CHEM 361A - Lecture 3 Activity
Internal Energy

In Class

1. Make the following table and fill in as much as you can:

Table 1: Table of thermodynamic properties.

	Isothermal	Adiabatic	Isobaric	Isochoric
q				
w				
ΔU				
ΔH				

2. A hydroflask filled with water is shaken vigorously. Consider the water as the system.
   (a) Has heat been added to the system?
   (b) Has work been done to the system?
   (c) Has the system's internal energy changed?
   (d) Will the temperature of the water rise due to the shaking?

3. Equipartition Theorem and Internal Energy
   (a) Explain why the heat capacity at constant volume for diatomic gases are generally around 20.8 J K^{-1} mol^{-1} at room temperature.
   (b) What would the heat capacity at constant volume for diatomic gases generally be at very high temperatures?

4. Reversible vs irreversible work
   (a) One mole of a gas in a 1 L chamber at 298 K is expands against a piston open to the atmosphere (1 atm of pressure). Assume that the process is isothermal and the gas behaves ideally.
      i. Sketch how the pressure and volume evolve using a P-V plot and indicate the work performed by the gas.
      ii. Is this process reversible or irreversible?
   (b) In a separate 1 L chamber at 298 K, one mole of gas is allowed to expand in two stages. In the first stage it expands against an external pressure of 12 atm until the chamber reaches 2.04 L, and then it expands against an external pressure of 1 atm. Assume that the process is isothermal and the gas behaves ideally.

i. Sketch how the pressure and volume evolve using a P-V plot and indicate the work performed by the gas.

ii. Is this process reversible or irreversible?

(c) In a final 1 L chamber at 298 K, one mole of gas is allowed to expand such that the external pressure always matches the internal pressure of the chamber. Assume that the process is isothermal and the gas behaves ideally.

i. Sketch how the pressure and volume evolve using a P-V plot and indicate the work performed by the gas.

ii. Is this process reversible or irreversible?

(d) Which process produced the most amount of work?

(e) Suppose now that you have an ideal gas which is isothermally compressed from p_1, V_1 to p_2, V_2.

i. Under what conditions would the work done to the gas be a minimum?

ii. Under what conditions would the work done to the gas be a maximum?

5. The equation of state for a certain gas is given by

$$P(V - nb) = nRT$$

Find the expression that calculates the maximum amount of work done by the gas in an isothermal, reversible process between V_1 and V_2.

Homework

6. For an isothermal process, 100 J of work is done to the system. Determine ΔU and the heat transferred for this process. ($\Delta U = 0$ and $q = -100J$)

7. Artificial snow is made my quickly releasing a mixture of compressed air and water vapour at about 20 atm from a snow-making machine to the surroundings. Assume that the expansion occurs so fast that no heat is transferred. Use the First Law of Thermodynamics to explain why snow forms. ($\Delta U = w$ so air and water does lots of work to surroundings which drops its temperature)

8. Calculate the amount of work performed in the first three parts of question 4 (2a: $w = -2381$ J, 2b: $w = -3539$ J, 2c: $w = -7925$ J)

9. In this problem we are going to examine how attractive and repulsive forces in a gas can affect the work done by a gas.

(a) Calculate an expression for the work done during an isothermal, reversible expansion for a gas which is described using the vdW equation of state. ($w = -nRT \ln \frac{V_2 - nb}{V_1 - nb} - an^2 \left(\frac{1}{V_2} - \frac{1}{V_1} \right)$)

(b) The vdW constants for a gas are $a = 506.5$ kPa L^2 mol^2 and $b = 6.0 \times 10^{-2}$ L mol^{-1}. Determine the work done by 2.0 moles of a gas that expands from 1.5 L to 10 L at 325 K. ($w = -9607$ J)

(c) The a constant is attributed to attractive forces in the gas while the b constant is attributed to the repulsive forces in the gas. For the same conditions as before, if a were doubled, what is the amount of work done by the gas? Explain why this result makes sense. ($w = -8459$ J. Gas more attractive means it does not expand as easily so it does less work.)