Chemistry, 11e(Brown/LeMay/Bursten/Murphy)
Chapter 15 Chemical Equilibrium

15.1 Multiple-Choice and Bimodal Questions

1) The value of K_{eq} for the equilibrium

$$H_2(g) + I_2(g) \rightleftharpoons 2\,HI\,(g)$$

is 794 at 25 °C. What is the value of K_{eq} for the equilibrium below?

$$1/2H_2(g) + 1/2I_2(g) \rightleftharpoons HI\,(g)$$

A) 397
B) 0.035
C) 28
D) 1588
E) 0.0013

2) The value of K_{eq} for the equilibrium

$$H_2(g) + I_2(g) \rightleftharpoons 2\,HI\,(g)$$

is 794 at 25 °C. At this temperature, what is the value of K_{eq} for the equilibrium below?

$$HI\,(g) \rightleftharpoons 1/2H_2(g) + 1/2I_2(g)$$

A) 1588
B) 28
C) 397
D) 0.035
E) 0.0013

3) The value of K_{eq} for the equilibrium

$$H_2(g) + I_2(g) \rightleftharpoons 2\,HI\,(g)$$

is 54.0 at 427 °C. What is the value of K_{eq} for the equilibrium below?

$$HI\,(g) \rightleftharpoons 1/2H_2(g) + 1/2I_2(g)$$

A) 27
B) 7.35
C) 0.136
D) 2.92×10^{3}
E) 3.43×10^{-4}

4) Consider the following chemical reaction:

$$H_2(g) + I_2(g) \rightleftharpoons 2\,HI\,(g)$$

At equilibrium in a particular experiment, the concentrations of H_2, I_2, and HI were $0.15M$ $0.033M$ and $0.55M$ respectively. The value of K_{eq} for this reaction is _____.

A) 23
B) 111
C) 9.0×10^{-3}
D) 6.1
E) 61

5) A reaction vessel is charged with hydrogen iodide, which partially decomposes to molecular hydrogen and iodine:

$$2HI\,(g) \rightleftharpoons H_2(g) + I_2(g)$$

When the system comes to equilibrium at 425 °C, $P_{HI} = 0.708atm$, and $PH_2 = PI_2 = 0.0960$ atm. The value of K_p at this temperature is _____.

A) 6.80×10^{-2}
B) 1.30×10^{-2}
C) K_p cannot be calculated for this gas reaction when the volume of the reaction vessel is not given.
D) 54.3
E) 1.84×10^{-2}

6) Acetic acid is a weak acid that dissociates into the acetate ion and a proton in aqueous solution:

$$HC_2H_3O_2\,(aq) \rightleftharpoons C_2H_3O_2^{-}(aq) + H^{+}(aq)$$

At equilibrium at 25 °C a 0.100 M solution of acetic acid has the following concentrations:

$[HC_2H_3O_2] = 0.0990M$

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

$H^{+} = 1.33 \times 10^{-3}M$ The equilibrium constant, K_{eq}, for the ionization of acetic acid at 25 °C is _____.

A) 5.71×10^{4}
B) 0.100
C) 1.75×10^{-7}
D) 1.79×10^{-5}
E) 5.71×10^{6}

7) At elevated temperatures, molecular hydrogen

and molecular bromine react to partially form hydrogen bromide:

$$H_2(g) + Br_2(g) \rightleftharpoons 2HBr\ (g)$$

A mixture of 0.682 mol of H_2 and 0.440 mol of Br_2 is combined in a reaction vessel with a volume of 2.00 L. At equilibrium at 700 K, there are 0.566 mol of H_2 present. At equilibrium, there are _____ mol of Br_2 present in the reaction vessel.

A) 0.000
B) 0.440
C) 0.566
D) 0.232
E) 0.324

8) Dinitrogentetraoxide partially decomposes according to the following equilibrium:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

A 1.00-L flask is charged with $0.0400 mol$ of N_2O_4. At equilibrium at 373 K, 0.0055 mol of N_2O_4 remains. K_{eq} for this reaction is _____.

A) 2.2×10^{-4}
B) 13
C) 0.22
D) 0.022
E) 0.87

9) At 22 °C, K_p = 0.070 for the equilibrium:

$$NH_4HS\ (s) \rightleftharpoons NH_3(g) + H_2S\ (g)$$

A sample of solid NH_4HS is placed in a closed vessel and allowed to equilibrate. Calculate the equilibrium partial pressure (atm) of ammonia, assuming that some solid NH_4HS remains.

A) 0.26
B) 0.070
C) 0.52
D) 4.9×10^{-3}
E) 3.8

10) In the coal-gasification process, carbon monoxide is converted to carbon dioxide via the following reaction:

$$CO\ (g) + H_2O\ (g) \rightleftharpoons CO_2\ (g) + H_2\ (g)$$

In an experiment, 0.35 mol of CO and 0.40 mol of H_2O were placed in a 1.00-L reaction vessel. At equilibrium, there were 0.19 mol of CO remaining. K_{eq} at the temperature of the experiment is _____.

A) 5.47
B) 0.75
C) 1.78
D) 0.56
E) 1.0

11) A sealed 1.0 L flask is charged with 0.500 mol of I_2 and 0.500 mol of Br_2. An equilibrium reaction ensues:

$$I_2\ (g) + Br_2(g) \rightleftharpoons 2IBr\ (g)$$

When the container contents achieve equilibrium, the flask contains 0.84 mol of IBr. The value of K_{eq} is _____.

A) 11
B) 4.0
C) 110
D) 6.1
E) 2.8

12) The equilibrium constant (K_p) for the interconversion of PCl_5 and PCl_3 is 0.0121:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

A vessel is charged with PCl_5, giving an initial pressure of 0.123 atm. At equilibrium, the partial pressure of PCl_3 is _____ atm.

A) 0.0782
B) 0.0455
C) 0.0908
D) 0.0330
E) 0.123

13) K_p = 0.0198 at 721 K for the reaction

$$2HI\ (g) \rightleftharpoons H_2(g) + I_2(g)$$

In a particular experiment, the partial pressures of

H_2 and I_2 at equilibrium are 0.710 and 0.888 atm, respectively. The partial pressure of HI is _____ atm.

A) 7.87
B) 1.98
C) 5.64
D) 0.125
E) 0.389

14) At 200 °C, the equilibrium constant (K_p) for the reaction below is 2.40×10^3.

$$2NO\,(g) \rightleftharpoons N_2\,(g) + O_2(g)$$

A closed vessel is charged with 36.1 atm of NO. At equilibrium, the partial pressure of O_2 is _____ atm.

A) 294
B) 35.7
C) 17.9
D) 6.00
E) 1.50×10^{-2}

15.2 Multiple-Choice Questions

1) At equilibrium, _____.

A) all chemical reactions have ceased
B) the rates of the forward and reverse reactions are equal
C) the rate constants of the forward and reverse reactions are equal
D) the value of the equilibrium constant is 1
E) the limiting reagent has been consumed

2) What role did Karl Bosch play in development of the Haber-Bosch process?

A) He discovered the reaction conditions necessary for formation of ammonia.
B) He originally isolated ammonia from camel dung and found a method for purifying it.
C) Haber was working in his lab with his instructor at the time he worked out the process.
D) He developed the equipment necessary for industrial production of ammonia.
E) He was the German industrialist who financed the research done by Haber.

3) In what year was Fritz Haber awarded the Nobel Prize in chemistry for his development of a process for synthesizing ammonia directly from nitrogen and hydrogen?

A) 1954
B) 1933
C) 1918
D) 1900
E) 1912

4) Which one of the following is true concerning the Haber process?

A) It is a process used for shifting equilibrium positions to the right for more economical chemical synthesis of a variety of substances.
B) It is a process used for the synthesis of ammonia.
C) It is another way of stating LeChatelier's principle.
D) It is an industrial synthesis of sodium chloride that was discovered by Karl Haber.
E) It is a process for the synthesis of elemental chlorine.

5) Which one of the following will change the value of an equilibrium constant?

A) changing temperature
B) adding other substances that do not react with any of the species involved in the equilibrium
C) varying the initial concentrations of reactants
D) varying the initial concentrations of products
E) changing the volume of the reaction vessel

6) Which of the following expressions is the correct equilibrium-constant expression for the equilibrium between dinitrogen tetroxide and nitrogen dioxide?

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

A) $\dfrac{[NO_2]}{[N_2O_4]}$

B) $\dfrac{[NO_2]^2}{[N_2O_4]}$

C) $\frac{[NO_2]}{[N_2O_4]^2}$

D) $[NO_2]\,[N_2O_4]$

E) $[NO_2]^2\,[N_2O_4]$

7) The equilibrium-constant expression depends on the _____ of the reaction.

A) stoichiometry
B) mechanism
C) stoichiometry and mechanism
D) the quantities of reactants and products initially present
E) temperature

8) Given the following reaction at equilibrium, if $K_c = 6.44 \times 10^5$ at 230.0 °C, K_p = _____.

$$2NO\,(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

A) 3.67×10^{-2}
B) 1.56×10^{4}
C) 6.44×10^{5}
D) 2.66×10^{6}
E) 2.67×10^{7}

9) Given the following reaction at equilibrium at 450.0 °C:

$$CaCO_3(s) \rightleftharpoons CaO\,(s) + CO_2(g)$$

If $pCO_2 = 0.0160$ atm, K_c = _____.

A) 0.0160
B) 0.0821
C) 7.23
D) 2.70×10^{-4}
E) 723

10) Given the following reaction at equilibrium, if $K_p = 1.05$ at 250.0 °C, K_c = _____.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

A) 3.90×10^{-6}
B) 2.45×10^{-2}
C) 1.05
D) 42.9
E) 45.0

11) Given the following reaction at equilibrium at 300.0 K:

$$NH_4HS\,(s) \rightleftharpoons NH_3(g) + H_2S\,(g)$$

If $pNH_3 = pH_2S = 0.111$ atm, K_p = _____.

A) 1.23×10^{-2}
B) 4.99×10^{-4}
C) 1.11×10^{-1}
D) 8.12×10^{-2}
E) 5.66×10^{-3}

12) Which of the following expressions is the correct equilibrium-constant expression for the reaction below?

$$(NH_4)_2Se\,(s) \rightleftharpoons 2NH_3(g) + H_2Se\,(g)$$

A) $[NH_3][H_2Se] / (NH_4)_2Se$
B) $(NH_4)_2Se / [NH_3]^2[H_2Se]$
C) $1/[(NH_4)_2Se]$
D) $[NH_3]^2[H_2Se]$
E) $[NH_3]^2[H_2Se] / [(NH_4)_2Se]$

13) Which of the following expressions is the correct equilibrium-constant expression for the reaction below?

$$HF\,(aq) + H_2O\,(l) \rightleftharpoons H_3O^+(aq) + F^-\,(aq)$$

A) $[HF][H_2O] \;/\; \{H_3O^+][F^-]$
B) 1 / HF
C) $[H_3O^+][F^-] / [HF][H_2O]$
D) $[H_3O^+][F^-] / [HF]$
E) $[F^-] / [HF]$

14) The equilibrium constant for the gas phase reaction

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

is $K_{eq} = 4.34 \times 10^{-3}$ at 300 °C. At equilibrium, _____.

A) products predominate

B) reactants predominate
C) roughly equal amounts of products and reactants are present
D) only products are present
E) only reactants are present

15) The equilibrium constant for the gas phase reaction

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

is $K_{eq} = 230$ at 300 °C. At equilibrium, _____.

A) products predominate
B) reactants predominate
C) roughly equal amounts of products and reactants are present
D) only products are present
E) only reactants are present

16) The equilibrium constant for reaction 1 is K. The equilibrium constant for reaction 2 is _____.

(1) $SO_2(g) + (1/2)\,O_2(g) \rightleftharpoons SO_3(g)$

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

A) K^2
B) 2K
C) 1/2K
D) $1/K^2$
E) $-K^2$

17) The value of K_{eq} for the following reaction is 0.25:

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$

The value of K_{eq} at the same temperature for the reaction below is _____.

$$2SO_2(g) + 2NO_2(g) \rightleftharpoons 2SO_3(g) + 2NO(g)$$

A) 0.50
B) 0.063
C) 0.12
D) 0.25
E) 16

18) The equilibrium expression for Kp for the reaction below is _____.

$$2O_3(g) \rightleftharpoons 3O_2(g)$$

A) $\frac{3PO_2}{2PO_3}$

B) $\frac{2PO_3}{3PO_2}$

C) $\frac{3PO_3}{2PO_2}$

D) $\frac{PO_3^2}{PO_2^2}$

E) $\frac{PO_2^3}{PO_3^2}$

19) The K_{eq} for the equilibrium below is 7.52×10^{-2} at 480.0 °C.

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

What is the value of K_{eq} at this temperature for the following reaction?

$$Cl_2(g) + H_2O(g) \rightleftharpoons 2HCl(g) + \frac{1}{2}O_2(g)$$

A) 0.0752
B) 5.66×10^{-3}
C) 0.274
D) 0.0376
E) 0.150

20) The K_{eq} for the equilibrium below is 7.52×10^{-2} at 480.0 °C.

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

What is the value of K_{eq} at this temperature for the following reaction?

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

A) 0.0752
B) -0.0752
C) 13.3
D) 5.66×10^{-3}
E) 0.150

21) The K_{eq} for the equilibrium below is 7.52×10^{-2} at 480.0 °C.

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

What is the value of K_{eq} at this temperature for the following reaction?

$$2HCl(g) + \frac{1}{2}O_2(g) \rightleftharpoons Cl_2(g) + H_2O(g)$$

A) 13.3
B) 3.65
C) -0.0376
D) 5.66×10^{-3}
E) 0.274

22) The K_{eq} for the equilibrium below is 0.112 at 700.0 ° C.

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$$

What is the value of K_{eq} at this temperature for the following reaction?

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

A) 0.224
B) 0.335
C) 0.0125
D) 0.0560
E) 0.112

23) The K_{eq} for the equilibrium below is 0.112 at 700.0 °C.

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$$

What is the value of K_{eq} at this temperature for the following reaction?

$$SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$$

A) 0.224
B) 0.0125
C) 0.112
D) 8.93
E) -0.112

24) The K_{eq} for the equilibrium below is 0.112 at 700.0 °C.

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$$

What is the value of K_{eq} at this temperature for the following reaction?

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

A) 79.7
B) 2.99
C) 17.86
D) 4.46
E) 8.93

25) At 1000.0 K, the equilibrium constant for the reaction

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

is $Kp = 0.013$. Calculate Kp for the reverse reaction,

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

.

A) 0.013
B) $1.6Ź \times 10^{-4}$
C) 77
D) 0.99
E) 1.1

26) Consider the following equilibrium.

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

The equilibrium cannot be established when _____ is/are placed in a 1.0-L container.

A) 0.25 mol $SO_2(g)$ and 0.25 mol $O_2(g)$
B) 0.75 mol $SO_2(g)$
C) 0.25 mol of $SO_2(g)$ and 0.25 mol of $SO_3(g)$
D) 0.50 mol $O_2(g)$ and 0.50 mol $SO_3(g)$
E) 1.0 mol $SO_3(g)$

27) The expression for K_p for the reaction below is

$$4CuO(s) + CH_4(g) \rightleftharpoons CO_2(g) + 4Cu(s) + 2H_2O(g)$$

A) $\frac{PCH_4}{PCO_2 PH_2{}^2}$

B) $\frac{[Cu]PCO_2PH_2O^2}{[CuO]^4PCH_4}$

C) $\frac{PCO_2PH_2O^2}{PCH_4}$

D) $\frac{PCO_2PH_2O^2}{PCuO}$

E) $\frac{PCH_4}{PH_2O^2PCO_2}$

28) The equilibrium-constant expression for the reaction

$$Ti\,(s) + 2Cl_2\,(g) \rightleftharpoons TiCl_4(l)$$

is given by

A) $\frac{[TiCl_4(l)]}{[Ti\,(s)][Cl_2(g)]}$

B) $\frac{[Ti\,(s)][Cl_2(g)]^2}{[TiCl4(l)]}$

C) $\frac{[TiCl_4(l)]}{[Cl_2(g)]^2}$

D) $[Cl_2(g)]^{-2}$

E) $\frac{[TiCl_4(l)]}{[Ti(s)][Cl_2(g)]^2}$

29) At 400 K, the equilibrium constant for the reaction

$$Br_2(g) + Cl_2(g) \rightleftharpoons 2BrCl(g)$$

is $K_p = 7.0_p$. A closed vessel at 400 K is charged with 1.00 atm of $Br_2(g)$, 1.00 atm of $Cl_2(g)$, and 2.00 atm of $BrCl(g)$. Use Q to determine which of the statements below is true.

A) The equilibrium partial pressures of Br_2, Cl_2, and BrCl will be the same as the initial values.
B) The equilibrium partial pressure of Br_2 will be greater than 1.00 atm.
C) At equilibrium, the total pressure in the vessel will be less than the initial total pressure.
D) The equilibrium partial pressure of BrCl(g) will be greater than 2.00 atm.
E) The reaction will go to completion since there are equal amounts of Br_2 and Cl_2.

30) Which of the following statements is true?

A) Q does not change with temperature.
B) K_{eq} does not change with temperature, whereas Q is temperature dependent.
C) K does not depend on the concentrations or partial pressures of reaction components.
D) Q does not depend on the concentrations or partial pressures of reaction components.
E) Q is the same as K_{eq} when a reaction is at equilibrium.

31) How is the reaction quotient used to determine whether a system is at equilibrium?

A) The reaction quotient must be satisfied for equilibrium to be achieved.
B) At equilibrium, the reaction quotient is undefined.
C) The reaction is at equilibrium when $Q < K_{eq}$.
D) The reaction is at equilibrium when $Q > K_{eq}$.
E) The reaction is at equilibrium when $Q = K_{eq}$.

32) Nitrosyl bromide decomposes according to the following equation.

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

A sample of NOBr (0.64 mol) was placed in a 1.00-L flask containing no NO or Br_2. At equilibrium the flask contained 0.46 mol of NOBr. How many moles of NO and Br_2, respectively, are in the flask at equilibrium?

A) 0.18, 0.18
B) 0.46, 0.23
C) 0.18, 0.090
D) 0.18, 0.360
E) 0.46, 0.46

33) Of the following equilibria, only _____ will shift to the left in response to a decrease in volume.

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

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

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

D) $4\ Fe\ (s) + 3O_2(g) \rightleftharpoons 2Fe_2O_3(s)$

E) $2HI\ (g) \rightleftharpoons H_2(g) + I_2(g)$

34) The reaction below is exothermic:

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

Le Chatelier's Principle predicts that _____ will result in an increase in the number of moles of $SO_3(g)$ in the reaction container.

A) increasing the pressure
B) decreasing the pressure
C) increasing the temperature
D) removing some oxygen
E) increasing the volume of the container

35) For the endothermic reaction

$$CaCO_3(s) \rightleftharpoons CaO\ (s) + CO_2(g)$$

Le Chatelier's principle predicts that _____ will result in an increase in the number of moles of CO_2.

A) increasing the temperature
B) decreasing the temperature
C) increasing the pressure
D) removing some of the $CaCO_3(s)$
E) none of the above

36) In which of the following reactions would increasing pressure at constant temperature <u>not</u> change the concentrations of reactants and products, based on Le Chatelier's principle?

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

B) $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

C) $N_2(g) + 2O_2(g) \rightleftharpoons 2NO_2(g)$

D) $2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$

E) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

37) Consider the following reaction at equilibrium:

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g) \quad \Delta H° = +92.4\ kJ$$

Le Chatelier's principle predicts that adding $N_2(g)$ to the system at equilibrium will result in _____.

A) a decrease in the concentration of $NH_3(g)$
B) a decrease in the concentration of $H_2(g)$
C) an increase in the value of the equilibrium constant
D) a lower partial pressure of N_2
E) removal of all of the $H_2(g)$

38) Consider the following reaction at equilibrium:

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

Le Chatelier's principle predicts that the moles of H_2 in the reaction container will increase with _____.

A) some removal of NH_3 from the reaction vessel (V and T constant)
B) a decrease in the total pressure (T constant)
C) addition of some N_2 to the reaction vessel (V and T constant)
D) a decrease in the total volume of the reaction vessel (T constant)
E) an increase in total pressure by the addition of helium gas (V and T constant)

39) Consider the following reaction at equilibrium:

$$2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g) \quad \Delta H° = -514\ kJ$$

Le Chaelier's principle predicts that adding O_2 (g) to the reaction container will _____.

A) increase the partial pressure of $CO(g)$ at equilibrium
B) decrease the partial pressure of $CO_2(g)$ at equilibrium
C) increase the value of the equilibrium constant
D) increase the partial pressure of $CO_2(g)$ at equilibrium
E) decrease the value of the equilibrium constant

40) Consider the following reaction at equilibrium:

$$2CO_2(g) \rightleftharpoons 2CO\ (g) + O_2(g) \quad \Delta H° = -514\ kJ$$

Le Chatelier's principle predicts that an increase in temperature will _____.

A) increase the partial pressure of $O_2(g)$
B) decrease the partial pressure of $CO_2(g)$
C) decrease the value of the equilibrium constant
D) increase the value of the equilibrium constant
E) increase the partial pressure of CO

41) Consider the following reaction at equilibrium:

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$$

Which of the following conditions will increase the partial pressure of CO?
A) decreasing the partial pressure of $H_2O(g)$
B) removing $H_2O(g)$ from the system
C) decreasing the volume of the reaction vessel
D) decreasing the pressure in the reaction vessel
E) increasing the amount of carbon in the system

42) Consider the following reaction at equilibrium.

$$2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g) \quad \Delta H° = -514 \text{ kJ}$$

Le Chatelier's principle predicts that the equilibrium partial pressure of CO (g) can be maximized by carrying out the reaction _____.
A) at high temperature and high pressure
B) at high temperature and low pressure
C) at low temperature and low pressure
D) at low temperature and high pressure
E) in the presence of solid carbon

43) Consider the following reaction at equilibrium:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H° = -99 \text{ kJ}$$

Le Chatelier's principle predicts that an increase in temperature will result in _____.

A) a decrease in the partial pressure of SO_3
B) a decrease in the partial pressure of SO_2
C) an increase in K_{eq}
D) no changes in equilibrium partial pressures
E) the partial pressure of O_2 will decrease

44) The effect of a catalyst on an equilibrium is to _____.

A) increase the rate of the forward reaction only
B) increase the equilibrium constant so that products are favored
C) slow the reverse reaction only
D) increase the rate at which equilibrium is achieved without changing the composition of the equilibrium mixture
E) shift the equilibrium to the right

15.3 Short Answer Questions.

1) The equilibrium-constant expression for a reaction written in one direction is the _____ of the one for the reaction written for the reverse direction.

2) If Reaction A + Reaction B = Reaction C, then K_c Reaction C = _____.

3) If the value for the equilibrium constant is much greater than 1, then the equilibrium mixture contains mostly _____.

4) Pure _____ and pure _____ are excluded from equilibrium-constant expressions.

5) Exactly 3.5 moles if N_2O_4 is placed in an empty 2.0-L container and allowed to reach equilibrium described by the equation

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

If at equilibrium the N_2O_4 is 25% dissociated, what is the value of the equilibrium constant for the reaction?

6) The number obtained by substituting starting reactant and product concentrations into an equilibrium-constant expression is known as the _____.

7) If the reaction quotient Q for a reaction is less than the value of the equilibrium constant K for that reaction at a given temperature, _____ must be converted to _____ for the system to reach equilibrium.

8) If the reaction quotient Q for a reaction is greater than the value of the equilibrium constant K for that reaction at a given temperature, _____ must be converted to _____ for the system to reach equilibrium.

9) For an exothermic reaction, increasing the reaction temperature results in a(an) _____ in K.

10) If a reaction is endothermic, _____ the reaction temperature results in an increase in K.

15.4 True/False Questions

1) The relationship between the concentrations of reactants and products of a system at equilibrium is given by the law of mass action.

2) The effect of a catalyst on a chemical reaction is to react with product, effectively removing it and shifting the equilibrium to the right.

3) At constant temperature, reducing the volume of a gaseous equilibrium mixture causes the reaction to shift in the direction that increases the number of moles of gas in the system.

4) In an exothermic equilibrium reaction, increasing the reaction temperature favors the formation of reactants.

5) Le Chatelier's principle states that if a system at equilibrium is disturbed, the equilibrium will shift to minimize these disturbance.

15.5 Algorithmic Questions

1) Phosphorous trichloride and phosphorous pentachloride equilibrate in the presence of molecular chlorine according to the reaction:

$$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$$

An equilibrium mixture at 450 K contains $PPCl_3 = 0.202$ atm $PCl_2 = 0.256$ atm , and s $PPCl_5 = 3.45$ atm .What is the value of K_p at this temperature?

A) 66.7
B) 1.50×10^{-2}
C) 1.78×10^{-1}
D) 2.99
E) 7.54

2) Dinitrogen tetroxide partially decomposes according to the following equilibrium:

$$N_2O_4(g) \rightarrow 2NO_2(g)$$

A 1.000-L flask is charged with 3.00×10^{-2} mol of N_2O_4. At equilibrium, 2.36×10^{-2} mol of N_2O_4 remains. K_{eq} for this reaction is _____.

A) 0.723
B) 0.391
C) 0.212
D) 6.94×10^{-3}
E) 1.92×10^{-4}

3) The K_p for the reaction below is 1.49×10^{8} at 100.0 °C:

$$CO(g) + Cl_2(g) \rightarrow COCl_2(g)$$

In an equilibrium mixture of the three gases, $PCO = PCl_2 = 8.60 \times 10^{-4}$ atm . The partial pressure of the product, phosgene $(COCl_2)$, is _____ atm.

A) 1.10×10^{2Ź}
B) 2.01×10^{14}
C) 4.96×10^{-15}
D) 1.28×10^{5Ź}
E) 1.72×10^{11Ź}

4) At 900.0 K, the equilibrium constant (K_p) for the following reaction is 0.345.

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

At equilibrium, the partial pressure of SO_2 is 35.0 atm and that of O_2 is 15.9 atm. The partial pressure of SO_3 is _____ atm.

A) 82.0
B) 4.21×10^{-3}
C) 192
D) 6.20×10^{-4}
E) 40.2