Exam I

CH 353 Summer '07

Vanden Bout

Name: _____

Carefully read all the problems. The exam should have 4 pages of questions. The first page has potentially useful information. The last page is for extra writing space. Problems may have extraneous information.

Potentially useful information

$R = 8.314\ J\ K^{-1}\ mol^{-1}$ $R = 8.314 \times 10^{-2}\ L\ bar\ K^{-1}\ mol^{-1}$ $R = 8.206 \times 10^{-2}\ L\ atm\ mol^{-1}\ K^{-1}$

1 cal = 4.184 J 1 atm = 1.01325 bar T/K = T/°C + 273.15

1 atm-L = 101.325 J 1 bar-L = 100 J

$$\int \frac{dx}{a+x} = \ln(a+x) \qquad \int \frac{dx}{x^2} = -\frac{1}{x}$$

Van der Waals equation $(P + \frac{a}{V_m^{\,2}})(V_m - b) = RT$

$w = -\int P_{ex} dV$

$q = \int C_v dT$ $q = \int C_P dT$

$\Delta U = q + w$ $H \equiv U + PV$

Please sign at the bottom to certify that you have worked on your own.

I certify that I have worked the following exam without the help of others, and that the work I am turning in is my own.

Signed: ----------

Signature Date

1. True/False (10 points each)
Classify the following as either True or False

T F A process is considered thermodynamically reversible if the initial state and final state of the system are the same.

T F An ideal gas has no intermolecular attractions or repulsions

T F The van der Waals equation of state exactly describes the behavior of a real gas.

T F ΔH is always equal to q

T F At a constant pressure of 1 atm, 2000J of heat are used to increase the temperature of an aluminum block. For this process, ΔU of the block will be slightly less than 2000J.

2. Short Answer (25 points each)

The Redlich-Kwong (RK) equation of state is given below

$$P = \frac{RT}{V_m - b} - \frac{a}{T^{1/2} V_m (V_m - b)}$$ where a and b are both positive constants

a. Find an equation for the compression factor (Z) of a gas that obeys the RK eq'n of state in **the limit of infinitely high temperature**.

b. In this limit, is the gas dominated by attractive or repulsive forces?

B. It can be shown that

$$\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$$

For a gas that obeys the van der waals equation of state,

$$P = \frac{nRT}{V - nb} - \frac{an^2}{V^2}$$ where a and b are positive constants

Do you think the internal energy will increase, decrease, or stay the same for a volume increase at constant temperature. (provide some justification for your answer).

3. (50 points)

Benzoic acid ($C_7H_6O_2$) reacts with oxygen by the following reaction

$$C_7H_6O_2(s) + \frac{15}{2}O_2(g) \rightarrow 3H_2O(l) + 7CO_2(g)$$

Substance	$\Delta_f H°$ (kJ mol^{-1})	C_P (J K^{-1} mol^{-1})
$C_7H_6O_2$ (s)	-386	146.8
O_2 (g)	0	29.4
H_2O (l)	-286	75.3
CO_2 (g)	-393.5	37.11

Use the information below to find $\Delta_R H°$ for this reaction at 298K. (data at 298K)

Assuming you start with 1 g of benzoic acid and excess O_2 and the benzoic acid reacts completely at a constant temperature of 298 K and a constant pressure of 1 bar, what are ΔH, ΔU, q, and w?

ΔU = _____

ΔH = _____

w = _____

q = _____

4. (50 points)

2 moles of an ideal gas ($C_{V,m} = 1.5R$) are held in a piston at an initial temperature of 300 K and an initial pressure of 1 bar. You simultaneous increase the external pressure to a constant 4 bar, and change the surrounding temperature to a constant 400 K. The system evolves until it is at both mechanical and thermal equilibrium in a process that is neither isothermal nor adiabatic. What are ΔU, ΔH, w , and q for this process (give your answer in J).

ΔU = _____

ΔH = _____

w = _____

q = _____