Q4001 Thermodynamics of Materials **August, 2019**
Homework 3

1. Calculate the work that 1 mol of a perfect gas ($\overline{C}_V = 25\,\mathrm{J/mol\,K}$) produces when it expands from an initial volume of 10 L and 31.5°C to:
   (a) a final volume of 50 L, reversibly and isothermically.
   (b) irreversibly and isothermically against an external pressure of 0.5 atm.
   (c) a final volume of 50 L reversibly and adiabatically.
   (d) irreversibly and adiabatically against an external pressure of 0.5 atm.
   (e) For all cases above, determine the final state after the expansion.

2. A solar collector is used as a heat source for a Carnot engine with a heat sink at 300 K. The efficiency of the solar collector ε is defined as the fraction of the energy reaching the collector that is actually absorbed. It is related to the temperature of the collector as follows:

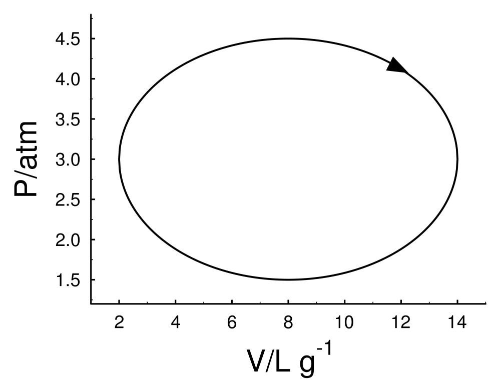
$$\varepsilon = 0.75 - 1.75\left(\frac{T}{300\,K} - 1\right)$$

   Determine the best operating temperature of the collector.

3. Produce a single graph of P_f/P_i vs. V_f/V_i for the following expansion processes:
   (a) Reversible isothermic process.
   (b) Reversible adiabatic processes for monoatomic, diatomic and polyatomic perfect gases.
   (c) Irreversible adiabatic processes for monoatomic, diatomic and polyatomic perfect gases.

   Compare the plots in the graph and discuss the different behaviors observed. Choose the representation of your axes wisely.

4. A PV diagram of an imaginary heat engine is represented in the following figure.



   (a) Find the work performed per cycle by 1 g of working fluid.
   (b) Find the engine efficiency if it rejects 5.7 kJ/g during each cycle

5. A heat engine, of which all steps in a cycle are reversible, absorbs thermal energy from a high-temperature reservoir, performs an amount of net work w_{net} , and rejects thermal energy into a lowtemperature reservoir. Initially, the reservoirs are at temperatures T_1 and T_2. Their heat capacities are constant with values C_1 and C_2, respectively. Calculate what will be the final temperatures for the heat reservoirs and the maximum amount of work produced by the engine.

Due date: Tuesday, september 3d.