

Chemistry 12Tutorial 5 - Solutions
The Equilibrium Constant (K_{eq})Answer to question 1 on page 2 of Tutorial 5

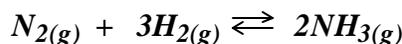
1. With this in mind, see if you can write the K_{eq} expression for the following reaction:



$$K_{eq} = \frac{[N_2] [H_2]^3}{[NH_3]^2}$$

Answer to question 2 on page 3 of Tutorial 5.

2. Write the K_{eq} expression for the following reaction:



$$K_{eq} = \frac{[NH_3]^2}{[N_2] [H_2]^3}$$

Notice that this time the $[NH_3]^2$ is on top and the $[N_2] [H_2]^3$ is on the bottom, because in the balanced equation, NH_3 was on the right side and N_2 and H_2 were on the left side.

Answer to question 3 on page of Tutorial 5

3. Write the K_{eq} expression for the following reaction:



$$K_{\text{eq}} = \frac{[\text{CO}_2]}{[\text{HF}]^2}$$

Notice that the solids and liquids are completely left out of the K_{eq} expression.

Answer to question 4 on page 6 of Tutorial 5

4. For the reaction: $\text{Cu}(\text{OH})_{2(s)} \rightleftharpoons \text{Cu}^{2+}_{(aq)} + 2\text{OH}^{-}_{(aq)}$ $K_{\text{eq}} = 1.6 \times 10^{-19}$

Describe the extent of the reaction and the relative amounts of reactant and product at equilibrium.

The value of K_{eq} is very small. This means that this reaction has proceeded to an

extremely small extent at equilibrium. At equilibrium almost all of the

$\text{Cu}(\text{OH})_{2(s)}$ would remain and there would be very little $\text{Cu}^{2+}_{(aq)}$ or $\text{OH}^{-}_{(aq)}$ formed.

Answers to question 5 on page 8-9 of Tutorial 5

5. Given the equation for an **exothermic** reaction:



- a) Write the K_{eq} expression for this reaction:

$$K_{eq} = \frac{[E]}{[C][D]}$$

- b) If the *temperature* of this exothermic reaction is **increased**, the equilibrium will shift to the **left**. (The heat term is on the right.)

- c) The shift will make [E] **smaller**, and [C] and [D] **larger** than they were before.

- d) Since the numerator is **smaller** and the denominator is **larger**, the value of the K_{eq} will be **smaller** than it was before.

$$K_{eq} = \frac{[E]}{[C][D]}$$

- e) If the temperature of this system is **decreased**, the equilibrium will shift to the



right, and the value of K_{eq} will **increase**.

f). Fill in the following blanks:

When the *temperature is increased* in an *exothermic* reaction, the equilibrium
 Will *shift to the left* and the *value of K_{eq} will decrease*.

and

When the *temperature is decreased* in an *exothermic* reaction, the equilibrium
 will *shift to the right* and the *value of K_{eq} will increase*.

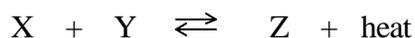
Answer to question 6 on page 9 of Tutorial 5

6. The reaction: $X + Y \rightleftharpoons Z$ has a $K_{eq} = 235$ at 100°C .

When the temperature is raised to 200°C , the value for $K_{eq} = 208$

Is this reaction endothermic or exothermic? exothermic

Explain your answer. **When the temperature is increased (heat is added), the value for K_{eq} decreases (from 235 down to 208). This can be explained by saying that the reaction is exothermic (the heat term is on the right)**



As heat is added, this equilibrium would shift to the left, [X] and [Y] would get larger and [Z] would get smaller.

Therefore the value of the K_{eq} would get smaller:

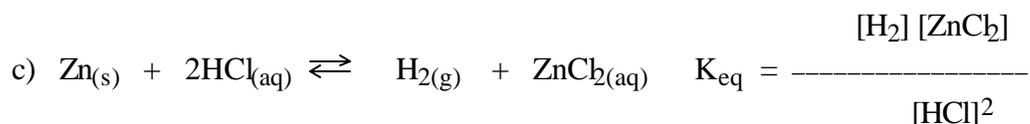
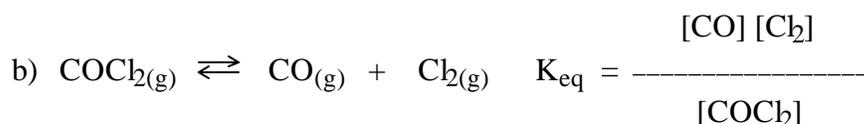
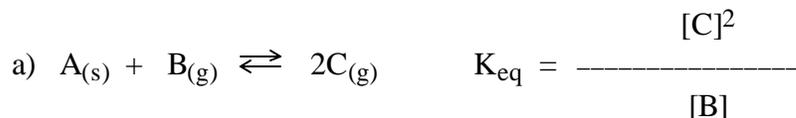
$$K_{eq} = \frac{[Z]}{[X][Y]}$$

the *numerator is smaller* and the
denominator is larger. This makes the
 value of K_{eq} *smaller*.

So this reaction is exothermic. This is consistent with the fact that the *value* for K_{eq} decreases when the *temperature is increased*.

Answers to Self-Test starting on page 12 of Tutorial 5*Self-Test on Tutorial 5*

1. Write the Equilibrium Constant Expression for each of the following reactions. (Be careful of the phases!)



2. A large value for K_{eq} means that a reaction has gone close to completion.
3. A small value for K_{eq} means that a reaction has **not** occurred to much of an extent.
4. A value of around 1.0 for K_{eq} means **there is roughly the same amount of products as reactants. (Depending on the coefficients - the exponents may complicate things)**

5. Given the equilibrium equation:



What will happen to the value of K_{eq} if the temperature is increased? decrease_____

Explain why **Since the reaction is exothermic (heat term is on the right), an increase in temperature will shift the equilibrium to the left. This will decrease the numerator and increase the denominator, thus the value of K_{eq} will decrease.**

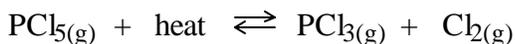
$$K_{\text{eq}} = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2} < 1.20$$

6. For the reaction: $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ $K_{\text{eq}} = 2.24$ at 227°C

$$K_{\text{eq}} = 33.3 \text{ at } 487^\circ\text{C}$$

Is this reaction endothermic or exothermic? endothermic_____

Explain your answer . **The value of K_{eq} increase when the temperature increases. This will only happen if the heat term is on the left (endothermic).**



When the temperature is increased, this equilibrium will shift to the right, increasing $[\text{PCl}_3]$ and $[\text{Cl}_2]$ while decreasing $[\text{PCl}_5]$. This would increase the value of K_{eq} .

$$K_{\text{eq}} = \frac{[\text{PCl}_3] [\text{Cl}_2]}{[\text{PCl}_5]}$$

7. If the temperature remains constant in an equilibrium:

a) Will changing the **concentration** of one of the substances change the value of K_{eq} ?

Answer no!_____

b) Will changing the **total pressure** of the system change the value of K_{eq} ?

Answer no!_____

c) Will changing the *total volume* of the system change the value of K_{eq} ?

Answer no!

d) Will adding a *catalyst* change the value of K_{eq} ?

Answer no!

8. The K_{eq} for the reaction: $2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$ is 85 at $25^{\circ}C$

Determine the value of K_{eq} for the reaction: $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ at $25^{\circ}C$

Since the second reaction is just the reverse of the first reaction, it's K_{eq} expression will just be the **inverse** of the K_{eq} expression for the first reaction.

$$K_{eq (1)} = \frac{[H_2][I_2]}{[HI]^2} = 85 \qquad K_{eq (2)} = \frac{[HI]^2}{[H_2][I_2]} = \frac{1}{85} = \underline{\underline{0.01176}}$$

Answer 0.012

This is the end of Tutorial 5. If you have any questions make sure you see your teacher!