AP CHEMISTRY

TOPIC 6: EQUILIBRIUM, PART D MORE QUESTIONS Day 67:

- Le Chatelier's Principle

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1. Suppose the reaction system

$$C_{(s)} + O_{2\,(g)} \leftrightarrow CO_{2\,(g)}$$

has already reached equilibrium. Predict the effect that each of the following changes has on the equilibrium position. Indicate whether the equilibrium will shift to the right, will shift to the left, or will not be affected.

a) Additional carbon is added to the system.

Answer:

No Effect, Adding more of a pure solid or pure liquid has no effect on the equilibrium position.

b) The reaction is exothermic, what will happen to the system if the temperature of the "whole system" increases?

Answer:

Shifts to the Left. Since the reaction is exothermic (heat is a product), if the temperature of the whole system increases (heat is added). Heat (on the product side) will cause a shift to the left to form more reactant.

c) Oxygen is removed.

Answer:

Shifts Left, As $O_{2\,(g)}$ is removed, the reaction will shift to the left to produce more $O_{2(g)}$ from the $CO_{2(g)}$.

2. Predict the shift in the equilibrium position that will occur for each of the following reactions when the volume of the reaction container is decreased.

Answer:

When the volume of a reaction container is decreased, the reaction itself will want to decrease its own volume by shifting to the side of the reaction that contains the fewer molecules of gas. When the molecules of gas are equal on both sides of the reaction (coefficients are the same number), then the reaction will remain at equilibrium no matter what happens to the volume of the container.

a) $2\,NH_{3\,(g)} \leftrightarrow N_{2\,(g)} + 3\,H_{2\,(g)}$	Shifts to left, toward reactants
b) $PCl_{5\,(g)} \leftrightarrow PCl_{3\,(g)} + Cl_{2\,(g)}$	Shifts to left, toward reactants
c) $2\,HF_{(g)} \leftrightarrow H_{2\,(g)} + F_{2\,(g)}$	No Shift, equal number of reactants and products
d) $COCl_{2\,(g)} \leftrightarrow CO_{(g)} + Cl_{2\,(g)}$	Shifts to left, toward reactants
e) $CaO_{(s)} + CO_{2\,(g)} \leftrightarrow CaCO_{3\,(s)}$	Shifts to right, toward products (ignore solids and pure liquids) to reduce the number of particles in the container. Yes, the number of gas molecules will be reduced – NOT ELIMINATED.

5. The system is at equilibrium when the following conditions are changed. Determine if the reaction is endothermic or exothermic.

a) Temperature decreases, *K* decreases ***ENDOTHERMIC***

b) Temperature increases, *K* increases ***ENDOTHERMIC***

c) *K* changes from 12.0 to 3.50, Heat is added from the system (with the use of a Bunsen burner). ***EXOTHERMIC***

d) *K* changes from 3.0 to 12.0, Heat is removed from the system (with the use of an ice bath). ***EXOTHERMIC***

e) Temperature	K_{eq}
5000 K	23.4
3000 K	100.3

EXOTHERMIC

6. The system is at equilibrium when the following conditions are changed. Determine if the temperature is increasing, decreasing or remains the same.

   a) Exothermic reaction and K decreases.

   The Temperature is INCREASING. Exothermic indicates that Energy is a PRODUCT, and when the equilibrium constant, K, decreases this indicates that the reaction is shifting to the LEFT. This shift indicates that the products are forming more reactants thus the product amounts are being lowered while the reactant amounts are getting greater.

$$K = \frac{[\text{products}]\downarrow}{[\text{reactants}]\uparrow} = lower\ \ K$$ ***Equals a SHIFT to the LEFT***

   b) Endothermic reaction and K does not change.

   The Temperature is CONSTANT. If the equilibrium constant, K, does not change then the temperature has not changed (and the volume has not changed as well).

   c) K changes from 3.50 to 12.0 and the reaction has a heat of formation value equal to – 400 kJ (ΔH^0 = -400 kJ)

   The Temperature is DECREASING. Exothermic indicates that Energy is a PRODUCT, and when the equilibrium constant, K, increases this indicates that the reaction is shifting to the RIGHT. This shift indicates that the reactants are forming more products thus the reactant amounts are being lowered while the product amounts are getting greater.

$$K = \frac{[\text{products}]\uparrow}{[\text{reactants}]\downarrow} = higher\ \ K$$ ***Equals a SHIFT to the RIGHT***

7. The system is at equilibrium when the following conditions are changed. Determine if the value for K is increasing, decreasing or remains the same.

   a) Exothermic reaction and heat is added to the reaction.

   The Value for K is DECREASING. Exothermic indicates that Energy is a PRODUCT and heat (energy) was ADDED to the reaction (which will cause it to shift AWAY). This shift is to the LEFT. When the equilibrium constant, K, decreases this indicates that the reaction is shifting to the LEFT. This shift indicates that the products are forming more reactants thus the reactant amounts are being increased while the product amounts are getting lower.

$$K = \frac{[\text{products}]\downarrow}{[\text{reactants}]\uparrow} = lower\ \ K$$ ***Equals a SHIFT to the LEFT***

   b) Endothermic reaction and heat is removed from the reaction.

   The Value for K is DECREASING. Endothermic indicates that Energy is a REACTANT and heat (energy) was REMOVED from the reaction (which will cause it to shift TOWARD the removal). This shift is to the LEFT. When the equilibrium constant, K, decreases this indicates that the reaction is shifting to the LEFT. This shift indicates that the products are forming more reactants thus the reactant amounts are being increased while the product amounts are getting lower.

$$K = \frac{[\text{products}]\downarrow}{[\text{reactants}]\uparrow} = lower\ \ K$$ ***Equals a SHIFT to the LEFT***

c) The temperature changes from 255 K to 335 K and the reaction has a heat of formation value equal to + 400 kJ (ΔH^0 = +400 kJ)

The Value for K is INCREASING. The POSITIVE heat of formation value indicates that the reaction is Endothermic and that Energy is a REACTANT. The temperature of the system increased which indicates that heat (energy) was ADDED to the reaction (which will cause it to shift AWAY from the addition). This shift is to the RIGHT. When the equilibrium constant, K, increases this indicates that the reactants are forming more products - thus the reactant amounts are being decreased while the product amounts are getting higher.

$$K = \frac{[\text{products}]\uparrow}{[\text{reactants}]\downarrow} = higher\ \ K$$ ***Equals a SHIFT to the RIGHT***