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Chemistry 30

Unit 3: Chemical Equilibrium

Assignment 2 2-1 to 2-2

The Equilibrium Constant

1. a) What is meant by a reversible reaction?

   b) Are all chemical reactions reversible?

   c) Are all reversible reactions always at equilibrium?

   d) Does a reaction have to be reversible in order to reach equilibrium?

   e) What, exactly, is equal at equilibrium? (define equilibrium)

   f) How is equilibrium different from a steady state system?

2. Write the equilibrium expression for each of the following reactions. Be sure to pay attention to physical states:

   a) $Br_2\,(g) + 5\,F_2\,(g) \rightleftharpoons 2\,BrF_5(g)$

   b) $4\,HCl\,(g) + O_2(g) \rightleftharpoons 2\,H_2O\,(g) + 2\,Cl_2\,(g)$

   c) $5\,Fe^{+2}(aq) + MnO_4^-(aq) + 8\,H^+(aq) \rightleftharpoons 5\,Fe^{+3}(aq) + Mn^{+2}(aq) + 4\,H_2O(l)$

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3. For each of the following reactions, state whether the value of the equilibrium constant favours the formation of reactants, products, or both sides equally.

   a) $I_2(g) + Cl_2(g) \rightleftharpoons 2\ ICl(g)$ $K_{eq} = 2 \times 10^{6}$

   b) $H_2(g) + Cl_2(g) \rightleftharpoons 2\ HCl(g)$ $K_{eq} = 1.08$

   c) $I_2(g) \rightleftharpoons I(g) + I(g)$ $K_{eq} = 3.8 \times 10^{-7}$

4. Molecular chlorine decomposes into atoms according to the reaction:

   $Cl_2\ (g) \rightleftharpoons 2\ Cl\ (g)$

   The equilibrium constant for the reaction at 25°C is 1.4×10^{-38}. Would many chlorine atoms be present at this temperature? How do you know?

5. Calculate K_{eq} for each of the following. Be sure to set up the equilibrium constant expression first, before substituting in the values.

   Show your work! Pay attention to exponents!

   a) $H_2(g) + Cl_2(g) \rightleftharpoons 2\ HCl$

   $[H_2] = 1.0 \times 10^{-2}$ M

   $[Cl_2] = 1.0 \times 10^{-2}$ M

   $[HCl] = 1.0 \times 10^{-2}$ M

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b) $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$

$[N_2] = 4.4 \times 10^{-2}$ M

$[H_2] = 1.2 \times 10^{-1}$ M

$[NH_3] = 3.4 \times 10^{-3}$ M

c) $2\ CO(g) + O_2\ (g) \rightleftharpoons 2\ CO_2\ (g)$

$[CO] = 2.5 \times 10^{-3}$ M

$[O_2] = 1.6 \times 10^{-3}$ M

$[CO_2] = 3.2 \times 10^{-2}$ M

d) $CH_4(g) + H_2O(g) \leftrightarrow CO(g) + 3\ H_2(g)$

$[CH_4] = 2.97 \times 10^{-3}$ M

$[H_2O] = 7.94 \times 10^{-3}$ M

$[CO] = 5.45 \times 10^{-3}$ M

$[H_2] = 2.1 \times 10^{-3}$ M

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6. For the following reaction at equilibrium at 2000°C, the concentration of N_2 and O_2 are both 5.2 M.

$$N_2(g) + O_2(g) \rightleftharpoons 2\ NO(g) \qquad K_{eq} = 6.2 \times 10^{-4}$$

Calculate the concentration of NO at equilibrium. Show your work; pay careful attention to exponents.

7. Acetic acid, $HC_2H_3O_2$, is in equilibrium with its ions:

$$HC_2H_3O_2(aq) \rightleftharpoons H^+(aq) + C_2H_3O_2^-(aq) \qquad K_{eq} = 1.8 \times 10^{-5}$$

At equilibrium, the concentration of the ions are: $[H^+] = 1.33 \times 10^{-3}$ M

$[C_2H_3O_2^-] = 1.33 \times 10^{-3}$ M

Calculate the concentration of the acid, $HC_2H_3O_2$.