Problem Set PS09

ISSUED: 11/1/01 **Due: 11/8/01**

Prof. Darin J. Ulness Name ______________________________

Instructions. Complete all questions before class on the due date. You are encouraged to work together. Be sure to struggle with the problem before seeking help. Many of the exercises are very similar to problems in the book. Understanding the solution to these problems will be helpful in completing the assigned exercises.

Exercises

1. One mole of an ideal gas in a piston expands irreversibly from 2.0L to 4.0L under a constant pressure of 1atm. (The molar heat capacity of the gas is $C_m = \frac{5}{2}R$, where R is the gas constant.)

   (a) How much work was done?

   (b) If the piston has adiabatic walls, what is the change in temperature of the gas?

   (c) If the piston has diathermic walls, how much heat is exchanged between the piston and its environment?

2. One mole of an ideal gas in a piston expands reversibly and isothermally from 2.0L to 4.0L. (The molar heat capacity of the gas is $C_m = \frac{5}{2}R$, where R is the gas constant.) How much work was done?

3. An ideal gas in a piston is reversibly heated at a pressure of 1.0atm. If the piston initially had a volume of 1.0L and a temperature of 200K, what is the final volume and temperature if 30J of heat energy is added? How much work was done? (The heat capacity of the gas is $C = \frac{5}{2}R$, where R is the gas constant.)

4. Derive an expression for the ratio of a Van der Waals gas to an ideal gas. Is this expression independent of temperature? Does this ratio behave how you would expect as one changes the volume?

Conceptual Problems

5. List the proper names of the all the intensive properties you can make from volume, moles, heat capacity and mass.

Reflective Questions

6. Visit `http://www.phds.org/ratings/`and select the subject that is of the most interest to you (if none interest you choose chemistry) then click on "next." Select the weighting criteria that are most important to you then click on "next." What are the top ten schools in your field?

① ⓐ $w = -P_{ex}\Delta V = -1(4-2) = -2$ l·atm

ⓑ $\Delta U = q + w$ adiabatic $\Rightarrow q = 0$

$\Delta U = w$ but $\Delta U = C_V \Delta T$

so $\Delta T = \frac{w}{C} = \frac{-2 \text{ l atm}}{\frac{5}{2}(0.082 \frac{\text{l atm}}{\text{K mol}})} =$ **−9.76 K**

ⓒ diathermic walls $\rightarrow$ isothermal transition

$q = -w =$ **+2 l·atm**

② $dw = -P_{ex}dV$ reversible $dw = -PdV$

$w = \int_2^4 -PdV = \int_2^4 -\frac{RT}{V}dV = -RT\ln V\Big|_2^4$

$= -R(310)\ln\frac{4}{2} =$ **−17 l·atm**

③ $n = \frac{PV_1}{RT_1} = \frac{(1)(1)}{R(200)} = 0.061$ moles

$\Delta T = \frac{q}{nC_p} = \frac{30}{(0.061)\frac{7}{2}(8.314)} = 16.9$

so $T_2 = 216.9$ K

$V_2 = \frac{nRT_2}{P} = \frac{(0.061)(0.0821)(216.9)}{1} = 1.08$

$w = -P_{ex}dV = 1.0(1.08 - 1.0) =$ **−0.08 l·atm**

⑤ density = $\frac{\text{mass}}{\text{vol}}$, molar mass = $\frac{\text{mass}}{\text{mol}}$

molar heat cap. = $\frac{\text{heat cap}}{\text{moles}}$, specific heat = $\frac{\text{heat cap}}{\text{mass}}$

number density = $\frac{\text{moles}}{\text{volume}}$, molar volume = $\frac{\text{volume}}{\text{moles}}$

④ $\frac{P_{vdw}}{P_{id}} = \frac{\frac{nRT}{V-nb} - \frac{n^2a^2}{V^2}}{\frac{nRT}{V}} = \frac{V}{V-nb} - \frac{na^2}{RTV}$ not independent of T

We expect increasing deviation from ideal as $V \rightarrow 0$

also we expect $\frac{P_{vdw}}{P_{id}} \rightarrow 1$ as $V \rightarrow \infty$ This is the case.