Chemistry 301
Thermodynamics
Midterm Exam
October 4, 2001

Name _____

Full credit will be given to correct answers only when ALL the necessary steps are shown. DO NOT GUESS THE ANSWER.

This is a open book open notes exam, and you are responsible to be sure that your exam has no missing pages(8 pages). Please cite all sources of information used to solve this exam.

If you consider that there is not enough information to solve a problem, you have to specify the missing information and describe the problem solving procedure.

But surely this is an old tale you tell, they say;
But surly this is a new tale you tell, other say.
Tell it once again, they say;
Or, do not tell it yet again, others say.
But I have heard all this before, say some;
Or, but this is not how it was before, say the rest

Naqshbandi recital, from The Way of the Sufi, by Idries Shah

Once you start the exam, you have up to 48 hours to solve it.

Starting time: _____

Ending time: _____

Exam is due Tuesday October 9th at 8:30am.

Honor Statement

Except from the instructor, you are not allowed to discussed with anybody any of the questions in this exam until October 9, 2001.

I have neither give nor received aid in this examination.

Full signature _____

Problem 1.- **(20 points)**

For the Redlich-Kwong (RK) equation of state,

$$P = \frac{RT}{V_m - b} - \frac{a}{\sqrt{T}} \frac{1}{V_m (V_m + b)}$$

Calculate the first two Virial coefficients, B(T), C(T), and the Boyle temperature.

Problem 2.**(40 points)**

The R-K parameters for $N_2(g)$ are:

$$a = 1.551 \text{ Pa m}^6 \text{ mol}^{-2} \text{ K}^{1/2}$$
$$b = 26.74 \ 10^{-6} \text{ m}^3 \text{ mol}^{-1} .$$

Consider an isothermal reversible expansion from 10 bar pressure to 1 bar at 300 K.

a) For this process, calculate the work done by the R-K gas.

b) Compare your result with the work done by a Perfect Gas.

c) Calculate the heat absorbed by the R-K gas in order to keep the temperature constant.

Problem 3. **(20 points)**

For a Berthelot equation of state,

$$P = \frac{RT}{V_m - b} - \frac{a}{T V_m^2}$$

calculate

a) The isothermal compressibility

b) Constant pressure coefficient of thermal expansion

c) C_P - C_V

Problem 4. (20 points)

For a van der Waals equation of state, prove that the Joule-Thomson coefficient can be approximated by

$$\mu_{JT} \cong \frac{1}{C_P}\left[\frac{2\,a}{R\,T} - b\right]$$

when

$$\frac{b}{V_m} << 1$$

$$\frac{a}{V_m} << R\,T$$

Problem 5. (20 points)

From the Pitzer and Stermer paper, consider equation (2) in page 3112. This equation of state with 50 parameters is used to study water and carbon dioxide. For this equation of state calculate the second Virial coefficient and prove equation (3) in the paper.

Bonus (10 points)(no partial credit)

Bonus (10 points) (nopartial credit)

Can an irrational number to an irrational power be a rational number?
Prove your answer.