Chapter 13 Test—Equilibrium
AP Chemistry

Name_____ Hour_____

Multiple Choice:

1) Which is the proper description of chemical equilibrium?

   A) The frequencies of reactant and of product collisions are identical.
   B) The concentrations of products and reactants are identical.
   C) The velocities of product and reactant molecules are identical.
   D) Reactant molecules react to form products as fast as product molecules are reacting to form reactants.

2) Carbon monoxide gas reacts with hydrogen gas to form methanol according to this equation. $CO_{(g)} + 2\ H_{2\ (g)} \leftrightarrows CH_3OH_{\ (g)}$

   When CO and H_2 are allowed to reach equilibrium in a 1.0 L container, 0.40 mol CO, 0.30 mol H_2, and 0.060 mol CH_3OH result. What is the value of K_c ?

   A) 0.50
   B) 0.98
   C) 1.7
   D) 5.4

3) The value of an equilibrium constant can be used to predict each of these **except**

   A) direction of a reaction.
   B) extent of a reaction.
   C) quantity of reactant(s) remaining at equilibrium.
   D) Time required to reach equilibrium.

4) Which factors will affect both the position of equilibrium and the value of the equilibrium constant for this reaction?

   $$N_{2(g)} + 3H_{2(g)} \leftrightarrows 2NH_{3(g)} \quad \Delta H = -92\ kJ$$

   A) Increasing the volume of the container
   B) Adding more N_2
   C) Removing some NH_3
   D) Lowering the temperature

5) Consider the reaction carried out at constant temperature and volume.

$PCl_{5(g)} \leftrightarrow PCl_{3(g)} + Cl_{2(g)}$

How can the position of equilibrium for this reaction be shifted to the right?

A) addition of a catalyst
B) removal of Cl_2
C) addition of an inert gas at constant volume
D) removal of PCl_5

6) In which reaction would an increase in pressure at constant temperature have no effect on the relative amounts of the substances present in the equilibrium mixture? All substances are gases.

A) $2\ NO + O_2 \leftrightarrow 2\ NO_2 + Heat$

B) $Heat + N_2 + O_2 \leftrightarrow 2\ NO$

C) $N_2 + 3\ H_2 \leftrightarrow 2\ NH_3$

D) $2\ CO + O_2 \leftrightarrow 2\ CO_2 + Heat$

7) The numerical value of the equilibrium constant for any chemical change is affected by changing the

A) nature of the catalyst
B) concentration of the products
C) pressure
D) temperature

8) Consider the reaction $AB_{3(g)} \leftrightarrow A_{(g)} + 3\ B_{(g)}$ What is the equilibrium constant expression if the initial concentration of AB_3 is 0.10 M and the equilibrium concentration of A is represented by "x"? Assume the initial concentrations of A and B are both zero.

A) $\frac{x - 3x}{0.1-x}$ B) $\frac{x - x^3}{(.01-x)^3}$ C) $\frac{(x)\ (x)^3}{(.01-3x)^3}$ D) $\frac{(x)\ (3x)^3}{0.1- x}$

9) Given the reaction $2\ X_{(g)} + Y_{(g)} \leftrightarrow 2\ Z_{(g)}$ $\Delta H = -335kJ$ which combination of pressure and temperature gives the highest yield of Z at equilibrium?

A) 1000 atm and 500^0C
B) 1000 atm and 100^0C
C) 500 atm and 500^0C
D) 500 atm and 100^0C
E) a catalyst

10) The reaction for the formation of ammonia by direct combination is

$N_{2(g)} + 3\ H_{2(g)} \leftrightarrows 2\ NH_{3(g)} \qquad \Delta H = -92\ kJ$

Which operation will increase the yield of ammonia in the equilibrium mixture?

A) doubling the concentration of hydrogen
B) reducing the total pressure
C) raising the temperature
D) increasing the reaction time
E) adding a catalyst

Name_____

Problems Solving

1)Write the mathematical expression for the K_c and the K_p for each of the following reactions:

A) $2\ SO_{2(g)} + O_{2(g)} \leftrightarrow 2\ SO_{3(g)}$ _____ _____

B) $SO_{3(g)} + H_2O_{(l)} \leftrightarrow H_2SO_{4(l)}$ _____ _____

C) $CaO_{3\ (s)} \leftrightarrow CaO_{\ (s)} + O_{2\ (g)}$ _____ _____

2) The initial concentrations of reactants and products are given for each of the following systems. Calculate the reaction quotient (Q), and determining the direction in which each system will shift to reach equilibrium. (Show Work) Reactions contain **All Gases**

A) $2\ NO + Cl_2 \leftrightarrow 2\ NOCl$ $K_c = 4.6 \times 10^4$
[1.00] [1.00] [0]

Q = _____ Direction = _____

B) $N_2 + O_2 \leftrightarrow 2\ NO$ $K_c = 0.050$
[1.00] [.200] [1.00]

Q=_____ Direction =_____

C) $2\ NH_3 \leftrightarrow N_2 + 3\ H_2$ $K_c = 17$
[0.90] [1.50] [2.0]

Q=_____ Direction=_____

3) A mixture of hydrogen and nitrogen in a 160 L vessel goes to equilibrium at 172^0 C. The equilibrium mixture of gases was found to contain 7.38 mol hydrogen, 2.46 mol nitrogen, and 0.166 mol of ammonia.(Remember you need molarity.) Calculate the equilibrium constant (k_c) for the reaction: $3\ H_{2\ (g)} + N_{2\ (g)} \leftrightarrows 2\ NH_{3\ (g)}$

4) Analysis of gases in a 3.0 L container has NO, Cl_2, and NOCl gases **at equilibrium** establishing the presence of 4.5 g of NO, and 3.30 g. of Cl_2.(**Remember to use molarity of each of the reactants.)** The equilibrium constant $k_c = 4.6 \times 10^4$. Calculate the molar concentration (M) of NOCl for the reaction

$$2NO\ (g) + Cl_2\ (g) \leftrightarrows 2NOCl\ (g)$$

5) Calculate the equilibrium concentrations that result when 1.5 M Cl_2 and 1.5 M H_2O react and come to equilibrium according to the equation

$$2\ Cl_2(g) + 2\ H_2O\ (g) \leftrightarrows 4\ HCl\ (g) + O_2\ (g) \qquad K_c = 3.2 \times 10^{-14}$$

(Must use an RICE Box and show work)

6) A sample of 0.30 M Cl_2 and 0.45 M Br_2 is allowed to reach equilibrium at constant temperature in a sealed container. What are the equilibrium concentrations? (Need quadratic equation to solve for X.)

$Cl_2(g) + Br_2(g) \leftrightarrow 2\ BrCl(g)$ $\quad K_c = 4.7 \times 10^{-2}$ (Use RICE Box)

7) How will the **increase in temperature** affect each of the following equilibria? How will a **decrease in pressure** affect the same systems?

A) $2\ H_2O(g) \leftrightarrow 2\ H_2(g) + O_2(g)$ $\quad \Delta H = +487$ kJ

B) $H_2(g) + F_2(g) \leftrightarrow 2\ HF(g)$ $\quad \Delta H = +541$ kJ

C) $2\ NO(g) \leftrightarrow N_2(g) + O_2(g)$ $\quad \Delta H = -181$ kJ

D) $P_4(s) + 6\ Cl_2(g) \leftrightarrow 4\ PCl_3(g)$ $\quad \Delta H = -287$ kJ

E) $2\ Cl_2(g) + 7\ O_2(g) \leftrightarrow 2\ Cl_2O_7(g)$ $\quad \Delta H = +272$ kJ

(Indicate **right, left, or no shift)**

Temperature Increase	**Pressure Decrease**
A)_____	A)_____
B)_____	B)_____
C)_____	C)_____
D)_____	D)_____
E)_____	E)_____

8) $K_p = K_c (RT)^{\Delta n}$ R= 0.0821

The equilibrium constant for the reaction
$SO_2 (g) + ½ O_2 (g) \leftrightarrow SO_3 (g)$ $k_c = 20.4$ at 700^0 C

A) What is the value of k_c for
$SO_3 \leftrightarrow SO_2 + ½ O_2$

k_c = _____

B) What is the value for k_c for
$2SO_2 + O_2 \leftrightarrow 2 SO_3$

k_c = _____

C) What is the value of k_p for
$2 SO_2 + O_2 \leftrightarrow 2 SO_3$

k_p = _____