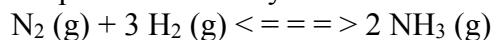


Problems set for week 6

1) (from problem set)

The Haber process for the synthesis of ammonia involves the reaction:



Using data from Appendix J, estimate the amount (in moles) of  $\text{NH}_3(\text{g})$  that would be produced from a gas mixture initially containing only  $\text{N}_2$  and  $\text{H}_2$  gases, each at 1.00 bar pressure at a constant pressure of  $450^\circ\text{C}$ . The total volume of the mixture is 500.0 L. [0.116 moles  $\text{NH}_3$ ].

Table: (for the problems 2-6 below)

Species	$\Delta H^\circ_f(\text{kJ/mol})$ (at 298K)	$S^\circ_f(\text{J/molK})$ (at 298K)	$\Delta G^\circ_f(\text{kJ/mol})$ (at 298K)
$\text{N}_2\text{O}_4(\text{l})$	-19.50	209	97.54
$\text{N}_2\text{O}_4(\text{g})$	9.16	304	97.89
$\text{NO}_2(\text{g})$	82.05	219.85	104.20

2) What is the boiling point (in  $^\circ\text{C}$ ) of  $\text{N}_2\text{O}_4$ ? (show clear calculations or there will be no credit given). [29 $^\circ\text{C}$ ]

3) What is  $K_p$  for this process at  $45^\circ\text{C}$ ? What is  $P_{\text{N}_2\text{O}_4}$ ? [  $K_p = 1.8$  ;  $P_{\text{N}_2\text{O}_4} = 1.8 \text{ bar}$  ]

4) Is the conversion of  $\text{N}_2\text{O}_4(\text{g})$  to  $\text{NO}_2(\text{g})$  product favored on a hot summer day? (for example, at  $120^\circ\text{C}$ ?) [ $\Delta G^\circ > 0$  for  $45^\circ\text{C}$ , not product-favored]

5) What is  $K_c$  for the conversion of  $\text{N}_2\text{O}_4(\text{g})$  to  $\text{NO}_2(\text{g})$  at  $120^\circ\text{C}$ ? [ $9.7 \times 10^{-16}$ ]

6) Would the conversion of  $\text{N}_2\text{O}_4(\text{g})$  to  $\text{NO}_2(\text{g})$  be more favorable at higher temperatures? [ more favorable]