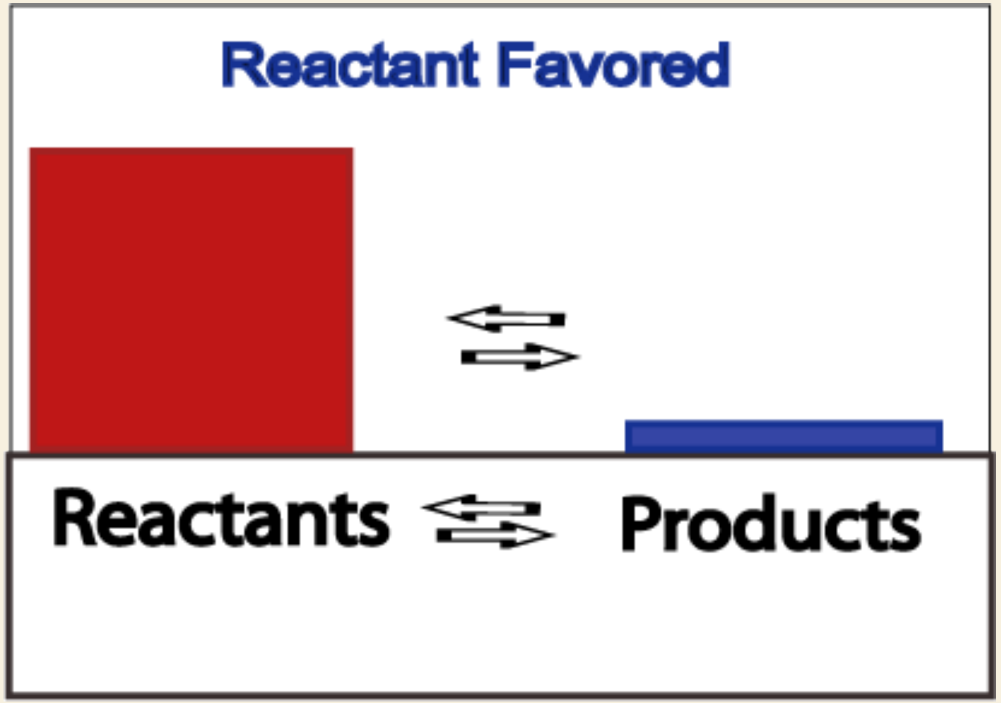
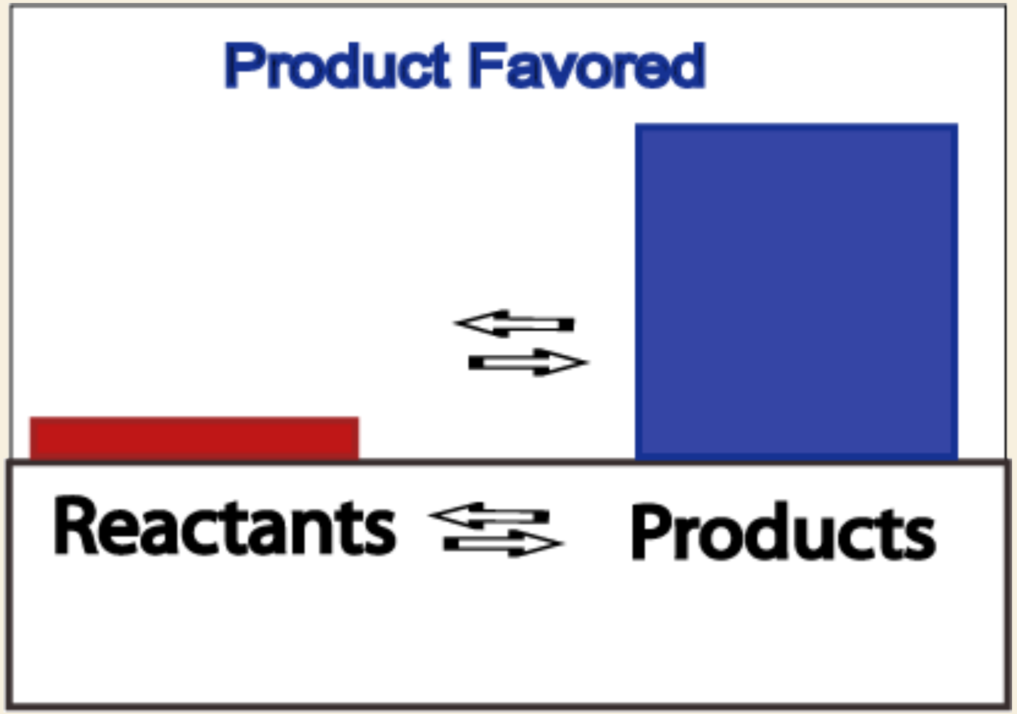
N44

Equilibrium Constant and Quotient

PRODUCT OR REACTANT FAVORED?

Once equilibrium is reached, you may have more products present, or you may have more reactants present.





PRODUCT FAVORED OR REACTANT FAVORED?

K_{eq} is a value (with no units) that allows us to determine if more products or reactants are being made. It is a ratio of products to reactants.

SIMPLIFIED VERSION FIRST: $K_{eq} = \frac{[Products]}{[Reactants]}$

- **K > 1 then more products!**
- **K < 1 then more reactants!**

CALCULATING K_{eq}

- The "Law of Mass Action" will allow us to calculate K_{eq} – **Ratio of Products over Reactants**

$$aA + bB \leftrightarrow cC + dD$$

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Still simplified, there is an additional part that we wont use that helps "fix" the units so Keq can have no units. Don't worry about it!

* **Remember** how solids and liquids don't factor into equilibrium? They don't have true concentrations so there is nowhere to plug them into this equation is there!

PRACTICE PROBLEM:

- Write the equilibrium expression for the reaction:

$2NO_{2(g)} \leftrightarrow 2NO_{(g)} + O_{2(g)}$

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$$K_{eq} = \frac{[NO]^2[O_2]^1}{[NO_2]^2}$$

ASSUME FORWARD REACTION…BUT WHAT IF ASKED FOR BACKWARDS RXN?

- Just flip it! Write K as K' for backwards reaction.

$2NO_{2(g)} \leftrightarrow 2NO_{(g)} + O_{2(g)}$

$$K'_{eq} = \frac{[NO_2]^2}{[NO]^2[O_2]^1}$$

$$K'_{eq} = \frac{1}{K_{eq}}$$

Don't even bother writing the equation flipped!
Just flip your Law of Mass Action!

WHAT IF I HAVE PRESSURES NOT [ ] ?

- Just use partial pressures the same way you use concentrations!

$$aA + bB \leftrightarrow cC + dD$$

$$K_{eq} = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b}$$

HOW CAN YOU TELL IF IT IS AT EQUILIBRIUM OR NOT?

- Calculate the values you have, and compare them to the K_{eq} value
  - Reaction Quotient is what it is called if it isn't at equilibrium

$$aA + bB \leftrightarrow cC + dD$$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

SO WHAT DOES Q TELL YOU?

- **K = Q then you are at equilibrium!**
- **K < Q you have too many products!**
  - – SHIFT LEFT until you make enough reactants to get back to equilibrium
- **K > Q you have too many reactants!**
  - – SHIFT RIGHT until you make enough product to get back to equilibrium

WHY DO WE CARE ABOUT K_{eq} ?

Knowing K_{eq} allows you to solve for:

- Which combos of [ ]s would reach an equilibrium position
- Whether or not your given [ ]s are at an equilibrium point by comparing to Q
  - If you can compare K and Q then you can predict which way it needs to shift to reach equilibrium

PRACTICE PROBLEM

Given the equation X(*g*) ↔ *Y*(*g*) + 2 *Z*(*g*). *At a particular temperature*, K = 1.4 x 10³. If you mixed 1.2 mol Y, 0.070 mol Z, and 0.003 mol X in a 1-L container, in which direction would the reaction initially proceed?

$$Q = \frac{[Y]^1[Z]^2}{[X]^1} \qquad Q = \frac{[1.2]^1[0.070]^2}{[0.003]^1} = 1.96$$

$$K\ 1.4\ x\ 103 > Q\ 1.96$$

Q is too small - Not enough products!

Shift to the RIGHT!

REMEMBER…

These things DON'T CHANGE K_{eq}

- Changing Concentrations
- Changing Pressures
- Adding Solids or Liquids
- Adding Catalysts

These things DO CHANGE K_{eq}

- Temperature

CAN IT CHANGE ANYTHING?

Factor	Rate of Reaction	Rate Constant k	Equilibrium Point	Equilibrium Constant Keq
Δ [ ]	✓	✗	✓	✗
Δ Pressure	✓	✗	✓	✗
Δ Surface Area	✓	✗	✗	✗
Δ Amount of s/l	✗	✗	✗	✗
Inert Gas	✗	✗	✗	✗
Catalyst	✓	✓	✗	✗
Temperature	✓	✓	✓	✓

YOUTUBE LINK TO PRESENTATION

- https://youtu.be/stWybrjoM3w

> Guest Lecturer of this presentation