AREN 2110
Spring 2011

Homework #4: Due Friday, Feb. 11, 6 PM (30 points)

1. (1 point) Is the relation $\Delta U = mc_v\Delta T$ restricted to constant volume processes only or does it apply to any process with an ideal gas?

2. (1 point) Is the relation $\Delta H = mc_P\Delta T$ restricted to constant pressure processes only or does it apply to any process with an ideal gas?

3. (2 points) A fixed mass of an ideal gas is heated from 50 to 80 ^oC at a constant volume of a) $1m^3$ and b) $3\ m^3$. Show which case requires more energy? Why?

4. (2 points) A fixed mass of an ideal gas is heated from 50 to 80 ^oC at a constant pressure of a) 1atm and b) 3 atm. Show which case requires more energy? Why?

5. (2 points) A mass of 10 grams of nitrogen (N_2)is contained in a spring-loaded piston cylinder device. The spring constant is 1 kN/m, and the piston diameter is 10 cm. When the spring exerts no force on the piston, the nitrogen has a pressure of 120 kPa and temperature of 27 ^oC. The device is now heated until its volume increases by 10% from the original volume. Determine ΔU and ΔH of the nitrogen.

6. Two tanks (A and B) are separated by a removable partition. Initially tank A contains 2-kg steam at 1 MPa and 300 ^oC. Tank B contains 3-kg of saturated liquid-vapor mixture at 150 ^oC and quality = 0.5. The partition is removed and the contents of the two tanks mix and equilibrate. The pressure at the end state is 300 kPa.

    a. (1 point) What is the temperature of the steam at the final state?
    b. (1 point) Find the change in enthalpy during the process (kJ)?

7. (2 points) A frictionless piston-cylinder which maintains a constant pressure process and a rigid tank each contain 12 kg of an ideal gas whose molar mass is 25 kg/kmol. Each system has the same initial temperature, pressure and volume. The temperature of the gas in both systems is to be raised by 15 ^oC. How much extra heat must be added to the piston cylinder to achieve this result?

8. (2 points) A mass of 2.4 kg air at 150 kPa and 12 ^oC is contained in a closed piston cylinder device. The air is compressed to a final pressure of 600 kPa. During the process heat is transferred so that the temperature of the air remains constant. What is the work input during the process?

9. Nitrogen, an ideal gas, is expanded in a polytropic process according to the relation:

$$PV^n = constant$$

where P = pressure (kPa), V = volume (m^3) and n = a constant. The initial volume of the nitrogen is 2 m^3; the initial pressure is 500 kPa and the initial temperature is 300 ^oC. During the expansion, the volume triples and the pressure decreases to half its initial value.

a. (1 point) Find n.
b. (1 point) Calculate the equilibrium temperature after expansion.
c. (1 point) Calculate the boundary work by the gas during the process in kJ.

10. A device containing air is operated in a cycle consisting of four processes with no work exchanges other than boundary work.

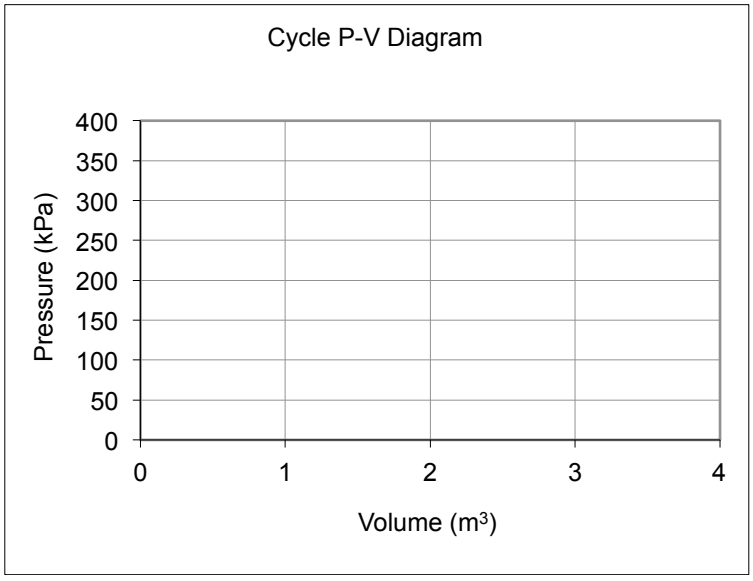
1 → 2: Isothermal compression, $V_1 = 3\ m^3$, $V_2 = 1\ m^3$; $P_1 = 100$ kPa

2 → 3: Isochoric heat loss, $P_3 = \frac{P_1}{2}\ m^3$

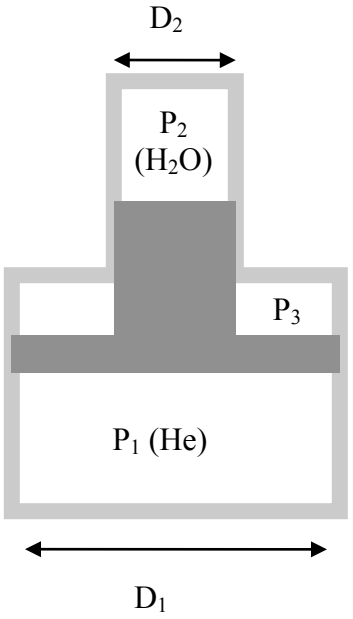
3 → 4: Isobaric expansion, $V_4 = 3\ m^3$

4 → 1: Isochoric heat addition, return to state 1

a. (1 point) Find P_2
b. (1 point) Find W_b for process 3 → 4
c. (1 point) Find W_b for process 1 → 2
d. (1 point) Find the net work for the cycle
e. (1 point) Graph the process on the P-V diagram below



11. (3 points) A cylindrical piston cylinder device has three chambers, as shown below. Chamber 1 contains 1 kg helium; chamber 2 contains condensing water vapor; chamber 3 is evacuated. The device is placed in surroundings whose temperature is 200 ^{o}C and allowed to come to equilibrium. The inside diameter of chamber 1 is 10 cm and the inside diameter of chamber 2 is 4 cm. Find the volume of the helium in chamber 1 when equilibrium is reached. (Answer: 3.95 m^3)



12. (5 points) THERMODYNAMICS IN THE NEWS. Thermodynamics is important for more than analyzing and designing mechanical devices. One of the potential impacts that climate scientists have proposed as a result of global warming is more intense storms. This week a category 5 cyclone hit northern Australia – one of the largest storms ever recorded there. Find an article (newspaper, on-line news source) describing the cyclone that also includes some mention of the possible relation of global warming to storm intensity. Read and summarize in no more than a paragraph. Include a citation for your source (publication or URL, author, and date)