

Chemistry 342
Fall 2001
Second Hour Exam

1. (20 points) Consider the chemical reaction $\text{CO} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO}_2$, which is carried out at 298 K and 1 atm. Use the data in the following table to calculate ΔS for the reaction and also ΔS for the surroundings. Based on your answer, determine whether or not the reaction occurs spontaneously.

Molecule	M (g/mol)	$\Delta H_{f,m}^{\circ}$ (kJ/mol)	S_m° (J/K/mol)	$C_{p,m}^{\circ}$ (J/K/mol)
CO(g)	28.011	-110.53	197.67	29.14
CO ₂ (g)	44.010	-393.51	213.74	37.11
O ₂ (g)	31.999	0	205.138	29.355

2. (18 points) The boiling point of benzene is 80 C. Estimate its vapor pressure at 25 C. (Hint: The key number in Trouton's rule is $85 \text{ J mol}^{-1} \text{ K}^{-1}$.)

3. (15 points) Alice and Bob return from a skiing vacation to discover that the landlord turned off the heat in their apartments. Bob warms up his apartment by turning on a space heater. Alice doesn't have a space heater, so she uses her refrigerator instead. She opens a window and places the open refrigerator against the window, taking care that the refrigerator seal makes good contact with the window frame. (The inside of the refrigerator faces the outside of the house.) Alice and Bob heat their apartments to the same final temperature. Who has the larger electric bill in the end? Prove your answer.

4. (20 points) In the Joule experiment, a gas expands adiabatically into a vacuum. Suppose the initial conditions are n , T_1 , P_1 , and V_1 , and the final conditions are n , T_2 , P_2 , and V_2 . Express the answers to the following questions in terms of these quantities, as well as any other constants (C_v , R , α , κ_T) that you may think are appropriate.

- A. If the gas is ideal, the temperature doesn't change. What is the entropy change for this case?
- B. Suppose the gas is not ideal, so that $T_2 \neq T_1$. What is the entropy change in this case?

5. (27 points) In this problem we will calculate the temperature change in a Joule expansion.

- A. Explain why U is constant during a Joule expansion.
- B. To calculate the temperature change, you need to evaluate the quantity

$$\mu_J = \left(\frac{\partial T}{\partial V} \right)_U. \text{ Show that } \mu_J = -\frac{1}{C_v} \left(\frac{\partial U}{\partial V} \right)_T.$$

- C. Derive an expression for $\left(\frac{\partial U}{\partial V} \right)_T$ that contains only P , V , T , and the partial derivative sign. (Algebraic signs and parentheses are also OK.)
- D. Consider a gas that obeys the equation of state $PV = nRT - a\left(\frac{n}{V}\right)^2$. Evaluate μ_J for this gas.
- E. Calculate the temperature change for a Joule expansion of the gas described in part D.



