

CHEM 401--Physical Chemistry

Exam #1

18 October 1996

1. (40 points) Another equation of state proposed to describe the non-ideal behavior of gases is

$$\left(P + \frac{n^2 a}{TV^2} \right) (V - nb) = nRT$$

Prove that pressure, P, is a state variable using the total differential for P.

2. Consider the van der Waals' equation of state for gases.

a. (10 points) An imaginary gas is composed of molecules with zero volume, but possessing a strong attractive potential energy between molecules. Express van der Waals' equation under these conditions.

b. (20 points) For the real gases benzene (C_6H_6), buckminsterfullerene ($C_{60}H_{60}$), carbon dioxide (CO_2), helium (He), and nitrogen (N_2), rank in order from smallest to largest these gases according to their van der Waals' b constant.

3. (80 points) An ideal gas undergoes the following steps reversibly:

I. Adiabatic expansion from (P_1, T_1, V_1) to (P_2, T_2, V_2)

II. Isothermal compression from (P_2, T_2, V_2) to (P_1, T_2, V_3)

III. Isobaric expansion from (P_1, T_2, V_3) to (P_1, T_1, V_1)

Determine dw and dq for each step, and the total Δw , Δq , ΔU , and ΔH for the entire cycle.

4. (50 points) 1.00 mol of an ideal gas at 300 K and 1.00 atm is suddenly compressed isothermally and irreversibly by a force exerting an additional 5.00 atm pressure. Determine the final volume of the gas, and the amount of work performed.