**AP Thermochemistry questions**

1. Under standard conditions, the enthalpy change for the reaction is ΔH˚ = -294 kJ.

Xe(g) + 3F2(g)  XeF6(g)

1. Is the value of ΔS˚, for the above reaction positive or negative. Justify your conclusion.
2. The above reaction is spontaneous under standard conditions. Predict what will happen to ΔG for this reaction as the temperature is increased. Justify your prediction.
3. Show how the temperature at which the reaction changes from spontaneous to non-spontaneous can be predicted. What additional information is needed?

2. As ammonium nitrate dissolves spontaneously in water at constant pressure the solution gets cold. What is the sign of ΔH for this process? Is it possible to identify the sign of the entropy change for the process from this information? Explain your answer.

3. The standard molar enthalpies of formation of NO(g), NO2(g), and N2O3(g) are 90.25 kJmol-1, 33.2 kJ mol-1, and 83.72 kJ mol-1, respectively. Their standard molar entropies are 210.65 J mol-1 K-1, 239.9 J mol-1 K-1, and 312.2 J mol-1 K-1, respectively.

a. Use this data to calculate the free energy change for the following reaction at 25.0˚C.

N2O3(g) 🡪 NO(g) + NO2(g)

b. Repeat the above calculation for 0.00˚C and 100.0˚C, assuming that the enthalpy and entropy changes do not vary with a change in temperature. Is the reaction spontaneous at 0.00˚C and 100.0˚C?

4. The overall reaction in commercial heat packs can be represented as

4Fe(s) + 3O2(g) 🡪 2Fe2O3(s) H = -1652 kJ

a. How much heat if released when 4.00 mol iron is reacted with excess O2?

b. How much heat is released when 1.00 mol Fe2O3(s) is produced?

5. A 15.0 g sample of nickel metal is heated to 100.0˚C and dropped into 55.0 g of water, initially at 23.0˚C. Assuming that all the heat lost by the nickel is absorbed by the water, calculate the final temperature of the nickel and water. The specific heat of nickel is 0.444 J/g˚C.

6. Given the following data:

P4(s) + 6Cl2(g) 🡪 4PCl3(g) H = -1225.6 kJ

P4(s) + 5O2(g) 🡪 P4O10(s) H = -2967.3 kJ

PCl3(g) + Cl2(g) 🡪 PCl5(g) H = -84.2 kJ

PCl3(g) + ½ O2(g) 🡪 Cl3PO(s) H = -285.7 kJ

Calculate H for the reaction

P4O10(s) + 6PCl5(g) 🡪 10Cl3PO(g)

7. CH3OH*(l)* + 3/2 O2*(g)*  2 H2O*(l)* + CO2*(g)*

The value of *S* for the reaction is -19.3 cal/mol-degree at 25C.

*Hf* S

kcal/mole at 25C cal/mole-degree at 25C

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CH3OH*(l)* -57.0 30.3

H2O*(l)* -68.3 16.7

CO2*(g)* -94.0 51.1

(a) Calculate *G* for the complete combustion of methanol shown above at 25C.

(b) Calculate the value for the equilibrium constant for this reaction at 25C.

(c) Calculate the standard absolute entropy, S, per mole of O2*(g)*.

8. CO*(g)* + 2 H2*(g)* → CH3OH*(l)* *H* = -128.1 kJ

*Hf* *Gf* S

(kJ mol-1) (kJ mol-1) (J mol-1 K-1)

CO*(g)* -110.5 -137.3 +197.9

CH3OH*(l)* -238.6 -166.2 +126.8

The data in the table above were determined at 25C.

(a) Calculate *G* for the reaction above at 25C.

(b) Calculate Keq for the reaction above at 25C. (leave out)

(c) Calculate *S* for the reaction above at 25C.

(d) In the table above, there are no data for H2. What are the values of *Hf*, *Gf*, and of the absolute entropy, S, for H2 at 25C?

9.

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| H2(g) + (1/2) O2(g) 🡪 H2O(l) | ΔH° = - 286 kJ |
| 2 Na(s) + (1/2) O2(g) 🡪 Na2O(s) | ΔH° = - 414 kJ |
| Na(s) + (1/2) O2(g) + (1/2) H2(g) 🡪 NaOH(s) | ΔH° = - 425 kJ |

Based on the information above, what is the standard enthalpy change for the following reaction?

Na2O(s) + H2O(l) 🡪 2 NaOH(s)

(A) -1,125 kJ  
(B) -978 kJ  
(C) -722 kJ  
(D) -150 kJ  
(E) +275 kJ

10. N2(g) + 3 H2(g) 🡪 2 NH3(g)

The reaction indicated above is thermodynamically spontaneous at 298 K, but becomes nonspontaneous at higher temperatures. Which of the following is true at 298 K?

(A) ΔG, ΔH, and ΔS are all positive.  
(B) ΔG, ΔH, and ΔS are all negative.  
(C) ΔG and ΔH are negative, but ΔS is positive.  
(D) ΔG and ΔS are negative, but ΔH is positive.  
(E) ΔG and ΔH are positive, but ΔS is negative.

11. For which of the following processes would ΔS have a negative value?

I. 2 Fe2O3(s) 🡪 4 Fe(s) + 3 O2(g)

I I. Mg2+ + 2 OH¯ 🡪 Mg(OH)2(s)

III. H2(g) + C2H4(g) 🡪 3 C2H6(g)

(A) I only  
(B) I and II only  
(C) I and III only  
(D) II and III only  
(E) I, II, and III