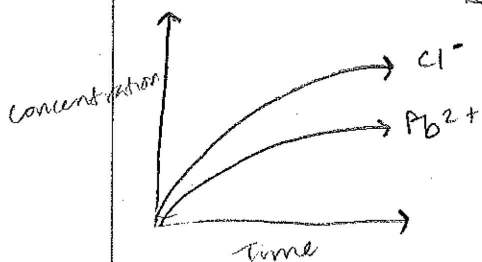
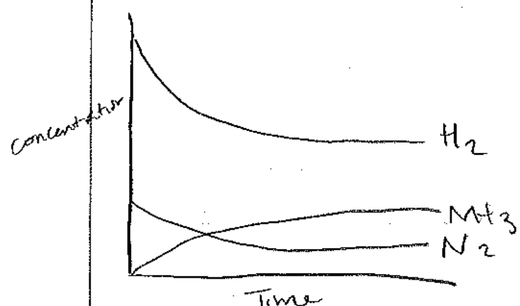
Unit 6 : Day 1



$PbCl_2(s) \longleftrightarrow Pb^{+2}(aq) + 2Cl^-(aq)$

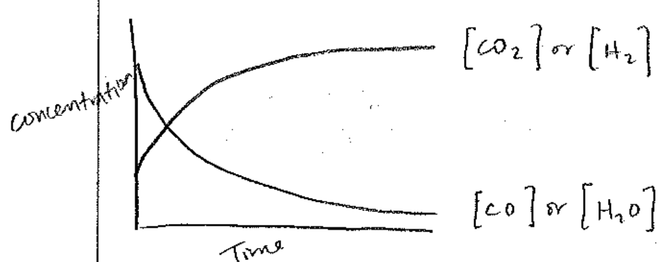
graph: solubility over time
- dissolving in a 1-2 ratio



Equation?

$N_2(g) + 3H_2(g) \longleftrightarrow 2NH_3(g)$

• dynamic equilibrium



Picture?

At equilibrium you have 1 mole of NH_3.
How many moles of H_2 at equilibrium?

$3H_2 + N_2 \longrightarrow 2NH_3$

(you start w/ 10 moles H_2 & 1 mole N_2)

C. 8.5 moles H_2

$$\frac{1\text{ mol } NH_3 \;\big|\; 3H_2 \text{ mol}}{\;\;\big|\; 2\text{ mol } NH_3} = 1.5 \text{ mol } H_2O$$

initial 10 mol
− used 1.5
8.5

Rice Diagram

R	$3H_2$ +	N_2	$\rightarrow 2NH_3$
I	10	1	$\emptyset$
C	$-3x$	$-x$	$+2x$
E	$10-3x$	$1-x$	$2x$
	$10-3(.5)$ $=8.5$	$1-.5=.5$	$2(.5)=1$

can we quantify the end?
- yes, using K

K

- ratio of the molecules stops changing, we discover the ratio is a constant, K.

Activity = a — unitless

$jA + kB \longleftrightarrow lC + mD$ $\qquad K = \dfrac{a_C^l \cdot a_D^m}{a_A^j \cdot a_B^k}$

What is activity?
- comes from notion about free energy (how free energy is changing for sol^n this is [ ]).

Solutions: $a = \dfrac{[\ ]}{1M}$ • express as Molar concentration

gases: $a = \dfrac{P_{gas}}{atm}$ or $\dfrac{P_{gas}}{1\,bar}$ ← partial pressure

solid or liquid: $a = 1$ • free energy does not change w/ solids or liquids

$PbCl_2(s) \longleftrightarrow Pb^{2+}(aq) + 2Cl^-(aq)$

$$K = \frac{a_{Pb^{2+}} \cdot a_{Cl^-}^2}{a_{PbCl_2}} = \frac{\frac{[Pb^{2+}]}{1M} \; \frac{[Cl^-]^2}{1M^2}}{1}$$

$$= [Pb^{2+}][Cl^-]^2 = K_{sp}$$

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equilibrium constant?

$3H_2(g) + N_2(g) \longleftrightarrow 2NH_3(g)$

c. $(P_{NH_3})^2 / (P_{N_2})(P_{H_2})^3$

partial pressure

Law of Mass Action

- at equilibrium, can be expressed in K
  (products raised to stoichiometric coefficients
  divide by reactants raised)
  - use concentration value

- flip equation - $K \rightarrow \frac{1}{K}$

K in terms of pressure?

gas phase use → K_p = partial pressures → $\frac{[NH_3]^2}{[N_2][H_2]^3}$

K_c = concentrations → $\frac{P_{NH_3}^2}{P_{N_2} P_{H_2}^3}$

Homogeneous - reactants & products all in same phase

Heterogeneous - different phases

- $CaCO_3\,(s) \leftrightarrow CaO\,(s) + CO_2\,(g)$

$a_{H_2O} = 1$

What does the value of K tell us?

K > 1
- more product than reactants
- product favored equilibrium

K < 1
- more reactants than products
- "favors" reactants

- Equilibrium does not depend on starting conditions
- Each Equilibrium has different concentrations, but same value for K_c

initial concentration

$[H_2] = .1\,M$ $[N_2] = .2\,m$ $[NH_3] = .2m$

$$K = ? \quad \frac{[NH_3]^2}{[H_2]^3[N_2]} = \frac{(0.2)^2}{(0.1)^3(0.2)} = 200$$

$$3H_2\,(g) + N_2\,(g) \longleftrightarrow 2NH_3\,(g)$$

Step 2: mass action expression

R	$3H_2$ +	N_2 $\leftrightarrow$	$2NH_3$
I	1.25	0.7	0.1
C	$\binom{-1.05}{-3x}$	$\binom{-.35}{-x}$	$+2x$
E	0.2	0.4	? = .8

$$K = \frac{[NH_3]^2}{[H_2]^3[N_2]}$$

$$200 = \frac{[NH_3]^2}{[0.2]^3[0.4]}$$

$[NH_3] =$

$0.1 + 2x = 0.8$

$x = 0.35$

$K = 200 \quad C_{H_2} = .2\ M \quad N_2 = 0.2\ M$

What are the concentrations at equilibrium

R	$3H_2$	$+ N_2 \longleftrightarrow$	$2NH_3$
I	.2	.2	$\emptyset$
C	$-3x$	$-x$	$+2x$
E	$0.2-3x$	$0.2-x$	$+2x$

$$K = \frac{[NH_3]^2}{[H_2]^3[N_2]} = 200 = \frac{(2x)^2}{(0.2-3x)^3(0.2-x)}$$

$\uparrow$

use WolframAlpha

$\boxed{x = 0.045}$

impossible, use more than you have $\rightarrow$ $x = 0.211$

~~x = imaginary~~

~~x = imaginary~~

(negative wouldn't be it)

K of water at room temp?

- reactant favored
- extremely small