ASSIGNMENT 9

CHEMISTRY 200

Due: 4:30 pm Friday 21 November 2008

The Cycle Assignment

1. A statement of the first law is:

$$\Delta U = w_{ad} \quad \text{and} \quad dU = đw_{ad}.$$

The complete differential of U is:

$$dU = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV$$

where

$$\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_V - p.$$

Use these to find an expression relating the initial temperature and volume of a van der Waals gas to the final temperature and volume of the gas undergoing adiabatic reversible work. Assume the heat capacity at constant volume of the gas is $C_v = \frac{5}{2}nR$.

2. Consider a four step cycle which is carried out reversibly.

Step 1: State A to State B. 6.06 mole of a perfect gas, initially at 5.26 atm, is expanded isothermally at 64.0°C to twice its volume.

Step 2: State B to State C. The gas is cooled adiabatically to 7.00°C.

Step 3: State C to State D. The gas is compressed isothermally to state D.

Step 4: State D to State A. The gas is heated adiabatically.

(a) Calculate p, V, and T at each point A, B, C, D. (Hint: State D is at the intersection of the isotherm through C and the adiabat through A.)

(b) Calculate q, w, ΔU, and ΔH for each step of the cycle and for the entire cycle.

(c) What fraction of the heat transferred in the expansion steps is converted to work over the cycle?

3. Consider a four step cycle which is carried out reversibly.

Step 1: State A to State B. 0.297 mole of a van der Waals gas with $a = 0.1657$ dm^6 atm mol^{-2}, $b = 58.10$ cm^3 mol^{-1}, and $C_v = \frac{5}{2}nR$, initially at a volume of 83.6 L, is expanded isothermally at 90.3°C to twice its initial volume.

Step 2: State B to State C. The gas is expanded adiabatically to five times the volume it had in state A.

Step 3: State C to State D. The gas is compressed isothermally to state D.

Step 4: State D to State A. The gas is heated adiabatically.

(a) Calculate p, V, and T at each point A, B, C, D. (Hint: State D is at the intersection of the isotherm through C and the adiabat through A.)

(b) Calculate q, w, ΔU, and ΔH for each step of the cycle and for the entire cycle.

(c) What fraction of the heat transferred in the expansion steps is converted to work over the cycle?