Problems set for week 6

1) (from problem set)
The Haber process for the synthesis of ammonia involves the reaction:

$N_2$ (g) + 3 $H_2$ (g) < = = = > 2 $NH_3$ (g)

Using data from Appendix J, estimate the amount (in moles) of $NH_3$(g) that would be produced from a gas mixture initially containing only $N_2$ and $H_2$ gases, each at 1.00 bar pressure at a constant pressure of 450°C. The total volume of the mixture is 500.0 L. [0.116 moles $NH_3$].

Table: (for the problems 2-6 below)

| Species | $\Delta H°_f$(kJ/mol) (at 298K) | $S°_f$(J/molK) (at 298K) | $\Delta G°_f$ (kJ/mol) (at 298K) |
|---|---|---|---|
| $N_2O_4$ (l) | -19.50 | 209 | 97.54 |
| $N_2O_4$ (g) | 9.16 | 304 | 97.89 |
| $NO_2$(g) | 82.05 | 219.85 | 104.20 |

2) What is the boiling point (in °C) of $N_2O_4$ ? (show clear calculations or there will be no credit given). [29°C ]

3) What is $K_p$ for this process at 45°C? What is $P_{N2O4}$? [ $K_p$ = 1.8 ; $P_{N2O4}$ = 1.8 bar ]

4) Is the conversion of $N_2O_4$ (g) to $NO_2$(g) product favored on a hot summer day? (for example, at 120°C?) [$\Delta G°>0$ for 45°C, not product-favored ]

5) What is $K_c$ for the conversion of $N_2O_4$ (g) to $NO_2$(g) at 120°C? [$9.7 \times 10^{-16}$]

6) Would the conversion of $N_2O_4$ (g) to $NO_2$(g) be more favorable at higher temperatures? [ more favorable]