EQUILIBRIUM: THE EXTENT OF CHEMICAL REACTIONS

Chapter 17 Outline

Text Problems: # 29, 38, 41*, 44, 46, 47, 56, 61
+ Supplementary Questions (attached)
*On Text #41, assume very little H_2S dissociates

Text Sample Problems: The text has a number of excellent sample problems (solved in detail) in each section. I would recommend that you study these problems + the "follow up" problems, which have brief solutions at the end of the chapter.

Sect.	Title and Comments	Required?
1.	The Equilibrium State and the Equilibrium Constant	YES
2.	The Reaction Quotient and the Equilibrium Constant	YES
3.	Expressing Equilibrium with Pressure Terms: Relation Between K_c and K_p I will discuss this very briefly, but you are not responsible for it.	NO
4.	Comparing Q and K to Predict Reaction Direction	YES
5.	Problems Involving Mixtures of Reactants and Products	YES
6.	Reaction Conditions and Equilibrium: Le Châtelier's Principle We will not cover the subsections on "Lack of Effect of a Catalyst" or "Industrial Production of Ammonia".	YES

Notes:

1. We will show the quantitative treatment of the temperature dependence of the Equilibrium Constant.

2. We will show the application of the Beer-Lambert Law to the determination of chemical equilibrium constants.

Chapter 17

Supplementary Homework Questions

S1. If a catalyst is added to a chemical reaction, the equilibrium yield of a product will be_____, and the time taken to come to equilibrium will be _____than before.

a. higher; less
b. lower; the same
c. higher; the same
d. the same; less
e. lower; less

S2. Consider the reaction

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g) \quad .$$

If an equilibrium mixture of these three substances is compressed, equilibrium will _____, because _____.

a. shift to the right; higher pressure favors fewer moles of gas
b. shift to the right; higher pressure favors more moles of gas
c. shift to the left; higher pressure favors fewer moles of gas
d. shift to the left; higher pressure favors more moles of gas
e. be unchanged; solid NH_4Cl does not appear in the equilibrium constant expression.

S3. An endothermic reaction which results in an increase in moles of gas will be most product-favored under conditions of _____ pressure and _____ temperature.

a. high; high
b. high; moderate
c. high; low
d. low; high
e. low; low

S4. Consider the equilibrium system

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g) \quad .$$

If more C(s) is added, the equilibrium will ____; if CO is removed the equilibrium will ____.

a. shift to the left; shift to the left
b. shift to the right; shift to the right
c. shift to the right; shift to the left
d. be unchanged; shift to the left
e. be unchanged; shift to the right

S5. Consider the exothermic reaction at equilibrium:

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$$

If the system is cooled, the equilibrium will _____, because _____.

a. be unchanged; temperature has no effect on equilibrium
b. shift to the left; decreased temperature favors an exothermic reaction
c. shift to the right; decreased temperature favors an exothermic reaction
d. shift to the right; decreased temperature favors an endothermic reaction
e. shift to the left; decreased temperature favors an endothermic reaction

S6. Consider the equilibrium: $N_2(g) + 3\ H_2(g) = 2\ NH_3(g)$. $\Delta H^o = -92.2$ kJ. Determine whether the ratio, $[NH_3]/[H_2]$ will increase, decrease, or remain the same for the following changes.

a. N_2 is added to the mixture at constant volume.

b. NO(g) is added to the mixture at constant volume.

c. NO(g) is added to the mixture at constant total pressure.

d. The volume of the container is halved.

e. The temperature is decreased.

S7. The equilibrium constant for the reaction

$$NO(g) + 1/2\ O_2(g) \rightleftharpoons NO_2(g)$$

has a value of $K_c = 1.23$ at a certain temperature. What is the value of K_c for the reaction

$$2\ NO_2(g) \rightleftharpoons 2\ NO(g) + O_2(g) \qquad ?$$

S8. The equilibrium constant for the reaction

$$4\ NO(g) + 2\ Br_2(g) \rightleftharpoons 4\ NOBr(g)$$

has a value of $K_c = 39$ at a certain temperature. What is the value of K_c for the reaction

$$2\ NOBr(g) \rightleftharpoons 2\ NO(g) + Br_2(g) \qquad ?$$

S9. For the reaction

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

$K_c = 0.0600$ at a certain temperature. In an equilibrium mixture of the three gases, $[NH_3] = 0.24$ M and $[H_2] = 1.03$ M. What is the concentration of N_2 in this system?

S10. Consider the reaction, $Br_2(g) + 2\ NO(g) \rightleftharpoons 2\ NOBr(g)$.

A sample of pure NOBr is isolated at low temperature. It is placed in a flask at a concentration of 0.200 M and warmed up to 50^{o}C. When the reaction has come to equilibrium, the concentration of NOBr is 0.176 M. What is the value of K_c at 50^{o}C for this reaction?

S11. Consider the reaction, $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

The equilibrium constant, K_c, for this reaction is 10.0 at 420 ^oC and 45.0 at 300 ^oC.

a. Calculate the Enthalpy Change (ΔH^o) for this reaction (in kJ/mol).

b. Calculate the value of K_c for this reaction at 350 ^oC.

c. Calculate the temperature (in ^oC) at which the value of the equilibrium constant is 2.0

S12. Consider the gas phase equilibrium, $2\ A(g) \rightleftharpoons B(g) + 2\ C(g)$, $K_c = 800$.
2.0 mol of B(g) and 1.5 mol of C(g) are placed in a 5.0 L →container and the mixture is allowed to come to equilibrium.
Calculate the concentration of A(g) at equlibrium.
NOTE: You can assume that very little B(g) and C(g) react to form A(g).

S13. Consider the aqueous solution equilibrium, $A(aq) + 2\ B(aq) \rightleftharpoons 2\ C(aq)$.
The product, C, has an absorption in the UV range of the spectrum at 320 nm, with a Molar Absorptivity, $\varepsilon = 15{,}500\ M^{-1}\ cm^{-1}$

A solution is prepared in a 0.50 cm cell with initial concentrations of A and B, $[A]_o = 4.00 \times 10^{-4}$ M and $[B]_o = 6.00 \times 10^{-4}$ M, and the solution is allowed to reach equilibrium. At equilibrium, the percent transmission is %T = 32.0%.

Calculate the equilibrium constant, K_c, for this reaction.

**Answers to the Supplementary Homework Questions are posted on the course web site.
Questions about these Problems will be answered in Recitation**