

Equilibrium Lecture #1

Schweitzer

What is equilibrium?

- Remember
 - Equilibrium process between to competing reactions.
 - At equilibrium the forward process is equal to the reverse process.
 - *** It appears that nothing is happening***

Practice Problem

(Ebbing14.10)

A state of dynamic equilibrium exists at constant temperature in

1. a stoppered flask half full of water
2. an open pan of boiling water.
3. a stoppered flask of a solution of sodium carbonate solution

a. 1 only

d. 1 and 2 only

b. 2 only

e. 1 and 3 only

c. 3 only

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Writing equilibrium Expressions

- $2A(s) + B(aq) \rightleftharpoons 2C(g) + D(aq)$
 - Notice: There are now substances on both sides of the reaction.
- K_c
 - This is a K for a general reaction
 - “c” stands for general concentrations.
- $K_c = [C]^2[D]/[B]$
 - Note: The solid does not show up in Equilibrium Expression.

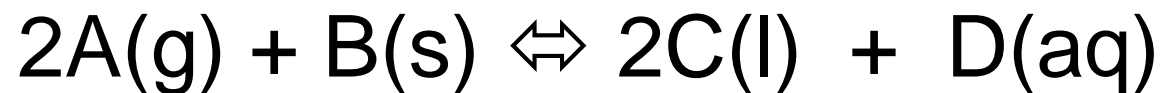
What is the difference between K_c and K_p

- K_c
 - Measures all units in Moles/Liter
 - Can not include pure solids and liquids
- K_p
 - Measures all units in Atmospheres
 - Only includes **gases**

Practice writing equilibrium expressions

- $2A(s) + B(aq) \rightleftharpoons 2C(g) + D(aq)$
- K_p
 - This is a K for a general reaction
 - “p” stands for Pressure (atmospheres).
- $K_p = [C]^2/1$
 - Note: Only include gases

Write an equilibrium expression



$$K_c = [D]/[A]^2$$

$$K_p = 1/[A]^2$$

Remember: all units are in ATM
and only gases are used

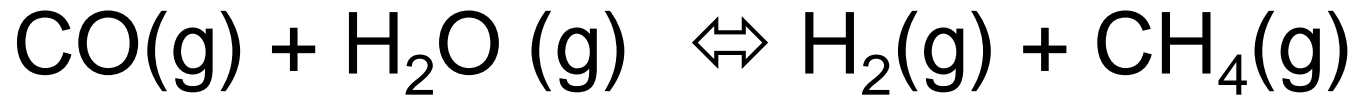
Problems involving Equilibrium

- What information can a problem give you?
 - They can give you the equilibrium constant.
 - They can give you initial conditions
 - They can give you equilibrium conditions

Note:

- Equilibrium conditions can be put directly into the equilibrium expression.
- THE FOLLOWING PROBLEMS ARE GOING TO BE DIFFERENT COMBINATIONS OF THIS INFORMATION. THERE ARE NOT THAT MANY DIFFERENT TYPES OF PROBLEMS KEEP TRACK...

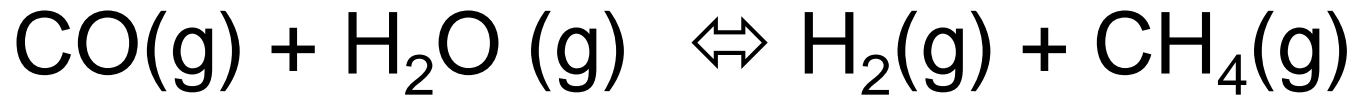
Solving for Concentration given: K and starting materials



Suppose you start with 1 mol of each CO and water in a 50.0L vessel. How many moles of each substance are in the equilibrium mixture at 1000C? $K_c = 0.58$

What are they giving you here in this problem?

Answer



1/50

I	.02	.02	0	0
C	-x	-x	x	x
E	(.02-x)	(.02-x)	x	x

$$K_c = \frac{[\text{H}_2][\text{CH}_4]}{[\text{H}_2\text{O}][\text{CO}]}$$

$$.58 = x^2 / (.02-x) (.02-x) \quad \text{Solve for X}$$

Notice the short cut can NOT be used in this problem

Look for alternate methods

$$.58 = x^2 / (.02-x) (.02-x) \text{ Solve for X}$$

$$.58 = x^2 / (.02-x)^2$$

Square root both sides

$$\pm .76 = x / 0.0200 - x$$

Solve for x (x must be positive) = 0.0086

Substitute into the equilibrium expression

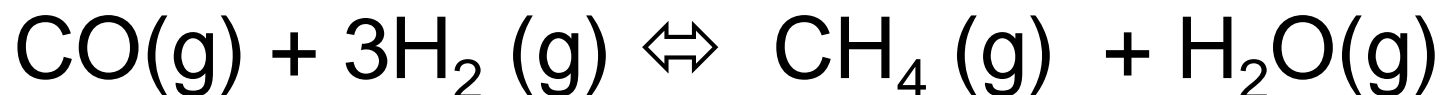


$$.57 \qquad .57 \qquad .43 \qquad .43$$

Practice problem

- Ebbing597

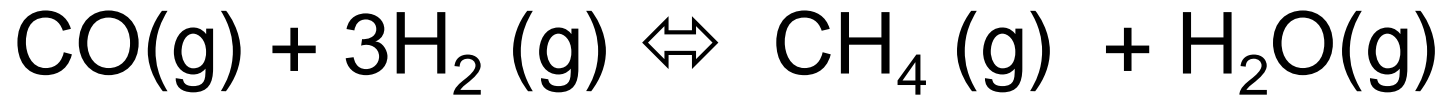
Carbon monoxide and hydrogen react according to the following equation



When 1 mol CO and 3 mol of H₂ are placed in a 10 L vessel at 927C and allowed to come to equilibrium, the mixture is found to contain 0.387 mol of H₂O.

What is the concentration of each substance at equilibrium and what is K_c for the reaction.

Answer



I.	.1M	.3M	0	0
C	-.0387	-.1161	.0387	.0387
E	.0613	.184	.0387	.0387

Note: This is simply a stoichiometry problem.

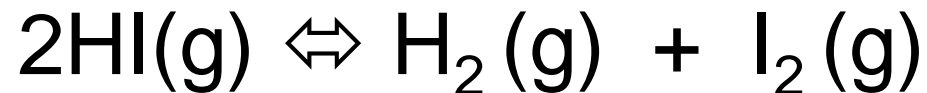
$$.1 - .0387 = .0613$$

$$.0387 * 3 = .1161$$

More Practice!!!

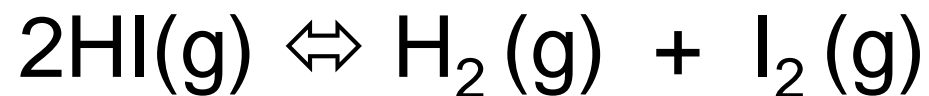
(Ebbing603)

Hydrogen Iodide decomposes at a moderate temperature according to the following reaction



When 4.00mol of HI was placed in a 5.00L vessel at 458C, the equilibrium mixture was found to contain 0.422 mol of I₂. What is the value of K_c for this reaction at the specified temperature?

Answer



I.	.8	0	0
C	-2x	+x	+x
E	.636	.0844	.0844

Plug these concentrations into K_c expression

$$K_c = .0201$$

What if they give you equilibrium concentrations?

- An **equilibrium** mixture of gases contains .30 mol CO, 0.10 mol of H₂, and 0.20 mol H₂O, plus an unknown amount of CH₄. The total volume of the system is 1 Liter. K_c for this reaction = 3.92



Answer



I

C

E .30 .10 .020 ?

Note: These are all equilibrium conditions.

These can be plugged directly in the Kc expression.

$$3.92 = [\text{CH}_4][.02]/[.30][.10]^3$$

$$\text{CH}_4 = 0.059\text{M}$$

Calculating percent change

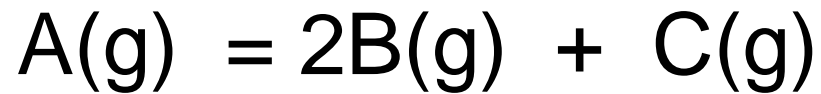
- Very often the percent change will be used to tell the extent of a reaction (amount it moves to product)
- Or they will want you to calculate % Change
- $\% \text{ change} = \text{Change}/\text{original} \times 100$

Using percent change

- Reaction $A(g) = 2B(g) + C(g)$ is ran at 100C and the initial concentration of A was .1M.
 $K_c(A) = 1.0 \text{ E-}8$
- What is the percent change of A in this reaction at equilibrium

Answer

- % change = Change/original x 100



I.	.1	0	0
C	-x	+2x	+x
E	.1-x	2x	x

$$1.0E-8 = [2x]^2 [x]/.1$$

$$1.0E-8 = 4x^3 /.1$$

Predicting the direction of a reaction using reaction quotient

- We used the reaction quotient when we predicted whether a reaction would precipitate or not.
- If $Q > K$ Then the mixture has too much product and will therefore shift toward reactant.
- If $Q < K$ Then the mixture has too much reactant and will therefore shift toward product.

Practice

(Ebbing610)

A 50.0L reaction vessel contains 1.0 mol N_2 , 3.00 mol H_2 , and .500 mol of NH_3 . Will more ammonia, NH_3 be formed or will it dissociate when the mixture goes to equilibrium?

The equilibrium constant(k) = 0.500

Answer

- $Q = [\text{NH}_3]^2 / [\text{N}_2][\text{H}_2]^3$
- $Q = (0.0100)^2 / (0.0200)(0.0600)^3$
- $Q = 23.1$

And

$$K = 0.500$$

So

$Q > K$ So we have too much product.

Reaction will shift back toward reactant