Chapter 12 − Problems 6, 16, 18, 22

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6. Write equilibrium constant (k) expressions for the following reactions:

   (a) $\mathrm{Na_2CO_3(s)} \rightleftharpoons 2\,\mathrm{NaO\,(s)} + \mathrm{CO_2(g)}$

   $$k = [P_{\mathrm{CO_2}}] \tag{1}$$

   (b) $\mathrm{C_2H_6(g)} + 2\,\mathrm{H_2O\,(l)} \rightleftharpoons 2\,\mathrm{CO\,(g)} + 5\,\mathrm{H_2(g)}$

   $$k = \left[\frac{(P_{\mathrm{CO}})^2\,(P_{\mathrm{H_2}})^5}{P_{\mathrm{C_2H_6}}}\right] \tag{2}$$

   (c) $4\,\mathrm{NO\,(g)} + 6\,\mathrm{H_2O\,(g)} \rightleftharpoons 4\,\mathrm{NH_3(g)} + 5\,\mathrm{O_2(g)}$

   $$k = \left[\frac{(P_{\mathrm{O_2}})^5\,(P_{\mathrm{NH_3}})^4}{(P_{\mathrm{NO}})^4\,(P_{\mathrm{H_2O}})^6}\right] \tag{3}$$

   (d) $\mathrm{NH_3(g)} + \mathrm{HI\,(l)} \rightleftharpoons \mathrm{NH_4I\,(s)}$

   $$k = \left[\frac{1}{(P_{\mathrm{NH_3}})}\right] \tag{4}$$

16. At $800[^\circ\,\mathrm{C}]$, $k = 2.2 \cdot 10^{-4}$ for the following reaction. Calculate k at $800[^\circ\,\mathrm{C}]$ for:

$$2\,\mathrm{H_2S\,(g)} \rightleftharpoons 2\,\mathrm{H_2(g)} + \mathrm{S_2(g)}$$

   (a) the synthesis of one mole of $\mathrm{H_2S}$ from $\mathrm{H_2}$ and $\mathrm{S_2}$ gases.

$$\begin{aligned} k_i &= \frac{1}{k_f} \\ k_i &= k_f^{\frac{1}{2}} \\ k &= \frac{1}{k^{\frac{1}{2}}} \\ &= 67.42 \end{aligned} \tag{5}$$

(b) the decomposition of one mole of H_2S gas

$$\begin{aligned} k_i &= k^{\frac{1}{2}} \\ \left(2.2 \cdot 10^{-4}\right)^{.5} &= .015 \end{aligned} \tag{6}$$

18. Given the following data at 25[° C], calculate k for the formation of one mole of NOBr from its elements in the gaseous state

$$\begin{aligned} 2\,\mathrm{NO\,(g)} &\rightleftharpoons \mathrm{N_2(g)} + \mathrm{O_2(g)} && k = 1 \cdot 10^{-30} \\ 2\,\mathrm{NO\,(g)} + \mathrm{Br_2(g)} &\rightleftharpoons 2\,\mathrm{NOBr\,(g)} && k = 8 \cdot 10 \end{aligned}$$

$$\begin{aligned} k_1 &= \left(\frac{1}{10^{-30}}\right)^{(}.5) \\ k_1 &= 10^{15} \\ k_2 &= \sqrt{80} \\ k_2 &= 8.94 \\ k_{total} &= 8.94 \cdot 10^{1}5 \end{aligned} \tag{7}$$

22. Calculate k for the formation of methyl alcohol at 100[° C], given that at equilibrium, the partial pressures of the gases are $P_{\mathrm{CO}} = .814[\mathrm{ATM}]$, $P_{\mathrm{H_2}} = .274[\mathrm{ATM}]$, and $P_{\mathrm{CH_3OH}} = .0512[\mathrm{ATM}]$

$$\mathrm{CO\,(g)} + 2\,\mathrm{H_2(g)} \rightleftharpoons \mathrm{CH_3OH\,(g)}$$

$$\begin{aligned} k &= \frac{.0512}{.814 \cdot (.274)^2} \\ k &= .838 \end{aligned} \tag{8}$$