EQUILIBRIUM LECTURE 2 Manipulating equilibrium constants

Schweitzer

Conversion between Kc and Kp

- What if you are given either a Kc and a Kp and you want to find the corresponding Kp or Kc.

Example

1A(g) + 1B(g) <=> 2C(g)

If Kc for this reaction = 10 then what is the Kp for this reaction?

How do you solve?

First, there is a short cut!!!!

1A(g) + 1B(g) <=> 2C(g)

1 + 1 = 2 2

Products – Reactants

2 – 2 = 0

If the coefficient of the products = the coefficient of the reactants then the Kc = Kp

Practice

1A(g) + 1B(s) <=> 2C(g) @ 25C

Note: The short cut only uses gases so the short cut will not work for this reaction.

If Kc = 10; What is Kp?

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

n = Products(moles of gaseous) – Reactants (moles of gaseous)

R = .0821 L atm/mol K

$K_p = 10(.0821 * 298)^{2-1}$

Kp = Calculate this!!!

Practice

- (ebbing14.14)
- For which of the following equilibria would Kc = Kp?
- a. $CO(g) + 3\ H_2(g) \leftrightarrow CH_4(g) + H_2O(g)$
- b. $CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g)$
- c. $CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$
- d. $CO(g) + 1/2O_2(g) \leftrightarrow CO_2(g)$
- e. $H_2(g) + O_2(g) \leftrightarrow 2H_2O(l)$

Practice

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Manipulation of Constants

$$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)} \quad K = 4.1E8$$

$$K = [NH_3]^2 / [H_2]^3 [N_2]$$

What would happen to the K if the reaction is reversed?

$$2NH_{3(g)} \leftrightarrow 3H_{2(g)} + N_{2(g)}$$

$$K = [H_2]^3 [N_2] / [NH_3]^2$$

$$K_{new} = 1/K_{original}$$

K is inverted

Manipulation of Constants

$$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)} \quad K = 4.1E8$$

$$K = [NH_3]^2 / [H_2]^3 [N_2]$$

- What would happen to K if the reaction is multiplied ?

$$2N_{2(g)} + 6H_{2(g)} \leftrightarrow 4NH_{3(g)}$$

$$K = [NH_3]^4 / [H_2]^6 [N_2]^2$$

$$K_{new} = 1.681E17$$

** Multiplying all the coeffiencents together will cause the

$$K_{new} = k_{(original)}{}^2$$

The k is always raised to the power of what ever the coefficients are multiplied or divided.

Manipulation of constants

$$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)} \quad K = 4.1E8$$

$$K = [NH_3]^2 / [H_2]^3 [N_2]$$

- What would happen to K if the reaction is multiplied ?

$$½\ N_{2(g)} + 1\ ½\ H_{2(g)} \leftrightarrow 1\ NH_{3(g)}$$

$$K_{new} = (K_{original})^{1/2}$$

Note: raising to the ½ power is the same as square rooting.

Practice

- (ebbing14.12)
- If K = 0.145 for A_2 + 2B == 2AB, then for AB == B + 1/2A_2, K would equal
- a. 0.145
- b. -0.145
- c. 0.381
- d. 2.63
- e. 6.90

Practice

(ebbing14.12)

- If K = 0.145 for A_2 + 2B == 2AB, then for AB == B + 1/2A_2, K would equal
- a. 0.145
- b. -0.145
- c. 0.381
- d. 2.63
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$K_{new} = (1/0.145)^{1/2}$

Elementary reactions

- Very often when you see a reaction it is actually a combination of several smaller individual reactions (elementary reactions)

Step 1: A + B => C

Step 2: C + A => D

Intermediate: Substance produced and consumed with in a reaction. These are removed from overall rxn.

Overall: A + B + C + A => C + D

2A + B => D

$$K_{12} = K_1 * K_2$$

Step 1: A + B => C K_1 .50

Step 2: C + A => D K_2 .20

Overall: 2A + B => D K_{12} .1

Problem

Given the equilibrium constants for the following reactions what is the new K_{12}

- $4Cu(s) + O_2g)$ «$2Cu_2O(s)$, K1
- $2CuO(s)$ « $Cu_2O(s) + 1/2O_2$, K2

- $2Cu(s) + O_2(g)$ « $2CuO(s)$ $K_{12} =$?
- a. K1 * K2
- b. $K1^{1/2}$ * K2
- c. $K1^{1/2}/K2$
- d. $K_2^{1/2}/K1$
- e. K1 * $K2^{1/2}$

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Given the equilibrium constants for the following reactions what is the new K_{12}

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- $2CuO(s) « Cu_2O(s) + 1/2O_2$, K2

- $2Cu(s) + O_2(g) « 2CuO(s)$ K_{12} = ?
- a. K1 * K2
- b. $K1^{1/2}$ * K2
- c. $K1^{1/2}/K2$
- d. $K_2^{1/2}/K1$
- e. K1 * $K2^{1/2}$

Answer

- $2Cu(s) + \frac{1}{2}O_2(g) « Cu_2O(s), K1$
  $4Cu(s) + O_2(g) « 2Cu_2O(s)\ K1\ K^{1/2}$
- $Cu_2O(s) + 1/2O_2(s) « 2CuO(s),\ K2$
  $2CuO(s) « Cu_2O(s) + 1/2O_2,\ 1/K2$
- $2Cu(s) + O_2(g) « 2CuO(s)\ \ K_{12} = \ ?$

$K1 * K2 = K12$

$K^{1/2} * 1/K$

You are going to have to rearrange the two elementary steps in order to add up to the overall reaction.

1st check to see if the reactants and products are on the right sides. Flip reaction to get correct!

2nd Multiply or divide so coefficients add up