

# EQUILIBRIUM LECTURE 2

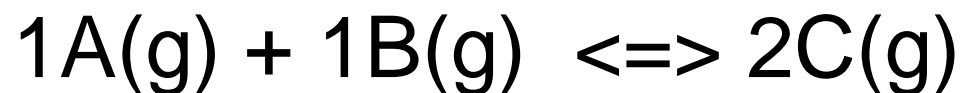
## Manipulating equilibrium constants

Schweitzer

# Conversion between $K_c$ and $K_p$

- What if you are given either a  $K_c$  and a  $K_p$  and you want to find the corresponding  $K_p$  or  $K_c$ .

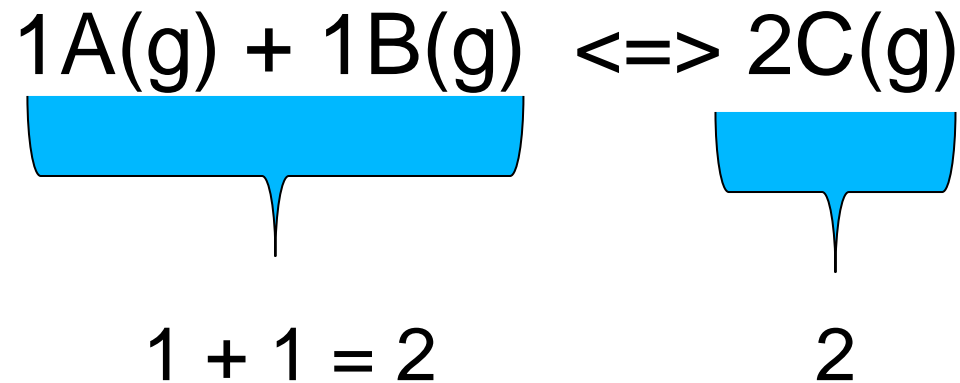
Example



If  $K_c$  for this reaction = 10 then what is the  $K_p$  for this reaction?

# How do you solve?

First, there is a short cut!!!!

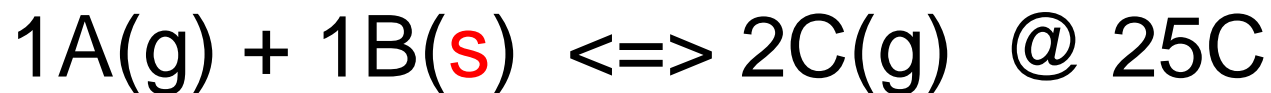


Products – Reactants

$$2 - 2 = 0$$

If the coefficient of the products = the coefficient of the reactants then the  $K_c = K_p$

# Practice



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

If  $K_c = 10$ ; What is  $K_p$ ?

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

$n = \text{Products (moles of gaseous)} - \text{Reactants (moles of gaseous)}$

$$R = .0821 \text{ L atm/mol K}$$

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

$K_p = \text{Calculate this!!!}$

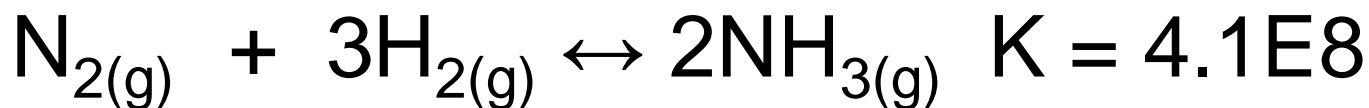
# Practice

- (ebbing14.14)
- For which of the following equilibria would  $K_c = K_p$ ?
- a.  $\text{CO(g)} + 3 \text{H}_2\text{(g)} \leftrightarrow \text{CH}_4\text{(g)} + \text{H}_2\text{O(g)}$
- b.  $\text{CO(g)} + \text{H}_2\text{O(g)} \leftrightarrow \text{CO}_2\text{(g)} + \text{H}_2\text{(g)}$
- c.  $\text{CO(g)} + 2\text{H}_2\text{(g)} \leftrightarrow \text{CH}_3\text{OH(g)}$
- d.  $\text{CO(g)} + \frac{1}{2}\text{O}_2\text{(g)} \leftrightarrow \text{CO}_2\text{(g)}$
- e.  $\text{H}_2\text{(g)} + \text{O}_2\text{(g)} \leftrightarrow 2\text{H}_2\text{O(l)}$

# Practice

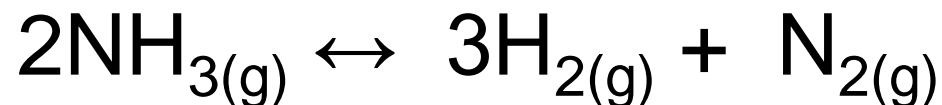
- (ebbing14.14)
- For which of the following equilibria would  $K_c = K_p$ ?
- a.  $\text{CO(g)} + 3 \text{H}_2\text{(g)} \leftrightarrow \text{CH}_4\text{(g)} + \text{H}_2\text{O(g)}$
- b.  $\text{CO(g)} + \text{H}_2\text{O(g)} \leftrightarrow \text{CO}_2\text{(g)} + \text{H}_2\text{(g)}$
- c.  $\text{CO(g)} + 2\text{H}_2\text{(g)} \leftrightarrow \text{CH}_3\text{OH(g)}$
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- e.  $\text{H}_2\text{(g)} + \text{O}_2\text{(g)} \leftrightarrow 2\text{H}_2\text{O(l)}$

# Manipulation of Constants



$$K = [\text{NH}_3]^2 / [\text{H}_2]^3 [\text{N}_2]$$

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



$$K = [\text{H}_2]^3 [\text{N}_2] / [\text{NH}_3]^2$$

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

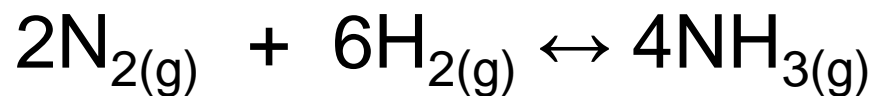
K is inverted

# Manipulation of Constants



$$K = [\text{NH}_3]^2 / [\text{H}_2]^3 [\text{N}_2]$$

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



$$K = [\text{NH}_3]^4 / [\text{H}_2]^6 [\text{N}_2]^2$$

$$K_{\text{new}} = 1.681\text{E}17$$

- \*\* Multiplying all the coefficients together will cause the

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

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

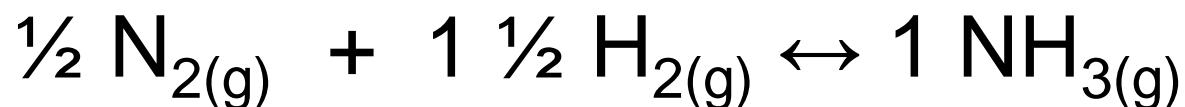


# Manipulation of constants



$$K = [\text{NH}_3]^2 / [\text{H}_2]^3 [\text{N}_2]$$

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



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

Note: raising to the  $\frac{1}{2}$  power is the same as square rooting.

# Practice

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

# Practice

(ebbing14.12)

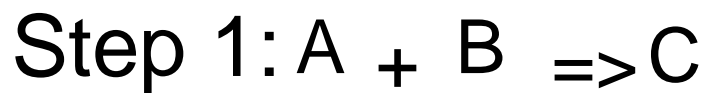
• If  $K = 0.145$  for  $A_2 + 2B \rightleftharpoons 2AB$ , then for  $AB \rightleftharpoons B + 1/2A_2$ ,  $K$  would equal

- a. 0.145
- b. -0.145
- c. 0.381
- d. **2.63**
- e. 6.90

$$K_{\text{new}} = (1/0.145)^{1/2}$$

# Elementary reactions

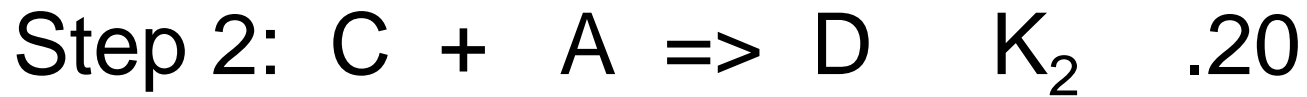
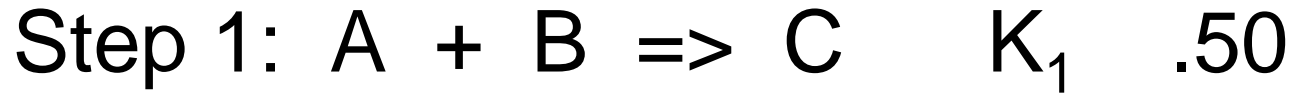
- Very often when you see a reaction it is actually a combination of several smaller individual reactions (elementary reactions)



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



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

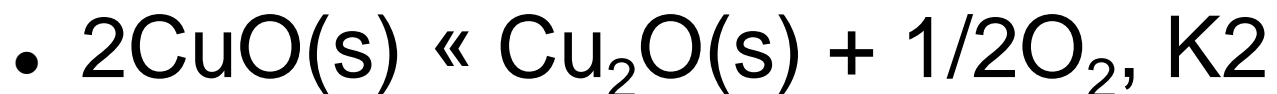
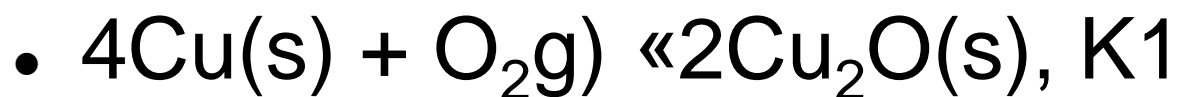


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# Problem

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



- a.  $K_1 * K_2$

- d.  $K_2^{1/2}/K_1$

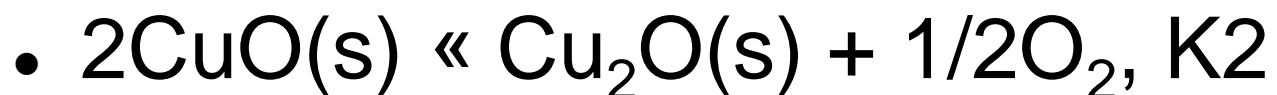
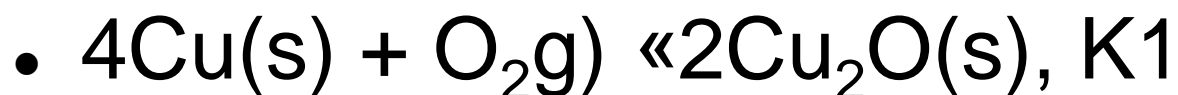
- b.  $K_1^{1/2} * K_2$

- e.  $K_1 * K_2^{1/2}$

- c.  $K_1^{1/2}/K_2$

# Problem

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



- a.  $K_1 * K_2$

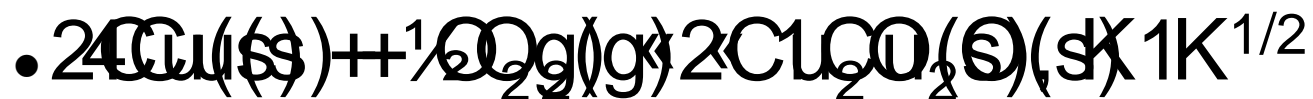
- d.  $K_2^{1/2}/K_1$

- b.  $K_1^{1/2} * K_2$

- e.  $K_1 * K_2^{1/2}$

- c.  $K_1^{1/2}/K_2$

# Answer



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

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



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

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

2<sup>nd</sup> Multiply or divide so coefficients add up