CM3230
Chemical Engineering Thermodynamics
Fall 2016
Quiz 1a

Name: ____

(Circle only one answer for each item. Each item is worth 20 points. Answer 5 items correctly for full 100 points. If all 6 items are correct, then a bonus of 20 points will be awarded.)

1. A rigid vessel contains two compartments separated by an impermeable membrane. On one compartment is an ideal gas at a pressure P_i occupying a volume of V_i. The other compartment is a vacuum and has a volume $V_{vac} = 0.5\, V_i$. After the membrane ruptures, the whole vessel settles to a final pressure $P_f = \frac{3}{4} P_i$. Assuming the molar heat capacity of the gas is $c_V = \alpha R$ (where R is the universal gas constant and α is a dimensionless factor), then the heat added to the system from initial to final condition is given by
   a. $Q = \frac{1}{8} \alpha P_i V_i$
   b. $Q = \frac{4}{3} \alpha P_i V_i$
   c. $Q = -\frac{1}{4} \alpha P_i V_i$
   d. $Q = 0$
   e. None of the above

2. At $P = 20\ bars$, saturated steam has specific volumes of liquid and vapor given by $\hat{v}_l = 0.001177\ m^3/kg$ and $\hat{v}_v = 0.09963\ m^3/kg$, respectively. Suppose the wet steam at this temperature has a specific volume $\hat{v} = 0.08\ m^3/kg$, then the fraction of liquid in the wet steam is closest to (within $\pm 5\%$)
   a. $f_{liq} = 0.1$
   b. $f_{liq} = 0.2$
   c. $f_{liq} = 0.8$
   d. None of the above

3. Supersaturated steam having $\hat{h}_{in} = 3050 \frac{kJ}{kg}$ is fed to a turbine (assumed adiabatic) at a rate of $\dot{m} = 2 \frac{kg}{sec}$ to deliver a power $\dot{W}_{s\_by} = 1000 \frac{kJ}{sec}$ and exits at $P_{out} = 1\ bar$ as wet steam. Saturated steam at $P_{out} = 1\ bar$ has specific enthalpy of liquid and vapor given by $\hat{h}_{l,out} = 417.4\ kJ/kg$ and $\hat{h}_{v,out} = 2676\ kJ/kg$, respectively. The quality of the steam coming out of the turbine is closest to (within $\pm 5\%$)
   a. $x_{out} = 0.985$
   b. $x_{out} = 0.944$
   c. $x_{out} = 0.923$
   d. None of the above

4. An ideal gas undergoes a cyclic process (see Figure 1) as follows. Starting at P_{hi} and v_{small} (point a), it undergoes an isothermal expansion to P_{lo} (point b). Then it is heated at constant volume back to P_{hi} (point c). After this, it is compressed back to v_{small} (point a) at constant pressure. Let $c_v = 3/2R$. The net molar work done by the gas in the isobaric compression subpath (c → a) is

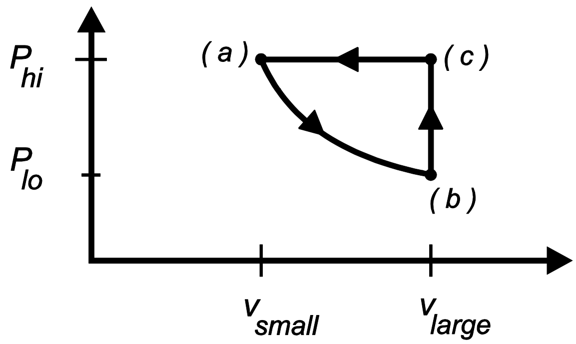

Figure 1. A cyclic process for an ideal gas.

a. $w_{by(c \to a)} = (P_{lo} - P_{hi})v_{small}$
b. $w_{by(c \to a)} = \left(1 - \frac{P_{hi}}{P_{lo}}\right) P_{hi} v_{small}$
c. $w_{by(c \to a)} = P_{lo} v_{small} \left(1 - \frac{P_{lo}}{P_{hi}}\right)$
d. None of the above

5. An ideal gas with $c_P = 3R/2$ at pressure P_{in} is passed through a throttle (assumed adiabatic) and exits at $P_{out} = P_{in}/2$. Then density ratio of outlet to inlet is then given by
a. $\rho_{out}/\rho_{in} = 1/3$
b. $\rho_{out}/\rho_{in} = 1/2$
c. $\rho_{out}/\rho_{in} = 4/3$
d. None of the above

6. An ideal gas initially at T_i and pressure P_i undergoes a sudden (<u>irreversible</u>) adiabatic compression under a constant external pressure P_{ext}, where the final pressure $P_f = P_{ext}$. Assuming c_v is constant, then the ratio of final temperature to initial temperature will be
a. $T_f/T_i = \left[(c_v + R)P_f\right]/[(c_v + R)P_i]$
b. $T_f/T_i = \left[c_v P_f\right]/[(c_v + R)P_i]$
c. $T_f/T_i = \left[c_v + R\left(P_f/P_i\right)\right]/[c_v + R]$
d. None of the above