Columbia University in the City of New York
New York, N.Y. 10027

Chemistry C2407x 2002
Exam Three George Flynn
November 26, 2002 Total Points: 150 75 Minutes

All questions are not weighted equally. I have attempted to order the questions from the least difficult to the most difficult, but "beauty is in the eye of the beholder", so skip around to find the problems that are easiest for you. Good luck!

Please print your name in the boxes provided and sign where indicated. Tear off this sheet and pass it to the right for the proctors to pick up.

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Do not write anything else on this page. Answer the questions in the spaces provided on the following pages.

1a	2a	3a	4a
1b	2b	3b	4b
1c	2c	3c	4c
1d	2d	3d	4d
1e	2e	3e	4e

Total Score:

Print your name here:

Problem 1: (35 points)[Oxtoby problem 8.17] 4.00 moles of hydrogen gas, H_2, (C_p = 28.8 J/K-mole) are expanded reversibly and isothermally at 400 K from an initial volume of 12.0 L to a final volume of 30.0 L.

a)(5 points) Calculate the change in energy ΔE for the gas. Show all reasoning clearly.

b)(5 points) Calculate the change in enthalpy ΔH for the gas. Show all reasoning clearly.

Print your name here:

c)(10 points) Calculate w, the work done on the gas for this process. Show all reasoning clearly.

d)(5 points) Calculate q, the heat absorbed by the gas for this process. Show all reasoning clearly.

Print your name here:

e)(10 points) Calculate the change in entropy ΔS for the gas. Show all reasoning clearly.

Print your name here:

Problem 2 (40 points) The enthalpy of fusion of ethanol is $\Delta H^\circ = 5.031$ kJ/mole at its normal melting point of 159 °K. Assume that the volume of 1 mole of liquid ethanol is 0.050 liter and the volume of one mole of solid ethanol is 0.045 liter at this melting temperature.

a) (5 points) Determine q, the heat absorbed by the system for the reversible conversion of one mole of solid ethanol to one mole of liquid ethanol at one atmosphere pressure and T=159 °K. Show reasoning clearly.

b) (10 points) Determine w, the work done (in Joules) on the system for the conversion of one mole of solid ethanol to one mole of liquid ethanol at a constant pressure of one atmosphere and T=159 °K. (Even though this process takes place at constant external pressure, you may assume that it takes place reversibly. Note that no gases are involved in this problem.) Show reasoning clearly.

Print your name here:

c) (10 points) Determine ΔS, the entropy change for the system, in the reversible conversion of one mole of solid ethanol to one mole of liquid ethanol at one atmosphere pressure and T=159 °K. Show reasoning clearly.

d) (5 points) Determine ΔE, the energy change for the system, in the conversion of one mole of solid ethanol to one mole of liquid ethanol at one atmosphere pressure and T=159 °K. Show reasoning clearly.

Print your name here:

e) (10 points) Using the data from parts a-d, determine ΔG, the free energy change for the system, in the melting of one mole of solid ethanol to one mole of liquid ethanol at one atmosphere pressure and T=159 °K. Does the result surprise you? Show reasoning clearly.

Print your name here:

Problem 3: (40 points) Consider the very important chemical transformation (one at the heart of the alternate fuels industry):

$$H_2O(g) + CO(g) = CO_2(g) + H_2(g)$$

and the data:

	$\Delta H°_f(25°C)$	$S°\ (25°C)$	$\Delta G°_f\ (25°C)$	$C_p(25°C)$
	(kJ/mole)	(J/K°mole)	(kJ/mole)	(J/K°mole

$CO(g)$	-110.5	197.6	-137.2	29.14
$CO_2(g)$	-393.5	213.6	-394.4	37.11
$H_2O(g)$	-241.8		-228.6	35.58
$H_2(g)$		130.6		28.82

Blank entries in the table above are not necessarily zero!

a)(5 points) Calculate $\Delta H°_{298}$ for this reaction. Show all reasoning clearly.

b)(5 points) Calculate $\Delta G°_{298}$ for this reaction. Show all reasoning clearly.

Print your name here:

c)(5 points) Calculate $\Delta S°_{298}$ for this reaction. Show all reasoning clearly.

d)(10 points) Assuming all the gases involved in this reaction are ideal gases, calculate ΔE°_{298} for this reaction. Show all reasoning clearly.

Print your name here:

e)(15 points) Compute the absolute entropy $[S^\circ_{298}]$ for $H_2O(g)$ at 298 K. Show all reasoning clearly.

Print your name here:

Problem 4: (35 points) The equilibrium constant for the reaction

$$(1/2)Cl_2(g) + (1/2)F_2(g) \rightleftharpoons ClF(g)$$

is measured to be 9.3×10^9 at 298 °K and 3.3×10^7 at 398 °K. In what follows you may assume the enthalpy and entropy changes for the reaction are independent of temperature.

a)(5 points) Calculate the standard free energy change $\Delta G°$ for the reaction at 298 °K. Show all reasoning clearly.

b)(5 points) Calculate the standard free energy change ΔG° for the reaction at 398 °K. Show all reasoning clearly.

Print your name here:

c)(10 points) Calculate the standard entropy change ΔS° for the reaction. Show all reasoning clearly.

d)(5 points) Calculate the standard enthalpy change ΔH° for the reaction. Show all reasoning clearly.

Print your name here:

e)(10 points) Suppose that a mixture is prepared with 1.0 atm. of ClF(g), 0.1 atm. of Cl_2(g), and 0.1 atm. of F_2(g), at a temperature of 298 °K. Beginning with $G_i=G°_i+RTlnP_i$ (where G_i is the free energy of each component in the reaction mixture with partial pressure P_i) compute ΔG for the reaction for this mixture. Tell whether the mixture will spontaneously form ClF by combining Cl_2 and F_2, whether ClF will spontaneously decompose to form $Cl_2 + F_2$, or whether this mixture is in equilibrium. Show all reasoning clearly.

The End