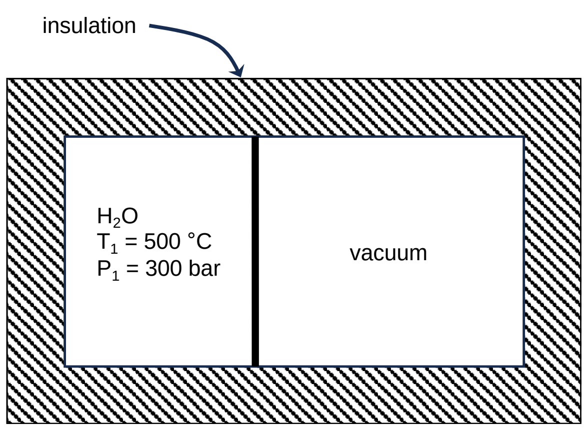
ECHE 363 – Thermodynamics of Chemical Systems
Homework #2

100 points total. Complete the following problems and upload your solutions to the Canvas assignment dropbox by the due date/time.

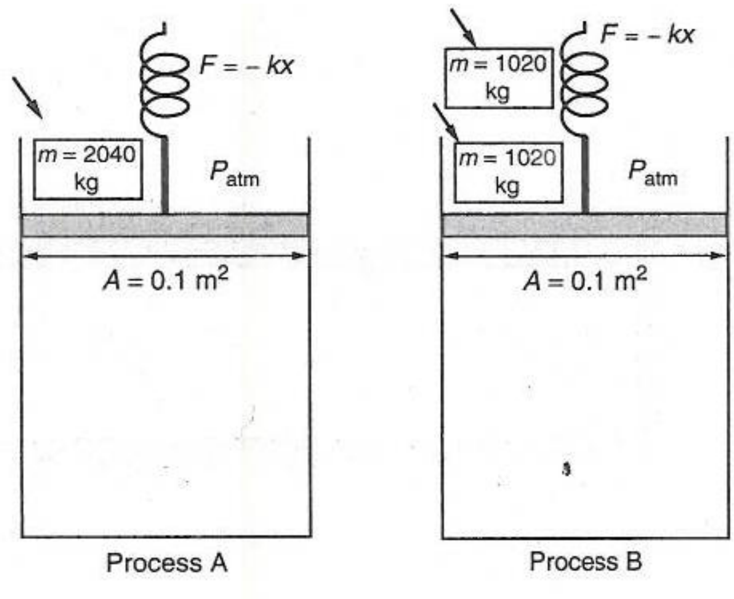
You are strongly encouraged to collaborate with your classmates on the homework, but each student is required to come up with a unique solution to the homework problems. For full credit, you must show all work. This includes showing all steps involving algebra and/or calculus. Your calculator can only be used for the final evaluation of numerical answers and may not be used for solving algebraic equations and/or integrals.

1. Find the work of a reversible, isothermal compression of 1 mole of gas, from pressure P_i to P_f, in a piston if $v_\mathrm{m} = \frac{RT}{P} + b$, where b is a positive constant.

2. The insulated vessel shown below has two compartments separated by a membrane. On one side is 1 kg of steam at 500 °C and 300 bar. The other side is evacuated. The membrane ruptures and the steam fills the entire volume. The final pressure is 100 bar. Determine the final temperature of the steam and the volme of the vessel.



3. Consider the piston–cylinder assembly containing a pure ideal gas shown below. The initial volume of the gas is 0.1 m^3, the initial pressure is 1 bar, and the cross-sectional area of the piston is 0.1 m^2. Initially the spring exerts no force on the very *thin* (i.e., massless) piston.



a. A block of mass $m = 2040$ kg is then placed on the piston. The final volume is 0.05 m^3, and the final pressure is 2×10^5 Pa. You may assume that the force exerted by the spring on the piston varies linearly with x and that the spring is very "tight", so that the volume of the gas is never less than the final volume. Precisely draw the process on a *PV* diagram, labeling it "process A." Draw the area that represents the work for this process. What is the value of the work? [*Hint*: First find the value of the spring constant, k.]

b. Consider instead a process in which a block of mass 1020 kg is placed on the piston in the *original initial state*, and after the gas inside has been compressed another block of mass 1020 kg is placed on the piston. Draw the process on the same *PV* diagram as in (a), labeling it "process B." Draw the area that represents the work for this process. What is the value of the work? For these processes, you may assume that PV^c = constant, where "c" is a constant that you must determine.

c. Describe the process in which it will take the least amount of work to compress the piston. Draw the process on the same *PV* diagram, labeling it "process C." Draw the area that represents the work for this process. What is the value of the work?

4. Consider a piston–cylinder assembly that contains 3 L of an ideal gas at 30 °C and 8 bar. The gas reversibly expands to 2 bar.

    a. Write an energy balance for this process.

    b. Suppose that the process is done isothermally. What is the change in internal energy, ΔU, for the process? What is the work done, W, during the process? What is the heat transferred, Q?

    c. If the process is done adiabatically (instead of isothermally), will the final temperature be greater than, equal to, or less than 30 °C? Explain.

5. Answer the following reflection questions (5 points):

    a. What about the way this class is taught is helping your learning?

    b. What about the way this class is taught is inhibiting your learning?