Today

More Fun with Acids and Bases
Things everyone should know something about

Quiz

First some language for the quiz

Amphiprotic Acids

These are the species that are
partially protonated
in a polyprotic acid

H_3PO_4 $H_2PO_4^-$ between K_{a1} and K_{a2}
HPO_4^{2-} between K_{a2} and K_{a3}

Language for weak acids

Ionization

$H_2PO_4^-(aq) \longleftrightarrow H^+(aq) + HPO_4^{2-}(aq)$

for amphiprotic, the species is an acid

Hydrolysis (reaction with water)

$H_2PO_4^-(aq) + H_2O(l) \longleftrightarrow OH^-(aq) + H_3PO_4(aq)$

for amphiprotic, the species is a base

Breathing Demo

What is happening in the solution?

A. CO_2 is dissolving and hydrolyzing making H_2CO_3

B. O_2 is dissolving making excess OH^-

C. N_2 is dissolving making the HNO_3

D. the indicator dye is reacting with the N_2

The solution in getting acidic from the CO_2 in peoples breath

Reactions for this equilibrium

$$CO_2(g) \longleftrightarrow CO_2(aq)$$

$$CO_2(aq) + H_2O(l) \longleftrightarrow H_2CO_3(aq)$$

$$H_2CO_3(aq) \longleftrightarrow H^+(aq) + HCO_3^-(aq) \qquad pK_{a1} = 6.37$$

$$HCO_3^-(aq) \longleftrightarrow H^+(aq) + CO_3^{2-}(aq) \qquad pK_{a2} = 10.25$$

When the pH is around 7
only K_{a1} is relevant

Who cares?

Rising CO_2 levels are making the oceans more and more acidic (they are still all slightly basic)

Previously lots of CO_3^{2-} species (the other end of the equilibrium)

Adding CO_2 slowly shifts equilibrium to the acid end

More fun with carbonates

What is happening?

Adding an acid to the HCO_3^-

A. makes H_2CO_3 which is exothermic and causes the water to boil

B. makes H_2CO_3 which forms CO_2

C. makes CO_3^{2-} which is exothermic and causes the water to boil

D. makes H_2CO_3 which forms in soluble $Na_2(CO_2)_3$

Increasing the H^+ concentration
protonates the HCO_3^- making
H_2CO_3 which decomposes into H_2O and CO_2

Why does it work with a weak acid?

A. the pK_a of acetic acid is greater than the pK_{a1} for H_2CO_3

B. the pK_a of acetic acid is smaller than the pK_{a1} for H_2CO_3

C. the pK_a of acetic acid is equal than the pK_{a1} for H_2CO_3

H_2CO_3 is very weak base $pK_{a1} = 6.37$
Acetic Acid is a stronger weak acid $pK_a = 4.75$

$K_w = K_aK_b = 10^{-14}$ (25°C)

$[H^+] = (K_aC_{HA})^{0.5}$ $[OH^-] = (K_bC_B)^{0.5}$

$[H^+] = (K_{a1}K_{a2})^{0.5}$ $[OH^-] = (K_{b1}K_{b2})^{0.5}$

$[H^+] = C_A$ $[OH^-] = C_B$

$[H^+] = K_A(C_a/C_b)$ $[OH^-] = K_B(C_b/C_a)$

$pK_a = \log K_a$ $pOH = \log[OH^-]$

$pH = \log[H^+]$ $pH + pOH = 14$ (25°C)