Exam #1 Chem 471 Fall 2001 Name:________________________

Work independently. Do not look at others' exams.
Do not allow your exam responses to be shared.

1. (45 points) For the following short answer questions, circle ALL correct answers

For a process that can be carried out by either a reversible or an irreversible path, the change in (**P**, **T**, **V**, **q**, **E**, **H**, **w**) must be the same for both paths.
P,T,V,E,H

A reversible process is one that proceeds by a succession of very small incremental steps, all of which are (**at equilibrium, spontaneous, enthalpically and entropically driven**) .
At equilibrium

The path which produces the maximum work is (**reversible** / **irreversible**).
reversible

The heat needed to change the phase of a substance is typically (**smaller** / **larger**) than the heat needed to increase its temperature by 10 K.
Larger

(**ΔH**, **ΔS**, **ΔG**, **ΔE**) implies constant pressure.
ΔH, ΔG

ΔH equals the heat transferred to the system under constant (**T**, **P**, **V**).
Pressure

An ideal gas expands adiabatically against an external pressure of 2 atm. ΔE for the system is (**greater than zero / equal to zero / less than zero**).
Less than zero

An ideal gas expands isothermally against an external pressure of 2 atm. ΔE for the system is (**greater than zero / equal to zero / less than zero**).
Zero

An ideal gas expands adiabatically into a vacuum. ΔE for the system is (**greater than zero / equal to zero / less than zero**).
Zero

When a sample of liquid is converted reversibly to its vapor at its normal boiling point, (**q, w, ΔP, ΔV, ΔT, ΔE, ΔH, ΔS, ΔG**) is equal to zero for the system .
ΔT, ΔG

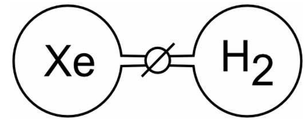
According to the 2nd law of thermodynamics, a spontaneous process, such as a balloon filled with a hot gas cooling to the surroundings at constant pressure, will always occur (**adiabatically**, **reversibly**, **irreversibly**, **without work done**).
Irreversibly

The internal energy of an ideal gas is a function of only (**T / P / V**).
T

For a sample of an ideal gas, the product PV remains constant as long as (**T / P / V**) is held constant.
T (PV=nRT)

The 2nd law of thermodynamics states that the entropy of a (**closed / isolated / isothermal**) system always increases during a (**spontaneous / equilibrium / unfavorable**) process .
isolated

2. (25 points) Two 1 liter containers initially containing, respectively, H_2 and Xe gas, are separated by a valve. Considering the entire assembly to be the system, for each of the system variables below, indicate whether that value will be *less* than zero, *greater* than zero, or *equal* to zero, for the process which accompanies opening of the valve between the containers.



a)

System variable	**Circle correct answer**	Assumptions/comments
q	< = > 0	=0
w	< = > 0	=0
ΔH	< = > 0	=0
ΔE	< = > 0	=0
ΔS	< = > 0	>0
ΔG	< = > 0	<0

b) Explain in 30 words or less, your answer for ΔE.

The system is the entire assembly. Since the total pressure and the total volume (of the system) do not chang, $T = \frac{PV}{nR}$ does not change. Therefore ΔE does not change

c) Explain in 40 words or less, your answer for ΔS, focusing on the *molecular* explanation – what does it mean?

Although, the pressures don't change, in the original situation each gas was restricted to its own container. Afterwards, the gases have more places to be / ways to arrange themselves. Entropy goes up.

3a. (15 points) Calculate ΔH and ΔS when 1 mole of H_2O (g) is cooled irreversibly at constant P from 120°C to 100°C.

$$C = \frac{dq}{dT} \qquad \Delta H = q_P = \int_{q_1}^{q_2} dq = \int_{T_1}^{T_2} n\bar{C}dT = n\bar{C}\int_{T_1}^{T_2} dT = n\bar{C}\left(T_2 - T_1\right)$$

$$\Delta H = (1 mole)\left(33.76 \text{ J K}^{-1} \text{ mol}^{-1}\right)(373K - 393K) = -675J = -0.675kJ$$

$$dS = \frac{dq_{rev}}{T} = \frac{CdT}{T} \qquad \left(C = \frac{dq}{dT}\right)$$

$$\int_{S_1}^{S_2} dS = \int_{T_1}^{T_2} \frac{CdT}{T} = C\int_{T_1}^{T_2} \frac{dT}{T}$$

$$S_2 - S_1 = \Delta S = n\bar{C}\ln\frac{T_2}{T_1} = (1 mole)\left(33.76 \text{ J K}^{-1} \text{ mol}^{-1}\right)\ln\frac{373K}{393K} = -1.76J\,K^{-1}$$

3b. (15 points) Calculate q, w, ΔE, T, and the final volume for the reversible, isothermal expansion of 2 moles of an ideal gas from an initial pressure of 1 atm and an initial volume of 1 L, to a final pressure of 0.1 atm.

$$\Delta E = 0 \quad \text{(isothermal)}$$

$$n_1 = 2 \text{ mole} \quad P_1 = 1 \text{ atm} \quad V_1 = 1 \text{ L} \quad T_1 = \frac{P_1V_1}{n_1R} = \frac{(1atm)(1L)}{(2mole)\left(0.08206 \text{ L atm K}^{-1} \text{ mole}^{-1}\right)} = 6.1K$$

$$n_2 = 2 \text{ mole} \quad \text{T} = \text{T}_2 = T_1 \quad P_2 = 0.1 \text{ atm}$$

$$V_2 = \frac{n_2RT_2}{P_2} = \frac{(2mole)(0.08206 \text{ L atm K}^{-1} \text{ mole}^{-1})(6.1\text{K})}{(0.1atm)} = 10.0\,L$$

$$w = -\int_{V_1}^{V_2} PdV = -\int_{V_1}^{V_2} \frac{n_2RT}{V}\,dV = -n_2RT\int_{V_1}^{V_2} \frac{dV}{V} = -n_2RT\ln\frac{V_2}{V_1}$$

$$w = -(2\ mol)\left(8.314 \text{ J K}^{-1} \text{ mol}^{-1}\right)(6.1\ K)\ln\frac{10.0L}{1L} = -233\ J$$

$$q = -w = 233\ J$$