(#11-3)

Honors Chemistry

Le Chatelier's Principle

Match the change to the equilibrium system below with the letter of the appropriate response. Each letter can be used once, more than once, or not at all.

$$2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g) + \text{heat}$$

a → 1. O_2 is added to the system. (3)

b ← 2. SO_3 is added to the system. (2)

b ← 3. The temperature of the system is increased.

c (no shift) 4. A catalyst is added to the system.

a → 5. The volume is decreased.

a. The reaction shifts to the right.

b. The reaction shifts to the left.

c. No Shift.

If the statement is true, write "true." If it is false, change the underlined word or words to make the statement true. Write your answer on the line provided.

$$NH_4Cl(s) + \text{heat} \Leftrightarrow NH_3(g) + HCl(g)$$

false endothermic The above reaction is exothermic. (energy) (heat on reactant side)

true 6. The production of ammonia from ammonium chloride will increase at higher temperature. → shift

true 7. For the above reaction at equilibrium, an increase in the concentration of HCl causes a decrease in gaseous ammonia concentration. ← shift

8. The following equilibrium may be established with carbon dioxide and steam.

$$CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g) + \text{heat}$$

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

Predict the direction of equilibrium shift (right, left, or no shift) if the following changes occur:

a.) The addition of more H_2O? → shift right
b.) The removal of some H_2? → shift right
c.) Raising the temperature? ← shift left
d.) Addition of a catalyst? no shift
e.) Increasing the volume? no shift (same # of mole of gas on each side)

9. What would be the effect of each of the following on the concentration of CO (increase, decrease, or no effect) when the following stresses are placed on the equilibrium involving the synthesis of methanol?

$$CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$$

a.) The removal of CH_3OH? → [CO] ↓
b.) Lowering the concentration of H_2? ← [CO] ↑
c.) The addition of a catalyst? no shift [CO] no change
d.) Decreasing the volume? → [CO] ↓

10. A small percentage of nitrogen gas and oxygen gas in the air combine at the high temperatures found in automobile engines to produce NO(g), an air pollutant.

$$N_2(g) + O_2(g) + heat \leftrightarrow 2NO(g)$$

Higher engine temperatures are used to minimize carbon monoxide production. What effect do higher engine temperatures have on the production of NO? Why?

- increased temperature, shifts toward products
- increases the production of NO

(#11-3)
Equilibrium: Le Chatelier's principle

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1 2 ΔH+ endothermic

1.(brown580) Consider the following equilibrium $N_2O_{4(g)} \leftrightarrow 2NO_{2(g)}$ $\Delta H = 58.0$ kJ/mol In what direction will the equilibrium shift when each of the following changes is made to a system at equilibrium

a. add N_2O_4 →
b. remove NO_2 →
c. increase the total pressure by adding N_2 N_2 is not in equilibrium expression (no shift)
d. increase the volume →
e. decrease the temperature. ← (energy on reactant side)

2.(Brady640) The air pollutant sulfur dioxide can be removed form a gas mixture by passing the gases over calcium oxide. The equation is $CaO_{(s)} + SO_{2(g)} \leftrightarrow CaSO_{3(s)}$ If the reaction is currently at equilibrium which means it looks as if the reaction has essentially ended… how will these alterations affect the direction the reaction will shift to return to equilibrium?

a. Addition of $CaO_{(s)}$ solid – no shift
b. Addition of $SO_{2(g)}$ →
c. Addition of a catalyst? no shift
d. Addition of additional O_2? no shift (not in reaction)

2 1

3. (brady645) Consider the equilibrium $PCl_{3(g)} + Cl_{2(g)} \leftrightarrow PCl_{5(g)}$ + energy , for which $\Delta H° = -88$kJ. How will the amount of Cl_2 at equilibrium be affected by a) adding PCl_3 b) adding PCl_5 c) raising the temperature, and d) decreasing the volume of the container? E. How will all of these changes affect Kp.

	shift	amount of Cl_2
a. add PCl_3	→	$[Cl_2]$ ↓
b. add PCl_5	←	$[Cl_2]$ ↑
c. raise temp	←	$[Cl_2]$ ↑
d. decrease V	→	$[Cl_2]$ ↓

more reactants

e. the only change that affects Kp (or any K) is temp change (c) Kp ↓

4. (brown573) At 448°C the equilibrium constant, K_c, for the reaction $H_{2(g)} + I_{2(g)} \leftrightarrow 2HI_{(g)}$ is 51. Predict how the reaction will proceed to equilibrium at 448°C if we start with 2.0E-2mol of HI, 1.00E-2 mol H_2 and 3.0E-2mol of I_2 in a 2.0L container. In other words, which way will it shift, products or reactants.

$$Q = \frac{[HI]^2}{[H_2][I_2]} = \frac{(2E\text{-}2)^2}{(1E\text{-}2)(3E\text{-}2)} = 1.3$$

Q < K
1.3 < 51
↑ more reactants ↑ more products

Shift toward products

Quiz 3 Topic reminder

$A(s) + 2B(aq) \leftrightarrow C(aq) + \text{energy}$

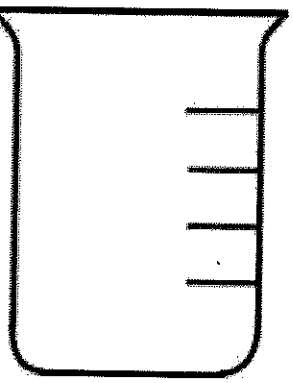
1. In a beaker the reaction above starts with a .2M B and .1M C. After a period of time, C is measured to have a concentration of 0.08.
   a. What is the reaction quotient at the start of the reaction?

$$Q = \frac{[C]}{[B]^2} = \frac{0.1}{(0.2)^2} = 2.5$$

   b. What is the equilibrium constant?

$$K = \frac{0.08}{(0.24)^2} = 1.38$$

   c. Draw a particulate drawing of this in the beaker provided.



$A(s) + 2B(aq) \rightleftharpoons C(aq) + \text{energy}$

I		0.2	0.1
C		+0.04	−0.02
E		0.24	0.08

2. How is the concentration of C affected by the following?
   a. Addition of B shift → [C]↑
   b. Removal of B shift ← [C]↓
   c. Addition of C shift ← (add C, [C]↑, after shift ← [C]↓ some)
   d. Addition of D no shift, no change in [C]
   e. Increased the temperature shift ← [C]↓