Chemistry 12
Notes on Equations and Keq Values

These notes explain what happens to the value of Keq when:

- Equations are Reversed
- Equations are Doubled (All Coefficients Doubled)
- Equations are Halved (All Coefficients Halved)
- Two Equations are Added to Give a Third Equation

FOR THESE NOTES ASSUME ALL SPECIES ARE GASES AND THE TEMPERATURE IS HELD CONSTANT

1. Reversing Equations

Given an equation: A + B ⇆ C + D , the value of Keq is 5.0

Let's say you were asked to find the value of Keq for the equation:

C + D ⇆ A + B What would you predict? Keq = _____

Let's check your prediction:

Since the Keq for: A + B ⇆ C + D , is 5.0, that means that the ratio:

$$\frac{[C][D]}{[A][B]} = 5.0$$

The Keq expression for: C + D ⇆ A + B would be:

$\frac{[A][B]}{[C][D]}$ and this, as you can see is the **reciprocal** of $\frac{[C][D]}{[A][B]} = 5.0$

So $\frac{[A][B]}{[C][D]} = \frac{1}{5} = 0.20$

To summarize: When you reverse an equation, the new Keq is the reciprocal (inverse) of the original equation.

2. Doubling Equations

Given that the value of Keq for: A + B ⇆ C + D is 5.0,

Predict the value of Keq for: 2A + 2B ⇆ 2C + 2D ? _____

Let's check your prediction!

Since the value of Keq for: A + B ⇆ C + D is 5.0, that means that the ratio:

$$\frac{[C][D]}{[A][B]} = 5.0$$

The Keq expression for 2A + 2B ⇆ 2C + 2D would be:

$\frac{[C]^2[D]^2}{[A]^2[B]^2}$ which would be equal to $(5.0)^2 = 25$

To summarize: When you double an equation, the new Keq value is the square of the Keq for the original equation.

3. Halving Equations (Multiplying all coefficients by ½)

Given that the value of Keq for: A + B ⇆ C + D is 5.0,

Predict the value of Keq for: ½ A + ½ B ⇆ ½ C + ½ D ? _____

Let's check your prediction!

Since the value of Keq for: A + B ⇆ C + D is 5.0, that means that the ratio:

$$\frac{[C][D]}{[A][B]} = 5.0$$

The Keq expression for ½A + ½B ⇆ ½C + ½D would be:

$\frac{[C]^{1/2}[D]^{1/2}}{[A]^{1/2}[B]^{1/2}}$ which would be equal to $\sqrt{\frac{[C][D]}{[A][B]}} = \sqrt{5.0} = 2.2$ (to 2 sig.digs)

To summarize: When you halve an equation, the new Keq value is the square root of the Keq for the original equation.

4. Adding Equations

Given that the value of Keq for: A + B ⇆ C + D is 5.0,

And the value of Keq for: C + D ⇆ E + F is 3.0

Predict the value of the Keq for the equation: A + B ⇆ E + F ? _____

Lets check our prediction:

Notice that if you ADD the first two equations, you get the third one:

A + B ⇆ ~~C~~ + ~~D~~ (Equation 1)
+ ~~C~~ + ~~D~~ ⇆ E + F (Equation 2)
A + B ⇆ E + F (Equation 3)

Look at what happens when you MULTIPLY the Keq expressions for Equation 1 and Equation 2:

$K_1 \times K_2 = \frac{[C][D]}{[A][B]} x \frac{[E][F]}{[C][D]} = \frac{[E][F]}{[A][B]}$

You can see the the last expression: $\frac{[E][F]}{[A][B]}$ is the Keq expression for Equation 3

So the value of K_3 (or the Keq for Equation 3) would be

$K_1 \times K_2 = 5.0 \times 3.0 =$ **15**

To summarize: When you add 2 equations to get a third one, the Keq value for the third one is the product of the Keq's for the original equations.

Questions:

1. Given the equilibrium: $2\ NO_{2(g)} \leftrightarrows N_2O_{4(g)}$ Keq = 2.2

   Find the value of the Keq for $NO_{2(g)} \leftrightarrows \frac{1}{2}\ N_2O_{4(g)}$ at the same temperature.

   Answer _____

2. Given the equilibrium: $2\ NO_{2(g)} \leftrightarrows N_2O_{4(g)}$ Keq = 2.2

   Find the value of the Keq for $4NO_{2(g)} \leftrightarrows 2N_2O_{4(g)}$ at the same temperature.

   Answer _____

3. Given the equilibrium: $2\ NO_{2(g)} \leftrightarrows N_2O_{4(g)}$ Keq = 2.2

   Find the value of the Keq for $N_2O_{4(g)} \leftrightarrows 2NO_{2(g)}$ at the same temperature.

   Answer _____

4. Given the equilibrium: $2\ NO_{2(g)} \leftrightarrows N_2O_{4(g)}$ Keq = 2.2

   Find the value of the Keq for $6NO_{2(g)} \leftrightarrows 3N_2O_{4(g)}$ at the same temperature.

   Answer _____

5. Given the equilibrium: $2A + B \leftrightarrows A_2B$ Keq = 2.5×10^{-4}

   and the equilibrium: $F_2B + C \leftrightarrows B + F_2C$ Keq = 2.0×10^{2}

   Find the value of Keq for the equilibrium: $2A + F_2B + C \leftrightarrows A_2B + F_2C$

   Answer _____