THERMO REVIEW

1. Answer the following questions in terms of thermodynamic principles and concepts of kinetic molecular theory.
   a. Consider the reaction represented below, which is spontaneous at 298 K.

   $$CO2(g) + 2\ NH3(g) \rightarrow CO(NH2)2(s) + H2O(l);\ \Delta H°_{298} = -134\ kJ$$

      (i) For the reaction, indicate whether the standard entropy change, $\Delta S°_{298}$, is positive, or negative, or zero. Justify your answer.
      (ii) Which factor, the change in enthalpy, $\Delta H°_{298}$, or the change in entropy, $\Delta S°_{298}$, provides the principal driving force for the reaction at 298 K? Explain.
      (iii) For the reaction, how is the value of the standard free energy change, $\Delta G°$, affected by an increase in temperature? Explain.

   b. Some reactions that are predicted by their sign of $\Delta G°$ to be spontaneous at room temperature do not proceed at a measurable rate at room temperature.
      (i) Account for this apparent contradiction.
      (ii) A suitable catalyst increases the rate of such a reaction. What effect does the catalyst have on $\Delta G°$ for the reaction? Explain.

2. $$O_3(g) + NO(g) \rightarrow O_2(g) + NO_2(g)$$

   Consider the reaction represented above.
   (a) Referring to the data in the table below, calculate the standard enthalpy change, $\Delta H°$, for the reaction at 25°C. Be sure to show your work.

	O_3(g)	NO(g)	NO_2(g)
Standard enthalpy of formation, $\Delta H°_f$, at 25°C (kJ mol^{-1})	143	90.	33

   (b) Make a qualitative prediction about the magnitude of the standard entropy change, $\Delta S°$, for the reaction at25°C. Justify your answer.
   (c) On the basis of your answers to parts (a) and (b), predict the sign of the standard free-energy change, $\Delta G°$, for the reaction at 25°C. Explain your reasoning.

3. $$N_2(g) + 2\ H_2(g) \leftrightarrow N_2H_4(g) \qquad \Delta H°_{298} = +95.4\ kJ\ mol^{-1};\ \Delta S°_{298} = -176\ J\ K^{-1}\ mol^{-1}$$

Answer the following questions about the reaction represented above using principles of thermodynamics.

(a) On the basis of the thermodynamic data given above, compare the sum of the bond strengths of the reactants to the sum of the bond strengths of the product. Justify your answer.

(b) Does the entropy change of the reaction favor the reactants or the product? Justify your answer.

(c) For the reaction under the conditions specified, which is favored, the reactants or the product? Justify your answer.

(d) Explain how to determine the value of the equilibrium constant, *Keq*, for the reaction. (Do not do any calculations.)

(e) Predict whether the value of *Keq* for the reaction is greater than 1,equal to 1, or less than 1. Justify your prediction.

4. Calculate ΔH for the combustion of 1 mol of glucose, $C_6H_{12}O_{6(s)}$, and then write the thermochemical equation.
   ΔH_f^o $C_6H_{12}O_{6(s)}$ = -1273.3 kJ/mole; $CO_{2(g)}$ ΔH_f^o = - 393.5 kJ/mole; $H_2O(l)$ ΔH_f^o = - 285.8 kJ/mole

5. **Using only the values of ΔH_f^o and S^o below**, calculate ΔG^o_{rxn} for the following reaction at 25 °C. Is the reaction spontaneous? If so, ***comment on whether it is entropy or enthalpy driven.***

	$2C_6H_6$ (g)	+ $15O_2$ (g)	$\longrightarrow$ $12CO_2$ (g)	+ $6H_2O$ (l)
ΔH_f^o (kJ/mole)	82.93	0	-393.5	-285.8
S^0 (J/K*mole)	269.2	205.0	213.6	69.91

6. Calculate the equilibrium constant for a given reaction at 25.0°C in which ΔG^o = 25600J. According to the equilibrium constant, will the reaction favor products or reactants? ***Comment on the connection between the sign of ΔG^o and the equilibrium constant.*** (R = 8.31 J/mol*K)

7. When 25.0 grams of NaOH is dissolved in 100.0 grams of water at 25.0°C the temperature of the water rises to 91.2 °C.
   a. Is the dissolving of NaOH (the q_{sys}) endo or exo and how do you know?
   b. What is the q of the water solution if the specific heat of the water is 4.184 J/g* °C?
   c. What is the $q_{sys?}$
   d. What is the molar enthalpy for the dissolution of 1 mole of NaOH in water?

8. Given the following rxns calculate the heat of formation(=from its elements) of hydrazine, N_2H_4.
   N_2H_4 (l) + O_2 (g) → N_2 (g) + 2 H_2O (g) ΔH_{rxn} = -534.2 kJ
   H_2 (g) + ½ O_2 (g) → H_2O (g) ΔH_{rxn} = -241.8 kJ