Chapter 12 Review Questions and Text Homework Solutions

Review Questions

3. $2\ NOCl(g) \rightleftharpoons 2\ NO(g) + Cl_2(g)$ $K = 1.6 \times 10^{-5}$

The expression for K is the product concentrations divided by the reactant concentrations. When K has a value much less than one, the product concentrations are relatively small and the reactant concentrations are relatively large.

$2\ NO(g) \rightleftharpoons N_2(g) + O_2(g)$ $K = 1 \times 10^{31}$

When K has a value much greater than one, the product concentrations are relatively large and the reactant concentrations are relatively small. In both cases, however, the rate of the forward reaction equals the rate of the reverse reaction at equilibrium (this is a definition of equilibrium).

5. When reactants and products are all in the same phase, these are homogeneous equilibria. Heterogeneous equilibria involve more than one phase. In general, for a homogeneous gas phase equilibria, all reactants and products are included in the K expression. In heterogeneous equilibria, equilibrium does not depend on the amounts of pure solids or liquids present. The amount of solids and liquids present are not included in K expressions; they just have to be present. On the other hand, gases and solutes are always included in K expressions. Solutes have (aq) written after them.

6. For the gas phase reaction $aA + bB \rightleftharpoons cC + dD$:

the equilibrium constant expression is: $K = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$

and the reaction quotient has the same form: $Q = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$

The difference is that in the expression for K, we use equilibrium concentrations, i.e., [A], [B], [C], and [D] are all in equilibrium with each other. Any set of concentrations can be plugged into the reaction quotient expression. Typically, we plug initial concentrations into the Q expression and then compare the value of Q to K to see if the reaction is at equilibrium. If $Q = K$, the reaction is at equilibrium with these concentrations. If $Q \neq K$, then the reaction will have to shift either to products or to reactants to reach equilibrium. For $Q > K$, the net change in the reaction to get to equilibrium must be a conversion of products into reactants. We say the reaction shifts left to reach equilibrium. When $Q < K$, the net change in the reaction to get to equilibrium must be a conversion of reactants into products; the reaction shifts right to reach equilibrium.

Text Homework

28. $[N_2O] = \dfrac{2.00 \times 10^{-2}\ \text{mol}}{2.00\ \text{L}}$; $[N_2] = \dfrac{2.80 \times 10^{-4}\ \text{mol}}{2.00\ \text{L}}$; $[O_2] = \dfrac{2.50 \times 10^{-5}\ \text{mol}}{2.00\ \text{L}}$

$$K = \frac{[N_2O]^2}{[N_2]^2[O_2]} = \frac{\left(\frac{2.00 \times 10^{-2}}{2.00}\right)^2}{\left(\frac{2.80 \times 10^{-4}}{2.00}\right)^2\left(\frac{2.50 \times 10^{-5}}{2.00}\right)} = \frac{(1.00 \times 10^{-2})^2}{(1.40 \times 10^{-4})^2(1.25 \times 10^{-5})}$$

$$= 4.08 \times 10^8$$

If the given concentrations represent equilibrium concentrations, then they should give a value of $K = 4.08 \times 10^8$.

$$\frac{(0.200)^2}{(2.00 \times 10^{-4})^2(0.00245)} = 4.08 \times 10^8$$

Because the given concentrations when plugged into the equilibrium constant expression give a value equal to K (4.08×10^8), this set of concentrations is a system at equilibrium.

30. $$K_p = \frac{P_{NH_3}^2}{P_{N_2} \times P_{H_2}^3} = \frac{(3.1 \times 10^{-2})^2}{(0.85)(3.1 \times 10^{-3})^3} = 3.8 \times 10^4$$

$$\frac{(0.0167)^2}{(0.525)(0.00761)^3} = 1.21 \times 10^3$$

When the given partial pressures in atmospheres are plugged into the K_p expression, the value does not equal the K_p value of 3.8×10^4. Therefore, one can conclude that the given set of partial pressures does not represent a system at equilibrium.

68. a. Shift to left

b. Shift to right; because the reaction is endothermic (heat is a reactant), an increase in temperature will shift the equilibrium to the right.

c. No effect; the reactant and product concentrations/partial pressures are unchanged.

d. Shift to right

e. Shift to right; because there are more gaseous product molecules than gaseous reactant molecules, the equilibrium will shift right with an increase in volume.