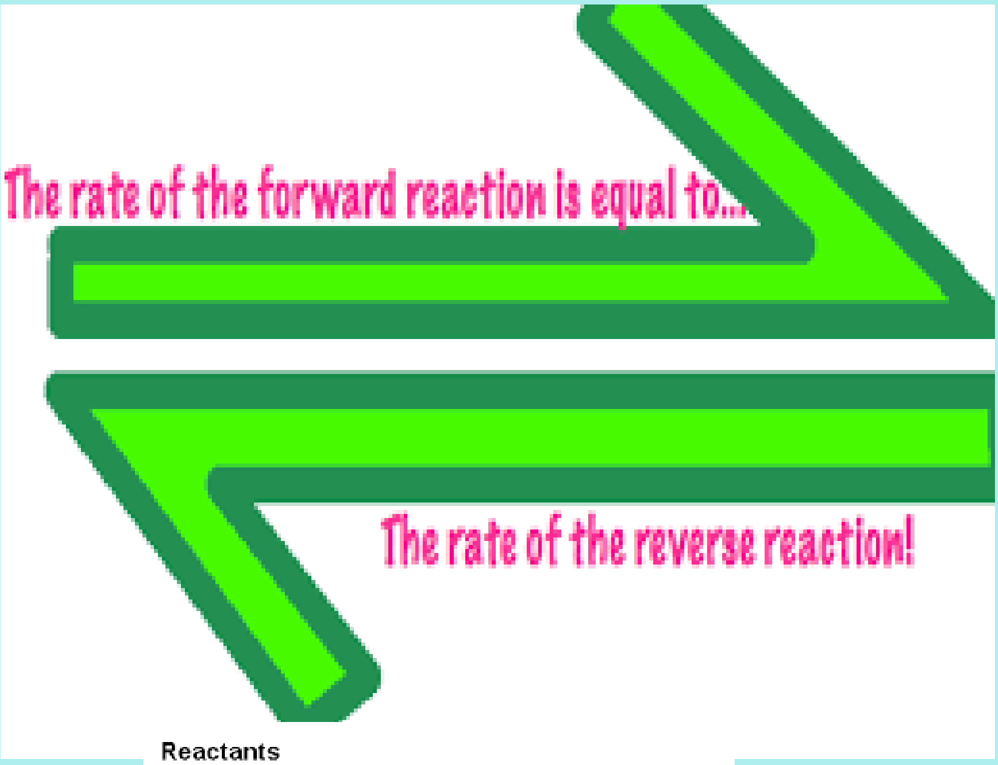
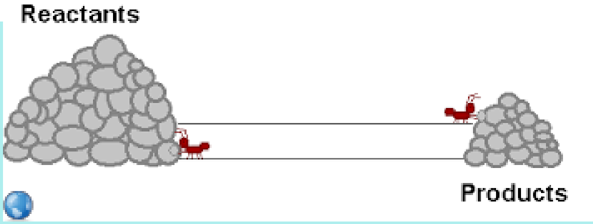
Chemical Equilibrium





Apr 30-3:07 PM

Objectives:

(#11-1) What is the difference between completion and equilibrium?

- I can represent a reaction going to equilibrium or to completion as a particulate model or graphically
- I can specifically model a solubility equilibrium system using particulate diagrams.

(#11-2) What is and why do we need a equilibrium constant?

- I can write an equilibrium constant expression Kc or Keq.
- I can write an equilibrium constant expression Kp (partial pressures)
- I can write an equilibrium constant expression for solubility Ksp.
- I can explain how the value of the equilibrium constant (K) relates to the extent of the reaction.
- I can calculate a new K value from an old K value if the reaction is altered (Altered means reversed or coefficients are a multiple of the original)

(#11-3)Can I fill out an ISE table?

- I can solve for an equilibrium concentration.
- I can solve for a k value given appropriate information.

(#11-4)How do I know how a reaction will proceed when approaching equilibrium?

- I can calculate a reaction quotient.
- I can relate reaction quotient to equilibrium constant to fudge how a reaction will proceed to get tot equilibrium
- I can determine if a stress (change) actually alters the equilibrium position.
- I can determine how the reaction will change if the reaction mixture was altered from equilibrium to get back to equilibrium (Le Chatelier's Principle.)

(#11-5) Modeling equilibrium

- I can model equilibrium using particulate drawings.

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What is the different between Completion and Equilibrium?

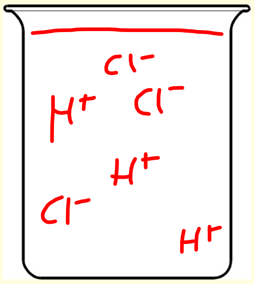
Completion

100 % product

$$K = \frac{\text{Products}}{\text{Reactants}} = \frac{100\%}{\text{very little}} = \text{very large}$$

examples:

Strong acids/Bases $HCl \rightarrow H^{+1} + Cl^{-1}$



Difficult to reverse

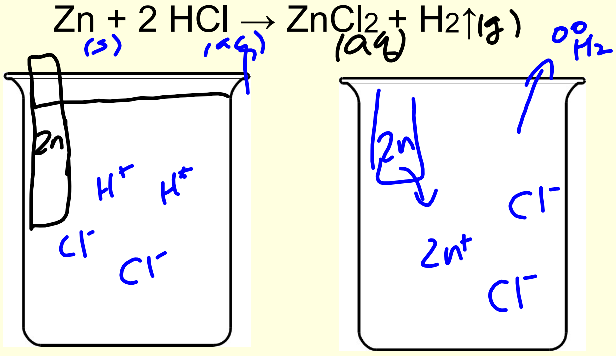
Combustion

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

Gas is given off

$$Zn + 2\,HCl \rightarrow ZnCl_2 + H_2\uparrow$$

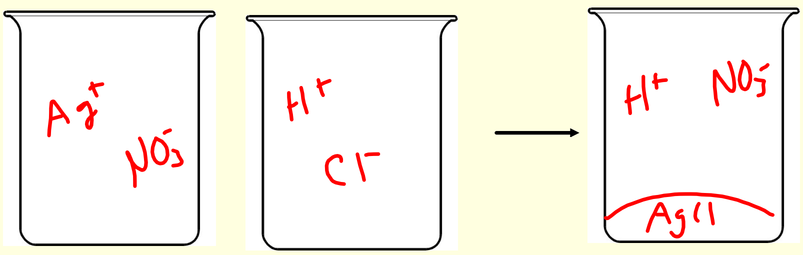
typical stoic



before end

Solid is formed

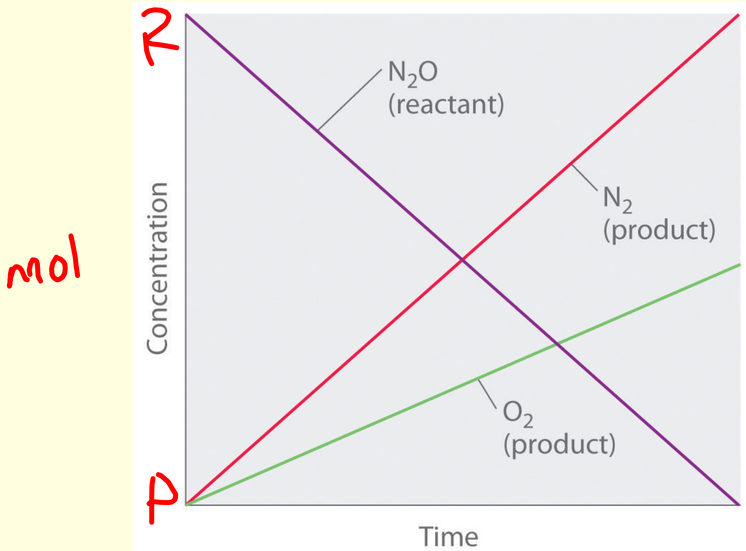
$$AgNO_3 + HCl \rightarrow AgCl\downarrow + HNO_3$$



Completion: all reactants used up

$$2N_2O \longrightarrow 2N_2 + O_2$$

graphing:



What is the different between Completion and Equilibrium?

Equilibrium

- reversible
- rate of forward reaction=rate of reverse reactions

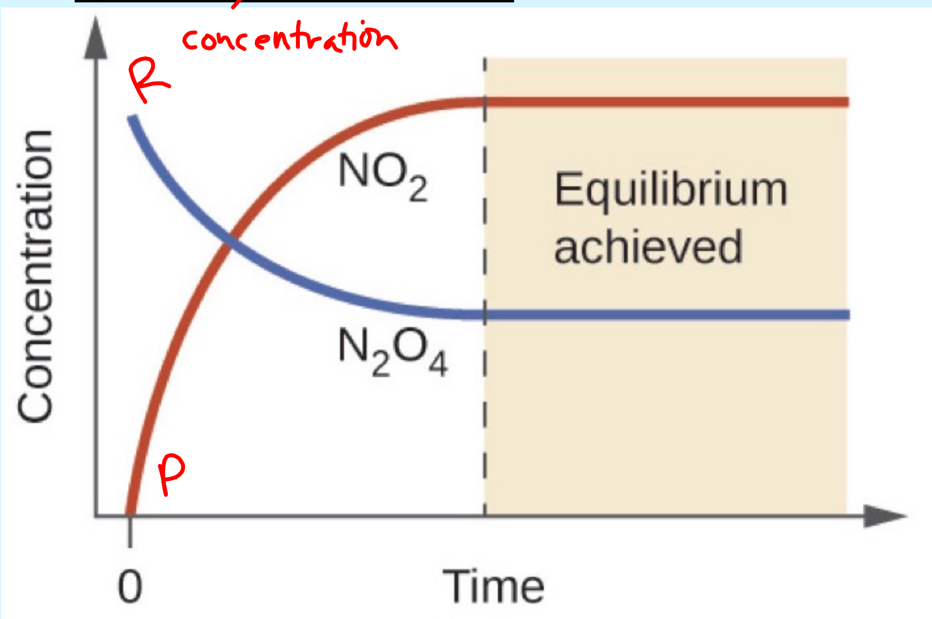
  [Products] and [Reactants] are constant

$$aA+bB \quad cC+dD$$

equilibrium expression:

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

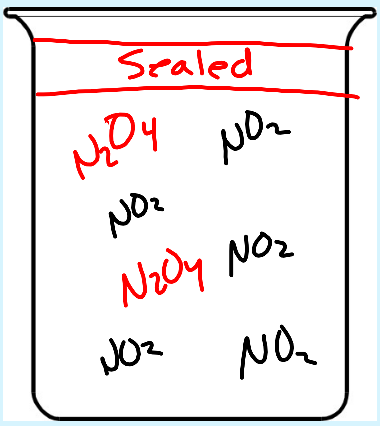
dependent on temperature



$$N_2O_4(g) \quad 2NO_2(g)$$

Equilibrium Expression

$$K = \frac{[NO_2]^2}{[N_2O_4]} = ~~0.066~~ \ 15$$



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The Equilibrium Constant, K

$$K = \frac{\text{products}}{\text{reactants}}$$

This is a **ratio** of concentrations, reported at 25⁰C

examples:

Equilibrium Constants can have a wide range of values

Small K $N_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2\,NO_{(g)}$ $K = 1 \times 10^{-30}$

$K = \frac{[NO]^2}{[N_2][O_2]}$

Essentially only reactants at eqbm. (10^{15} x products)

Large K $2\,CO_{(g)} + O_{2\,(g)} \rightleftharpoons 2\,CO_{2\,(g)}$ $K = 2.2 \times 10^{22}$

$K = \frac{[CO_2]^2}{[CO]^2[O_2]}$ ← Brackets conc.

Essentially only products at eqbm.

Intermediate K $2\,BrCl_{(g)} \rightleftharpoons Br_{2\,(g)} + Cl_{2\,(g)}$ $K = 5$

Comparable amounts of products and reactants at eqbm.

Equilibrium Expression:

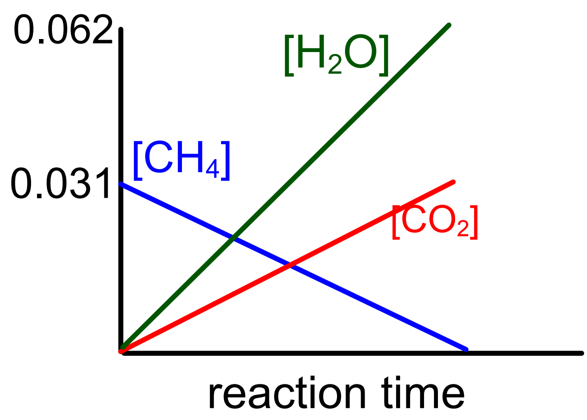
$$K = \frac{[Br_2]\,[Cl_2]}{[BrCl]^2}$$

p. 1

1.

	CH_4	+ $2\ O_2$	$\longrightarrow$ CO_2	+ $2\ H_2O$
I	0.031	excess		
S	-0.031	-0.062	+0.031	+0.062
E	0		0.031	0.062

$$\frac{0.5\text{ g } CH_4 \mid 1\text{ mol}}{\quad\mid 16\text{ g}} = 0.031\text{ mol}$$



completion

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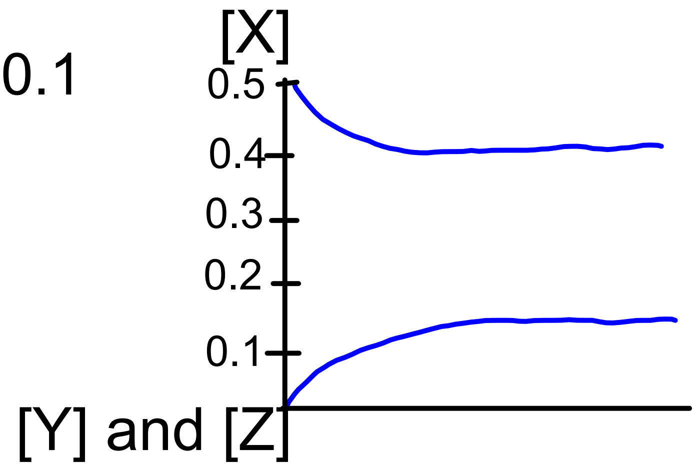
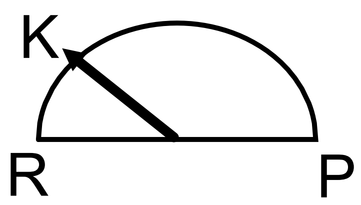
3. X ⇆ Y + Z

0.5 X 0.2=0.1

(20%)

	X	Y	Z
I	0.5		
S	-0.1	+0.1	+0.1
E	0.4	0.1	0.1

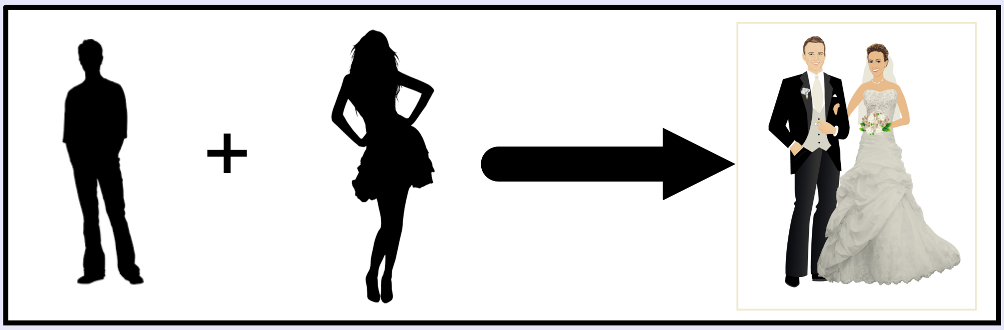




What is the different between Completion and Equilibrium?

What does Completion tell us?

Boy + Girl ⟶ Married Couple

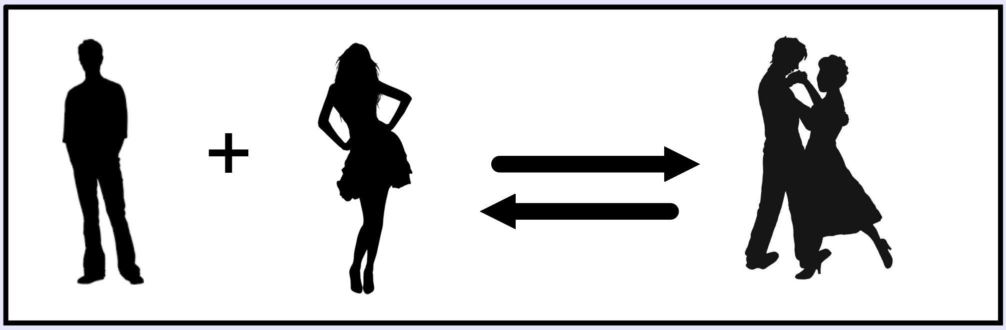


What does Equilibrium tell us?

Boy + Girl ⇌ Dancing Couple

Tells us:

1. 1 boy dances with just 1 girl
3. 1 Dancing couples consist of 1 boy and 1 girl
4. Dancing couple form and break up (double arrow)



Does not tell us:

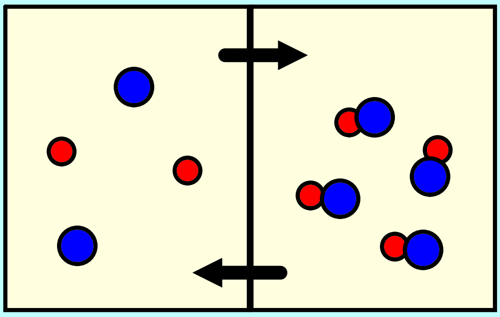
1. How many boys are at the dance compared to girls
2. The # of dancing couples compared to the # of single girls and boys

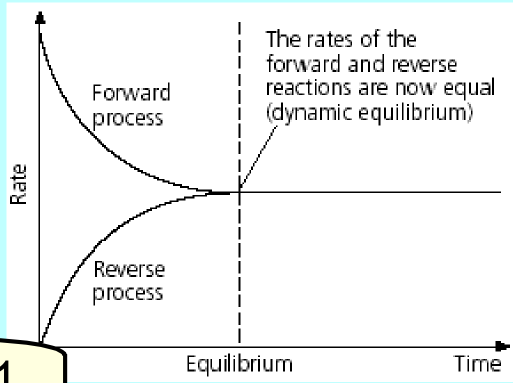
May 1-3:07 AM

Equilibruim

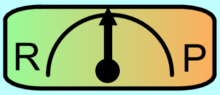
- forward reaction = reverse reaction
- the amounts of A and B at equilibrium can be the same (K = 1) or different (K<1 or K>1)

reaction: A + B → AB

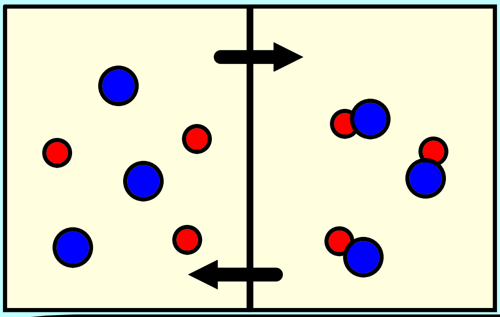


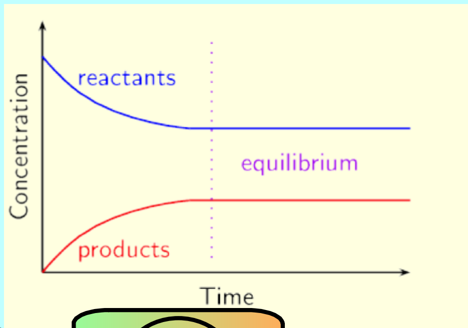


$$K = \frac{\text{products}}{\text{reactants}} = \frac{[AB]}{[A][B]} = \frac{4}{2x2} = 1$$

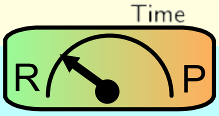


reactant favored

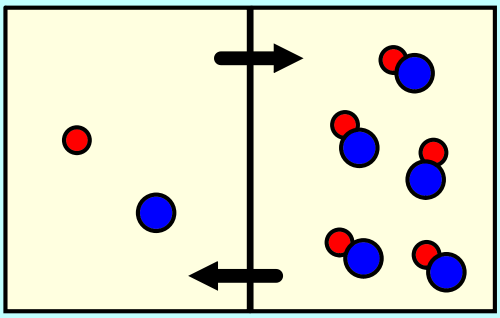


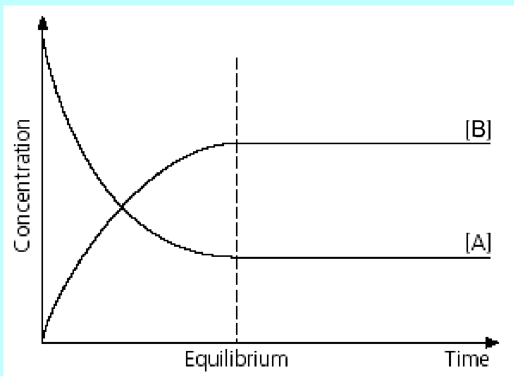


$$K = \frac{\text{products}}{\text{reactants}} = \frac{[AB]}{[A][B]} = \frac{3}{3x3} = 0.33$$

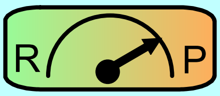


product favored





$$K = \frac{\text{products}}{\text{reactants}} = \frac{[AB]}{[A][B]} = \frac{5}{1x1} = 5$$



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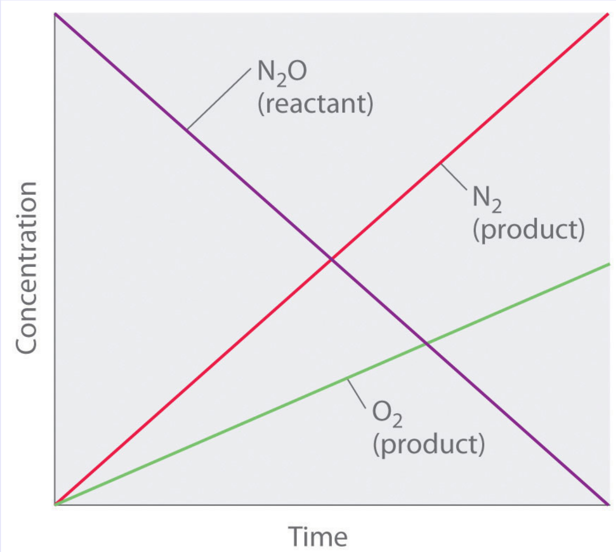
Compare Graphing:

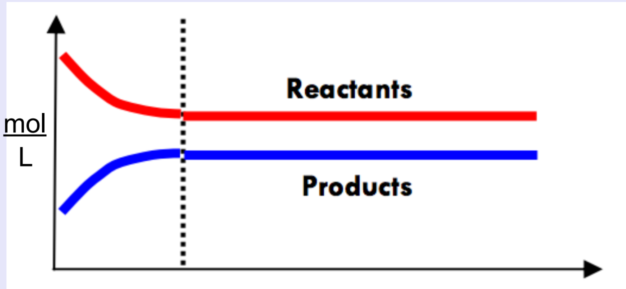
Completion: all reactants used up

$2N_2O \longrightarrow 2N_2 + O_2$



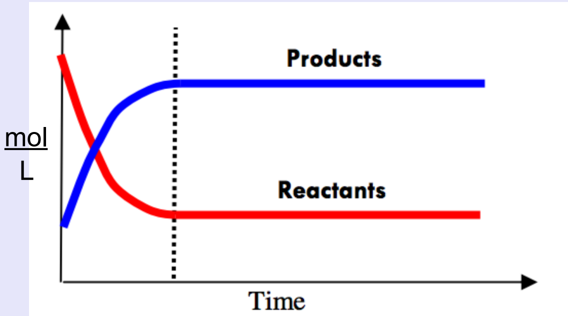
Equilibrium: reactants not used up

forward reaction rate = reverse reaction rate



Reactant favored

K < 1



Product favored

K > 1