Chem 1B, PAL – Week 8 (Wed/Th)
#13 Thermo Part 2 (sec 17.5-17.7) Name ______________________________

Part A: Using the Change in Gibbs Free Energy to predict spontaneity

Fill in the Blanks: Fill in the blanks with (<, >, =)

If ΔG ___ 0; the reaction is at equilibrium

If ΔG ___0; the reaction will proceed spontaneously towards products

If ΔG ___0; the reaction will proceed spontaneously towards reactants (is nonspontaneous in the forward direction).

True and False:

True or false? All exothermic reactions are spontaneous? ______

Nature tends towards lower energy and more disorder. ________

Part B: Calculating the Change in Gibbs Free Energy under Non-standard Conditions

1. The reaction below is endothermic and spontaneous at T = 525 K. Please answer the following questions and discuss your answers with your PAL group.

$$2\ HNO_3(aq) + NO(g) \rightarrow 3\ NO_2(g) + H_2O(l)$$

a) Which of the following must be true? Circle your answer.

$\Delta G > 0; \Delta S > 0; \Delta H > 0$ $\Delta G < 0; \Delta S > 0; \Delta H > 0$ $\Delta G > 0; \Delta S < 0; \Delta H > 0$

b) Calculate ΔG for the reaction above using the following information ΔH = +136.5 kJ; ΔS = +287.5 J/K at a Temp = 525 K.

c) Why do you think reaction is spontaneous? Take a look at the reaction. What do you notice?

d) At what temperature will the reaction be non-spontaneous?

Part B: Calculating the Change in Gibbs Free Energy under standard conditions

2. Calculate the ΔG°rxn using the following information.

	$4\ HNO_3(g)$	$+ 5\ N_2H_4(l)$	$\rightarrow 7\ N_2(g)$	$+ 12\ H_2O(l)$	ΔG°rxn = ?
ΔG°f (kJ/mol)	-73.5	149.3		-237.1	

3. Calculate the ΔG°rxn using the following information.

	$4\ HNO_3(g)$	$+ 5\ N_2H_4(l)$	$\rightarrow 7\ N_2(g)$	$+ 12\ H_2O(l)$	ΔG°rxn = ?
ΔH°f (kJ/mol)	-133.9	50.6		-285.8	
S°(J/mol·K)	266.9	121.2	191.6	70.0	

What do you notice about your answer to 2 and 3? Do they agree?

4. Calculate ΔG^o by adding Gibbs Free Energies of Reactions ($\Delta G^o_1 + \Delta G^o_2 + \Delta G^o_3\ldots$)

Use Hess's law to calculate ΔG°rxn using the following information.

$ClO(g) + O_3(g) \rightarrow Cl(g) + 2\ O_2(g)$ ΔG°rxn = ?

$2\ O_3(g) \rightarrow 3\ O_2(g)$ ΔG°rxn = +489.6 kJ

$Cl(g) + O_3(g) \rightarrow ClO(g) + O_2(g)$ ΔG°rxn = -34.5 kJ

5. Calculate ΔG^o by adding Gibbs Free Energies of Reactions (ΔG^o_1 + ΔG^o_2 + ΔG^o_3…)

$NO(g) + O(g) \rightarrow NO_2(g)$ $\Delta G°rxn = ?$

$2\ O_3(g) \rightarrow 3\ O_2(g)$ $\Delta G°rxn = +489.6$ kJ
$O_2(g) \rightarrow 2\ O(g)$ $\Delta G°rxn = +463.4$ kJ
$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ $\Delta G°rxn = -199.5$ kJ

A) +753.5 kJ
B) +277.0 kJ
C) -676.0 kJ
D) -1152.5 kJ
E) -225.7 kJ