CH302 Spring 2006 Worksheet 2 Key (Values for ΔS and ΔH can be found in Appendix 2 in the text.)

Part 1. Determining Reaction Spontaneity based on ΔS_{total}

Reaction at 300K, constant P & T	ΔS_{system}	ΔH	$\Delta S_{surroungding}$	ΔS_{total}	Is the rxn spontaneous?
$NaCl(s) \rightarrow Na(s) + ½\ Cl_{2(g)}$	(51.21 J/K +1/2 * 223.07 J/K) - 72.13 J/K = 90.615 J/K	411.15 kJ	-411.15 kJ/300K = -1370.5 J/K	-1279.885 J/K	No
$CaO(s) + H_20(l) \rightarrow Ca(OH)_{2\ (aq)}$	83.39 J/K – (39.75 J/K + 69.91) = -26.27 J/K	-986.09 kJ – (-635.09 -285.83) = -65.17kJ	65170 J/300K = 217.2333 J/K	190.963 J/K	Yes
$C_6H_{6(g)} \rightarrow 6C(s) + 3H_{2(g)}$	(3* 130.68 + 6* 5.74) – 269.31 = 157.17 J/K	-82.9kJ	82900J/300K =276.3333 J/K	433.503	Yes
$Cu_2O(s) + ½\ O_{2(g)} \rightarrow 2CuO_{(s)}$	2* 42.63 – (93.14 + ½ * 205.14) = -110.45 J/K	2* -157.3-(-168.6) = -146 kJ	146000J/300K = 486.6667 J/K	597.16667 J/K	Yes
$CO_2 + 4H_2 \rightarrow CH_4 + 2H_20(g)$	186.26 + 188.83 * 2 – (213.74 + 4* 130.68) = -172.54 J/K	(-74.81 + 2*-241.82) – (-393.51) = -164.94 kJ	164940 J /300 K = 549.8	277.26	Yes

Part 2. Finding an Equilibrium Temperature from ΔS (assume that S and H doesn't change much with temperature)

Reaction/Process	ΔS_{system}	ΔH	Temperature which reaction/process is in equilibrium
$CH_3OH_{(l)} \rightarrow CH3OH_{(g)}$	293.81-126.8 = 167.01 J/K	-200.66- (-238.86) = 38.2 kJ	- 38200 J / - 167.01 J/K = 228.72 K
$I_2(g) \rightarrow I_2(s)$	116.14 – 260.69 =-144.54 J/K	-62.04 kJ	62040 J/ 144.54 J/K = 429.22 K
$N_{2(g)} + 3/2H_{2(g)} \rightarrow NH_{3(g)}$	192.45 – (191.61 + 3/2 * 130.68) = -195.18 J/K	-80.29kJ	80 290 J / 195.18 J/K = 411.36 K
$3O_{2(g)} \rightarrow 2O_{3(g)}$	2* 238.93 – 3* 205.14 = -137.56 J	2* 142.7 = 285.4 kJ	- 285400 / - 137.56 = 2074.73 K

Part 3. True or False (if false, explain your answer)

1. The Second Law of Thermodynamics says that the entropy of any system is always increasing

False. The Second Law states that the entropy of the isolated system (universe) increases for a spontaneous reaction.

2. The universe is an isolated system.

True. Don't confuse the system (which is the reaction) and isolated system (which is usually the universe).

3. A process in which ΔS decreases is not spontaneous

False. If ΔS of the surroundings exceeds ΔS of the system then the reaction is spontaneous. This can occur when a reaction is sufficiently exothermic that the heat liberated in the process sufficiently increases the entropy of the surroundings.

4. ΔS equals to -ΔH/T when the process happens at constant pressure and temperature.

True.

Part 4. Determining Stability of a Compound from the Free Energy of Reaction

Write out and balance the formation reaction at 300K:	ΔH	ΔS	Free energy ΔG (using the formula with ΔH and ΔS)	Is the compound stable at room temperature?
$H_2(g) + ½ O_2(g) \rightarrow H_20(g)$	-241.82 kJ	188.83 – (130.68 + ½ 205.14) = -44.42 J	-241820 – (-44.42* 300) = -228494 J	Yes
$C + O2 \rightarrow CO_2$	-393.51 kJ	213.74 – (5.740 + 205.14) = 2.86 J/K	-393510 – 2.86*300 = -394368 J	Yes
$H_2 + I_2 \rightarrow 2HI$	26.48 kJ	2*206.59- (116.14+ 130.68) = 166.36 J/K	26480 – 166.36 *300 = -23428 J	Yes
$K(s) \rightarrow K(g)$	89.24 kJ	160.34-64.18 = 96.16 J/K	89240 – 96.16 *300=60392 J	No
$4P \rightarrow P_4$	58.91 kJ	279.93 – 4*41.09 = 109.57 J/K	58910 – 300*109.57 = 26039 J	No