality.
* Note that screencasts, which are organized on [www.LearnChemE.com](http://www.LearnChemE.com) by chapters in Elliott and Lira ([www.learncheme.com/screencasts/thermodynamics/textbook-elliottlira-2nd](http://www.learncheme.com/screencasts/thermodynamics/textbook-elliottlira-2nd)) might be useful in solving some problems. In some cases they will be solutions to similar problems.
* Answers must be boxed in and contain the correct number of significant figures
* The top of the first page of each assignment must include the statement: "This assignment was done jointly and each of us knows how to do each problem. On my honor, as a University of Colorado student, I have neither given nor received unauthorized assistance on this work." Each team member should then sign the page.
* You may want to watch the screencast [Problem Solving Approach](https://www.youtube.com/watch?v=ZuyzmjLKJ24). Here is a useful checklist that you should consider using:

To Do Draw a diagram, include knows and unknowns

To Do Restate the problem

To Do Write down a plan for obtaining the solution

To Do List assumptions

To Do Write equations before substituting numerical values

To Do Use units in all calculations

To Do Label axes of all plots

To Do Identify source of any data used (some problems will require data not in the book)

To Do Check answer: units correct? correct number of significant figures? Does the sign and amplitude of the answer make sense?

1. A well-insulated, 65-m3 storage tank contains 220 L of liquid water at 75oC. The rest of the tank contains steam in equilibrium with the water. Spent process steam at 2.3 bar and 91% quality enters the tank until the pressure is the tank reaches 2.3 bar. Assume no heat losses. How much steam enters the tank, and what is the amount of liquid water present at the end of the process?
2. 7.38 Ten grams ot liquid water at 950C are contained in the insulated container shown. The pin holding the trictionless piston in place breaks, and the volume available to the water increases 
   to 1 x 100 ma During the expansion some ot the water evaporates, but no neat is transterred to the cylinder. 
   Liquid 
   water 
   Vacuum 
   Find the temperature, pressure, and amounts ot vapor, liquid, and solid water present atter the expansion. The well-insulated container shown in the figure contains 10. g of liquid water at 60.oC. When the pin holding the frictionless piston breaks, the volume available to the water increases to 0.0010 m3. Find the temperature, pressure, and amounts of vapor, liquid, and solid water present after the expansion.
3. Initial 
   statc 
   Final 
   statc Suppose a compressed gas cylinder (cylinder A) contains an ideal gas at 12-bar pressure and 35oC. This gas is partially evacuated into an evacuated cylinder (B) of equal volume. What is the final temperature in gas cylinder A when the pressures in the two cylinders equalize? One way to solve this problem it to make your system the portion of the starting contents of cylinder A that remains when the pressures in the two cylinders equalize. That is, your system is the gas within the dashed lines. Cylinder A is adiabatic, and no heat transfers across the dashed line because the temperature is the same on both sides of the line. The gas undergoes a uniform expansion so there are no pressure gradients in the cylinder and thus the gas expands reversibly.
4. Water at 150oC and 12 bar enters a throttle whose outlet pressure is 1.2 bar. What is the outlet temperature and what phase or phases exit? If more than one phase, determine the fraction in each phase.
5. Propane is burned in air. What is its adiabatic temperature? That is, what is the maximum temperature that could be obtained if no heat were lost?
6. Air at 2-bar pressure is in a fixed-volume container. When 100 kJ of heat is added, is the enthalpy change is greater than, equal to, or less than 100 kJ? Explain why?
7. Machine generated alternative text:
   Consider argon in a well-insulated piston-cylinder. The 
   piston weighs 2 kg. The cylinder above the piston 
   contains N
   2
   at a pressure of 2 bar. The system is at 
   equilibrium. When the N
   2
   pressure is slowly increased 
   by flowing N
   2
   into the volume above the piston, the Ar 
   pressure _________ and the Ar temperature 
   __________.
   A.increases, does not change
   B.decreases, decreases
   C.increases, increases
   D.decreases, does not change
   E.increases, decreases
   N
   2
   piston
   A heat pump is used to heat rooms in a house. The outside temperature is 5.0oC and the room temperature is 21oC. For every 100. kJ of electricity put into the heat pump, what is the maximum kJ of heat that can be added to the rooms? Explain.
8. Consider argon in a well-insulated piston-cylinder. The piston weighs 2 kg and is also an insulator. The cylinder above the piston contains N2 at a pressure of 2 bar. The system is at equilibrium. When the N2 pressure slowly increases as more N2 flows into the volume above the piston, what happens to the Ar pressure and temperature?