

ASSIGNMENT 9

CHEMISTRY 200

Due: 4:30 pm Monday 13 November 2006

The Cycle Assignment

1. A statement of the first law is:

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

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.

- 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.)
- Calculate q, w, ΔU , and ΔH for each step of the cycle and for the entire cycle.
- 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 $a = 0.1657 \text{ dm}^6 \text{ atm mol}^{-2}$, $b = 58.10 \text{ cm}^3 \text{ mol}^{-1}$, 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.

- 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.)
- Calculate q, w, ΔU , and ΔH for each step of the cycle and for the entire cycle.
- What fraction of the heat transferred in the expansion steps is converted to work over the cycle?