Conjugate acids and bases

Different definitions of acids and bases

- Arrhenius definition
- acids generate H_3O^+ in water
- bases generate OH^- in water
- Brønsted Lowry definition
- Acids are proton donors
- Bases are proton acceptors
- which is an acid/base?
- $HF + H_2O \rightleftharpoons H_3O^+ + F^-$
- $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$
- By Arrhenius, HF is an acid, is a CH_3NH_2 base.

Follow the proton

- $HF + H_2O \rightleftharpoons H_3O^+ + F^-$

H^+ H^+

- $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$

H^+ H^+

- What about the reverse reaction?

Conjugate acids and bases

- When you run the reverse reaction you find the products are also acids and bases. The acids and bases that are formed are called ***conjugate acids or bases***
- H_2O + HF ⇆ H_3O^+ + F^-
  - base acid conjugate acid conjugate base
- CH_3NH_2 + H_2O ⇆ $CH_3NH_3^+$ + OH^-
  - base acid CA CB

Label Acid, Base, Conjugate Acid, Conjugate Base

- $HClO_3 + H_2O \rightleftharpoons ClO_3^- + H_3O^+$
-
- $ClO^- + H_2O \rightleftharpoons HClO + OH^-$
- $HSO_4^- + H_2O \rightleftharpoons SO_4^{2-} + H_3O^+$
- $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
-

Label Acid, Base, Conjugate Acid, Conjugate Base

- $HClO_3 + H_2O \rightleftharpoons ClO_3^- + H_3O^+$
- A B CB CA
- $ClO^- + H_2O \rightleftharpoons HClO + OH^-$
- B A CA CB
- $HSO_4^- + H_2O \rightleftharpoons SO_4^{2-} + H_3O^+$
- A B CB CA
- $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
- B A CA CB

Conjugate acids and bases …

- Conjugate acids and bases determine if an acid or base is strong or weak.
- If the conjugate acid/base readily reacts to run the reverse reaction it is a weak acid/base.
- If it does not react in the reverse reaction the acid or base is strong.

More with conjugate acids/bases

- $H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$
- Sulfuric acid is a strong acid so its conjugate base, HSO_4^-, will not run the reverse reaction.
- HSO_4^- is actually an acid in water.
- $HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$
- SO_4^{2-} will run the reverse reaction, so it is a *weak* acid

Strong acids and bases

- The strong acids and bases have no reverse reaction.
- They are not an equilibrium reaction.
- $HCl + H_2O \rightarrow H_3O^+ + Cl^-$
- No amount of stress will force this reaction the other way.
- (no way to make it less acidic, without a different reaction)

Strong acids

Acid	formula	Acid	Formula
Hydrochloric acid	HCl	Sulfuric Acid	H_2SO_4
Hydrobromic acid	HBr	Nitric Acid	HNO_3
Hydriodic acid	HI	Perchloric Acid	$HClO_4$

Strong bases

- All of group 1 and group 2 elements make strong bases.
- However, most of them are not very soluble.
- For example, $Mg(OH)_2$ is a saturated solution at 1.6×10^{-4} M

Commonly used Strong Bases

these make a lightning bolt on the periodic table!

Name	Formula	Name	Formula
Sodium Hydroxide	$NaOH$	Calcium Hydroxide	$Ca(OH)_2$
Potassium Hydroxide	KOH	Strontium Hydroxide	$Sr(OH)_2$
		Barium Hydroxide	$Ba(OH)_2$

Weak acids and bases

- can be forced the other way
- So ammonia…
- $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
- Ammonia is a gas with a distinct odor
- Ammonium and hydroxide are both odorless.
- If base is added to the solution you will smell ammonia, if hydroxide is removed you won't smell anything.

Pet "Stain" Problem

Urine has ammonia in it.

Most cleansers are basic.

After cleaning, we still leaves small amounts behind.

If it is small amount of ammonia and a basic cleanser the equilibrium will be shifted to the ammonia side so some thing with a great sense of smell (dog) could pick it up.

A slightly acidic cleanser shifts the equilibrium to the ammonium side to solve this problem

Other weak acids and bases

- Weak Acids
  - Acetic Acid (vinegar)
  - Citric Acid
  - Ascorbic Acid (vitamin C)
  - Boric Acid
  - Carbonic Acid
- Weak Bases
  - Sodium Bicarbonate
  - Ammonia
  - Sodium Hypochlorite (bleach)

Indicators

- Indicators are a substance that change color in the presence of (whatever they check for)
- They work because of Le Châtelier's principle. All you need an equilibrium reaction with different colored products and reactants.
- The pen used to check for counterfeit money is a <u>starch</u> indicator

How an acid base indicator works

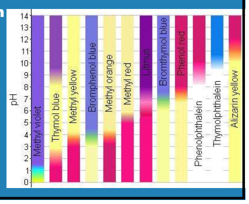
- A generic indicator will follow this reaction, **HID** is the reactant indicator, and ID^- is its product
- $[HID] + H_2O \rightleftharpoons H_3O^+ + [ID]^-$
- The color differences are important, **HID** is one color and ID^- is a different color!
- in an acidic solution (high H_3O^+), it shifts left so you see reactant
- $[HID] + H_2O \rightleftharpoons H_3O^+ + [ID]^-$
- in a basic solution (low H_3O^+), it shifts right so you see product
- $H[ID] + H_2O \rightleftharpoons H_3O^+ + [ID]^-$

Acid Base indicators

- Acid base indicators change color at certain pH levels
- They don't have to change at 7 (most don't)
- <u>Universal indicator solution</u> (phenolphthalein, bromthymol blue and methyl red dissolved in ethanol and water) changes color at each integral pH value

Other pH indicators

- Litmus and phenolphthalein are indicators
- Red cabbage juice has a pigment that changes colors at different pH values



Buffers

- Buffers are solutions that don't change in pH when acids or bases are added.
- They use weak acids/bases and Le Châtelier's principle.
- You will have a large amount of weak acid and conjugate base
- WA = weak acid
- $HWA + H_2O \rightleftharpoons H_3O^+ + WA^-$

pH

- pH depends on the concentration of hydronium
- $pH = -\log [H_3O^+]$
- Concentration of hydronium is the ratio of solute to solvent or in this case H_3O^+ / H_2O

What it does

- $HWA + H_2O \rightleftharpoons H_3O^+ + WA^-$
- adding H_3O^+ forces the equation to SHIFT the left
- The new hydronium reacts with the excess of conjugate base.
- Which makes more water and removes some H_3O^+, so the $[H_3O^+]$ remains constant

What it does

- $HWA + H_2O \rightleftharpoons H_3O^+ + WA^-$
- removing H_3O^+ or adding OH^- forces the equation to SHIFT to the right
- The new hydroxide will react with the excess weak acid.
- Which make more H_3O^+, and removes some water
- so the $[H_3O^+]$ remains constant
- There is a breaking point where the pH will begin to change.

What does this have to do with my life?

- Your blood is a buffered solution
- The pH must remain between 7.35-7.45
- Outside of that range can kill you
- below this range is called acidosis
- above is called alkalosis