Chem 103 Lecture 3b

Last time: pH calculations: 4 scenarios

Today: polyprotic acids

buffers

Polyprotic acids

*Poly*protic acids can donate more than 1 proton.

Examples: H_2CO_3 (carbonic acid); H_3PO_4 (phosphoric acid).

H_2CO_3 in water has following K_a equilibria:

$H_2CO_3 + H_2O <==> H_3O^+ + HCO_3^-$ $K_{a1} = 4.2x10^{-7}$

$NaHCO_3$ in water has following K_a equilibria :

$HCO_3^- + H_2O <==> H_3O^+ + CO_3^{2-}$ $K_{a2} = 4.8x10^{-11}$

There are 2 K_a's and deprotonation is *stepwise*

pH of pure polyprotic weak acid.

pH=? for 0.100 M H_2CO_3? (K_{a1}=4.2x10^{-7},K_{a2}=4.7x10^{-11})

Solution: there are 2 equilibria simultaneously occuring:

$H_2CO_3 \overset{Ka1}{<===>} HCO_3^- \overset{Ka2}{<===>} CO_3^{2-}$

In this problem, what is the major species?

H_2CO_3 , a weak acid!

Treat it as a *monoprotic weak acid* HA, using only K_{a1}

pH of pure weak polyprotic base

pH =? for 0.100M Na_2CO_3. (K_{a1}=4.2x10^{-7}, K_{a2}=4.7x10^{-11})

We have the same 2 equilibria as in the previous example:

$H_2CO_3 \underset{Kb2=Kw/Ka1}{\overset{Ka1}{<===>}} HCO_3^- \underset{Kb1=Kw/Ka2}{\overset{Ka2}{<===>}} CO_3^{2-}$

In this problem, what is the major species?

CO_3^{2-}, a weak base!

Treat it as a monoprotic weak base, using $K_{b1} = 10^{-14.00}/K_{a2}$

pH of pure intermediate form

pH =? for 0.100M $NaHCO_3$. (K_{a1}=4.2x10^{-7}, K_{a2}=4.7x10^{-11})

We have the same 2 equilibria as in the previous example:

$H_2CO_3 \overset{Ka1}{<===>} HCO_3^- \overset{Ka2}{<===>} CO_3^{2-}$

Express K_a's as pK_a's: pK_{a1}=-log(4.2x10^{-7})=6.38;pK_{a2}=10.33

What is the major species in this problem?

It's the intermediate species: HCO_3^-. (without proof)

pH = (1/2)(pK_{a1} + pK_{a2}) = (1/2)(6.38+10.33)= 8.36

Lewis Acids

Lewis acids = electron pair acceptors

Lews bases = electron pair donors

Consider ammonia, NH_3 and a boron trichloride, BCl_3

Do the Lewis structures of both of them.

NH_3 has a lone pair; BCl_3 has an empty orbital

NH_3 can "donate" it's lone pair to BCl_3 to form a coordinate covalent bond or "dative" bond:

$NH_3 + BCl_3$ ---> NH_3-BCl_3

Which is the base? Which is the acid?