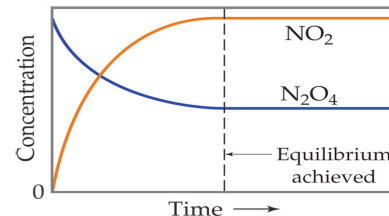


GASEOUS EQUILIBRIUM CH. 12

EQUILIBRIUM



I. EQUILIBRIUM IS REACHED WHEN

A. : BOTH REACTIONS ARE STILL OCCURRING BUT
EX. REACTION: $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$

B. WHEN THE REACTION STARTS, THE FOLLOWING HAPPEN SIMULTANEOUSLY:

- 1.
- 2.
- 3.
- 4.

C. AS EQUILIBRIUM IS REACHED,

D. ONCE EQUILIBRIUM IS REACHED

- 1.
2. FORWARD AND REVERSE REACTIONS ARE
3. ALL

E. EQUILIBRIUM IS SHOWN USING

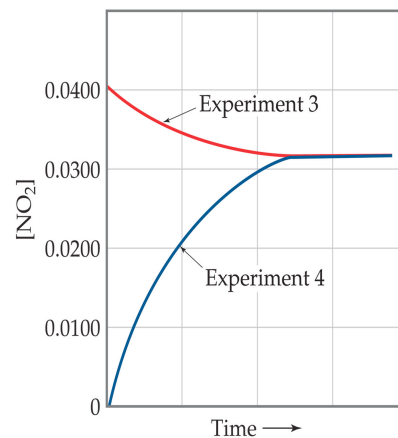
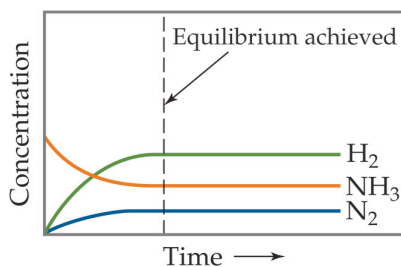
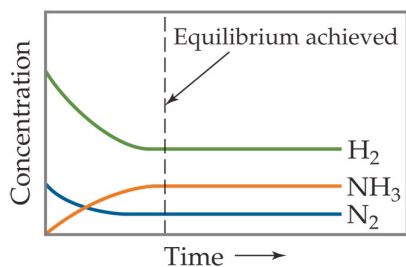
THIS SHOWS THAT

II. MORE ABOUT EQUILIBRIUM

A. EQUILIBRIUM CAN BE REACHED

1. IF YOU START WITH ALL PRODUCTS, ALL REACTANTS, OR A PROPORTION OF BOTH, THE RATIO OF PRODUCTS AND REACTANTS

Experiment	Initial N_2O_4 Concentration (M)	Initial NO_2 Concentration (M)	Equilibrium N_2O_4 Concentration (M)	Equilibrium NO_2 Concentration (M)	K_c
1	0.0	0.0200	0.00140	0.0172	0.211
2	0.0	0.0300	0.00280	0.0243	0.211
3	0.0	0.0400	0.00452	0.0310	0.213
4	0.0200	0.0	0.00452	0.0310	0.213



GASEOUS EQUILIBRIUM CH. 12

EQUILIBRIUM CONSTANT ()

I. FIRST, A BIT ABOUT RATE LAWS (EX. RXN: $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$):

A. RATE LAW OF FORWARD RXN:

B. RATE LAW OF REVERSE RXN:

C. AT EQUILIBRIUM,

THEREFORE

1.

2. AFTER REARRANGING, YOU GET:

3.

THEREFORE,

II. IN GENERAL, FOR THE RXN: $a\text{A} + b\text{B} \rightleftharpoons c\text{C} + d\text{D}$

A. THE

IS:

OR

B. EQUILIBRIUM EXPRESSION NOTES:

1.

2. YOU CAN USE

a. K_{eq} FOR

b. K_{eq} FOR

c. K_{eq} FOR

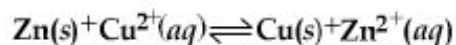
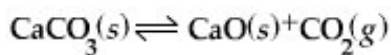
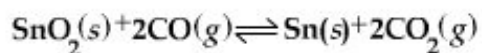
d. K_{eq} FOR

3. IN GENERAL, IT'S WRITTEN AS

4.

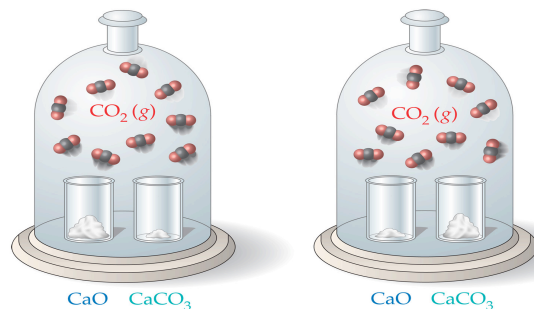
C. EXAMPLES:

1. WRITE THE EQUILIBRIUM EXPRESSIONS FOR THE FOLLOWING:



THE EXPRESSION
TO WRITE THE EXPRESSION

BUT



III. CALCULATING USING THE EXPRESSION

A. FOR EVERY REACTION,

B. FIND OUT WHAT YOU ARE LOOKING FOR AND WHAT'S GIVEN.

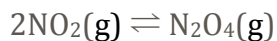
C. PLUG EVERYTHING IN TO FIND YOUR UNKNOWN.

D. BE CAREFUL WITH

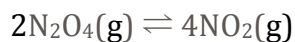
GASEOUS EQUILIBRIUM CH. 12

E. IMPORTANT NOTES:

1.

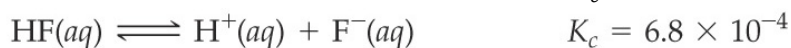


2.



3.

a. Given the following information, determine the value of K_c for the reaction



IV. RELATING K_c TO K_p

A. REMEMBER: CONCENTRATION IS

B. USE _____ TO RELATE THEM

C. IF TOTAL MOLES OF REACTANTS AND PRODUCTS (IN THE EQUATION) AND VOLUME DOES NOT CHANGE,

D. PLUGGING IN $PV = nRT$ INTO K_c AND K_p , YOU GET:

1.

V.

A. OBTAINED BY PLUGGING IN INITIAL CONC. OR PRESS. INTO THE EXPRESSION.

B. USED TO PREDICT THE DIRECTION OF THE REACTION.

1. IF $Q=K$,

2. IF $Q>K$, THE REACTION WILL _____

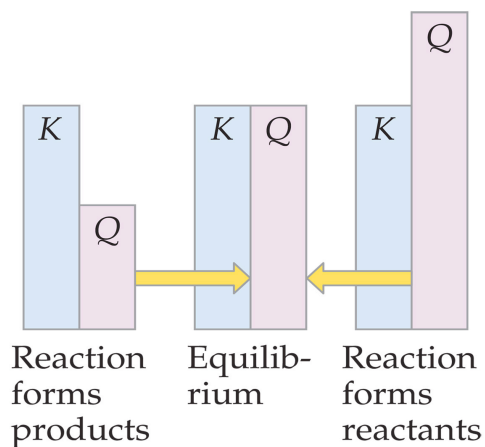
BECAUSE _____

THE _____ AND THE _____

3. IF $Q<K$, THE REACTION WILL _____

BECAUSE THE _____

AND THE _____



GASEOUS EQUILIBRIUM CH. 12

C. EXAMPLE: At 448°C the equilibrium constant K_c for the reaction $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2 \text{HI}(\text{g})$ is 50.5. Predict in which direction the reaction will proceed to reach equilibrium at 448°C if we start with 2.0×10^{-2} mol of HI, 1.0×10^{-2} mol of H_2 , and 3.0×10^{-2} mol of I_2 in a 2.00-L container.

D. Another one: At 1000 K the value of K_p for the rxn $2 \text{SO}_3(\text{g}) \rightleftharpoons 2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g})$ is 0.338. Calculate the value for Q_p , and predict the direction in which the rxn will proceed toward equilibrium if the initial partial pressures are $P_{\text{SO}_3} = 0.16 \text{ atm}$; $P_{\text{SO}_2} = 0.41 \text{ atm}$; $P_{\text{O}_2} = 2.5 \text{ atm}$.

VI. SIGNIFICANCE OF K_{eq}

- A. IF K_{eq} IS
- B. IF K_{eq} IS
- C. IF K_{eq} IS $\gg \gg 1$,

VII. FINDING EQUILIBRIUM CONCENTRATIONS:

- A. MANY TIMES, WHAT YOU'RE GIVEN ISN'T WHAT YOU USE UP
- B. INTRODUCING:

1. I = ; C = ; E =

2. USE THIS CHART TO FIND HOW MUCH REACTANT IS USED OR HOW MUCH PRODUCT IS FORMED.

3. THE CHANGE ROW MAINTAINS

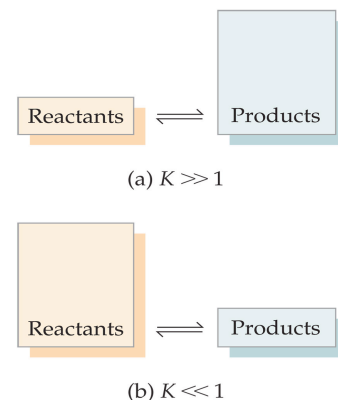
4. SOMETIMES, MAY BE NEEDED!

- a. ON YOUR GRAPHING CALC. MAY PROVE USEFUL!
- b. YOU WILL GET TWO ANSWERS BUT ONLY ONE WILL MAKE SENSE.

C. EXAMPLE:

1. A closed system initially containing $1.000 \times 10^{-3} \text{ M H}_2$ and $2.000 \times 10^{-3} \text{ M I}_2$ at 448°C is allowed to reach equilibrium. Analysis of the equilibrium mixture shows that the concentration of HI is $1.87 \times 10^{-3} \text{ M}$. Calculate K_c at 448°C for the reaction taking place, which is $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2 \text{HI}(\text{g})$

2. Sulfur trioxide decomposes at high temperature in a sealed container: $2 \text{SO}_3(\text{g}) \rightleftharpoons 2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g})$
Initially, the vessel is charged at 1000 K with $\text{SO}_3(\text{g})$ at a partial pressure of 0.500 atm. At equilibrium the SO_3 partial pressure is 0.200 atm. Calculate the value of K_p at 1000 K. (ans. 0.338)



GASEOUS EQUILIBRIUM CH. 12

3. USING INITIAL CONC.: A 1.000-L flask is filled with 1.000 mol of H_2 and 2.000 mol of I_2 at 448°C . The value of the equilibrium constant K_c for the reaction $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$ at 448°C is 50.5. What are the equilibrium concentrations of H_2 , I_2 , and HI in moles per liter?

LE CHÂTELIER'S PRINCIPLE

I. THIS STATES: IF A SYSTEM IS DISTURBED BY A CHANGE IN
, THE SYSTEM WILL

II. REMEMBER THE

A. DEPENDING ON WHAT IS DONE, THE SEE-SAW AND THE SYSTEM WILL
TO A CERTAIN DIRECTION TO

III. CHANGE IN CONC. EX: $2\text{NO}_{2(\text{g})} \leftrightarrow \text{N}_2\text{O}_{4(\text{g})}$ $\Delta H = -57.2 \text{ kJ}$:

Change to System	“Heavy” Side of See-Saw	Equil. Shift	By...
Add NO_2			
Add N_2O_4			
Remove NO_2			

A. BOTTOM LINE: EQUILIBRIUM SHIFTS

AND

IV. CHANGE IN TEMP.: EX: $2\text{NO}_{2(\text{g})} \leftrightarrow \text{N}_2\text{O}_{4(\text{g})}$ $\Delta H = -57.2 \text{ kJ}$:

Change to System	“Heavy” Side of See-Saw	Equil. Shift	By...
Decrease temp.			
Increase temp.			

A. REMEMBER

THIS IS BECAUSE

B. TREAT ENERGY AS A

TO DETERMINE EQUILIBRIUM SHIFT

