ECHE 363 – Thermodynamics of Chemical Systems
Homework #7

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. Propane at 350 °C and 600 cm^3/mol is expanded in an isentropic turbine. The exhaust pressure is atmospheric. What is the exhaust temperature? The Pv_mT behavior is well-described by the van der Waals equation of state with:

$$a = 92 \times 10^5 \text{ (atm cm}^6\text{)/mol}^2$$
$$b = 91 \text{ cm}^3\text{/mol}$$

   a. Solve this using T and v_m as the independent variables, that is $s_m = s_m(T,v_m)$.

   b. Solve this using T and P as the independent variables, that is $s_m = s_m(T,P)$.

2. A well-insulated, rigid vessel is divided into two compartments by a partition. The volume of each compartment is 0.1 m^3. One compartment initially contains 400 moles of gas A at 300 K, and the other compartment is initially evacuated. The partition is then removed and the gas is allowed to equilibrate. Gas A is not ideal under these circumstances, and can instead be described well by the following equation of state:

$$P = \frac{RT}{v_m - b} - \frac{a}{T v_m^2}$$

   with the following constants for gas A:

$$a = 40 \text{ J K m}^3 \text{ mol}^{-2}$$
$$b = 3 \times 10^{-5} \text{ m}^3\text{/mol}$$

   You may take the ideal gas heat capacity of the gas to be $c_{v,m}^{ideal} = 1.5R$.

   Calculate the final temperature.

3. Consider filling a gas cylinder with ethane from a high-pressure supply line. Before filling, the cylinder is empty (vacuum). The valve is then opened, exposing the tank to a 3 MPa line at 500 K until the pressure of the cylinder reaches 3 MPa. The valve is then closed. The volume of the cylinder is 50 L. For ethane, use the truncated virial equation of state, in pressure:

$$Z = \frac{P v_m}{RT} = 1 + B'P$$

with $B' = -2.8 \times 10^{-8}$ m^3/J

   a. What is the temperature immediately after the valve is closed?

   b. If the cylinder then sits in storage at 293 K for a long time, what is the entropy change of the universe (from the original unfilled state)?

4. 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?