

Chem Ch. 14 Notes: ACIDS, BASES, & pH

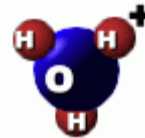
NOTE: Vocabulary terms are in **boldface and underlined**. Supporting details are in *italics*.

14.1 Notes

I. Macroscopic Properties and Examples of Acids and Bases

A. **Acids** produce hydrogen ions (H^+) when dissolved in water
*... more accurately, they produce **hydronium ions = H_3O^+***

- 1) properties: tart, sour, form electrolytic solutions of ions
- 2) examples: citric acid, vinegar, hydrochloric acid, sulfuric acid
- 3) *usually have H in front of the formula* or COOH at the end: HCl, CH₃COOH
- 4) turns litmus paper red
- 5) pH less than 7

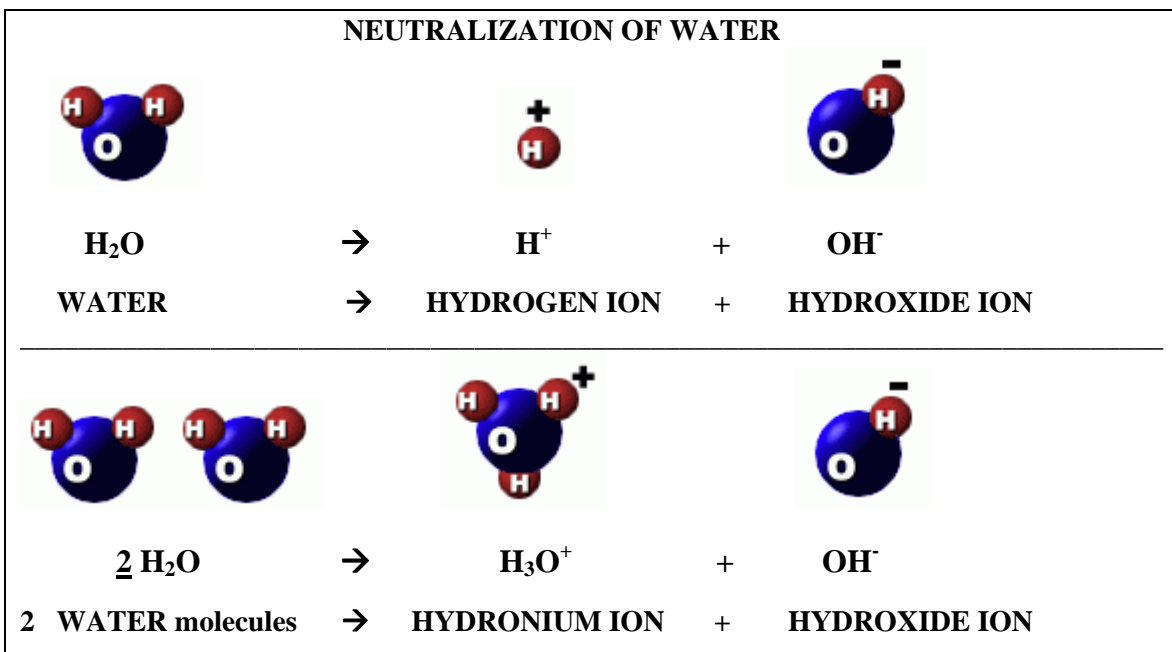


B. **Bases** produce hydroxide ions (OH^-) when dissolved in water

- 1) properties: bitter, slippery, form electrolytic solutions of ions
- 2) examples: lye/soap, ammonia, sodium hydroxide, other metal hydroxides
- 3) *usually have OH at the end of the formula:* KOH, NaOH, Ca(OH)₂
 - ammonia (NH₃) is a base, even though for formula doesn't look like one
- 4) turns litmus paper blue
- 5) pH greater than 7

II. Submicroscopic Properties of Acids and Bases

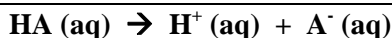
A. self-ionization of water:



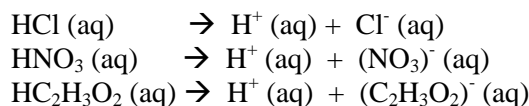
Images from www.worsleyschool.net/science/files/pH/page.html

B. **acidic hydrogen** atoms—hydrogen atoms that will be given up by acids as hydrogen ions

- 1) general format for acid dissociation

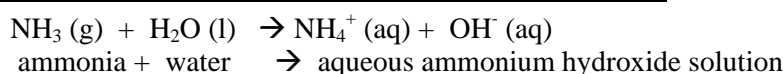


- 2) **monoprotic acids** donate 1 H^+ to the solution (HCl, HNO₃)



- 3) **diprotic acids** donate 2 H⁺ to the solution (H₂S, H₂SO₄)
- $$\begin{aligned} \text{H}_2\text{S (aq)} &\rightarrow \underline{2} \text{H}^+ \text{ (aq)} + \text{S}^{2-} \text{ (aq)} \\ \text{H}_2\text{SO}_4 \text{ (aq)} &\rightarrow \underline{2} \text{H}^+ \text{ (aq)} + \text{(SO}_4\text{)}^{2-} \text{ (aq)} \end{aligned}$$
- 4) **triprotic acids** donate 3 H⁺ to the solution (H₃BO₃, H₃PO₄)
- $$\begin{aligned} \text{H}_3\text{BO}_3 \text{ (aq)} &\rightarrow \underline{3} \text{H}^+ \text{ (aq)} + \text{(BO}_3\text{)}^- \text{ (aq)} \\ \text{H}_3\text{PO}_4 \text{ (aq)} &\rightarrow \underline{3} \text{H}^+ \text{ (aq)} + \text{(PO}_4\text{)}^{3-} \text{ (aq)} \end{aligned}$$
- 5) **polyprotic acids** donate more than 1 H⁺ to the solution (di- or tri-protic)

C. Bases that accept hydrogen ions:



D. Anhydrides

- 1) **acidic anhydrides**—nonmetal oxides which react with water to form acids
- $$\begin{aligned} \text{CO}_2 + \text{H}_2\text{O} &\rightarrow \text{H}_2\text{CO}_3 \\ \text{SO}_3 + \text{H}_2\text{O} &\rightarrow \text{H}_2\text{SO}_4 \end{aligned}$$
- 2) **basic anhydrides**—metal oxides which react with water to form bases
- $$\begin{aligned} \text{Na}_2\text{O} + \text{H}_2\text{O} &\rightarrow \underline{2} \text{NaOH} \\ \text{ZnO} + \text{H}_2\text{O} &\rightarrow \text{Zn(OH)}_2 \end{aligned}$$

14.2 Notes

III. Strengths of Acids and Bases

A. acid strength (see diagram on the next page)

- 1) **strong acids** *completely dissociate into ions*
no molecules left intact
- 2) **weak acids** *partially dissociate (not all come apart) into ions*

B. base strength

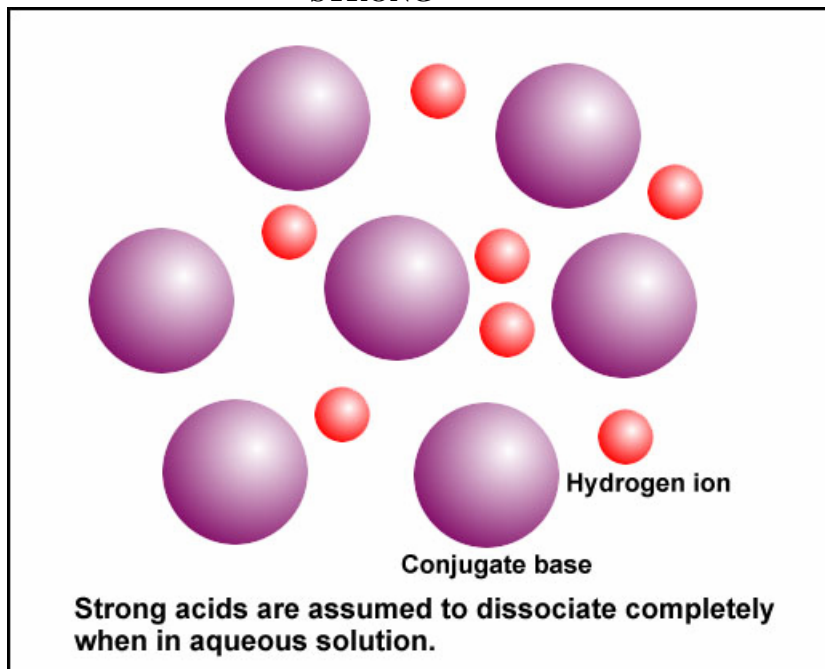
- 1) **strong bases** *completely dissociate (come apart) into ions*
- 2) **weak bases** *partially dissociate (not all come apart) into ions*

C. strength vs. concentration

- 1) weak and strong refer to dissociation only
- 2) concentrated vs. dilute
 - a) amount of particles in the solution
 - b) **molarity**—(M); *a measure of solution concentration in mol/L*
- 3) application

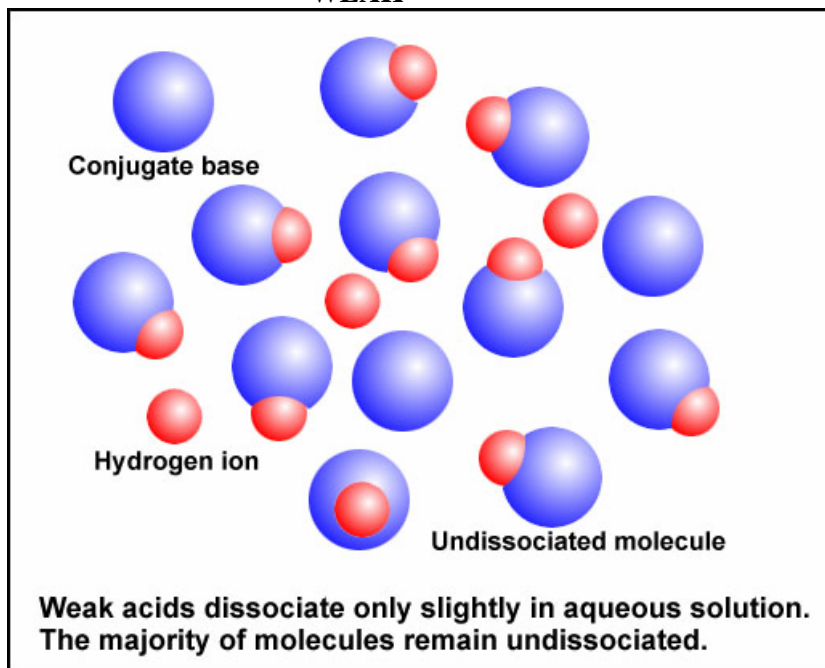
SAMPLE 1: a 0.10 M solution of H ₂ SO ₄	SAMPLE 2: a 1.00 M solution of HF
Which is more concentrated?	(HF, because the molarity is higher)
Which is the stronger acid?	(H ₂ SO ₄ , because it is listed as a strong acid and HF isn't)

“STRONG”



www.chem.ubc.ca/.../pH/section1/content.html

“WEAK”



www.chem.ubc.ca/.../pH/section1/content.html

IV. pH (the power of Hydrogen)

A. neutrality of water

- 1) Water is mostly neutral $[H^+] = [OH^-]$
 $[H^+] = 10^{-7} M$ and $[OH^-] = 10^{-7} M$

- 2) Ion product constant for water = K_w

$$K_w = [H^+][OH^-] = 10^{-14} M$$

- 3) Acidic solutions: $[H^+] > [OH^-]$
- 4) Basic (alkaline) solutions: $[OH^-] > [H^+]$

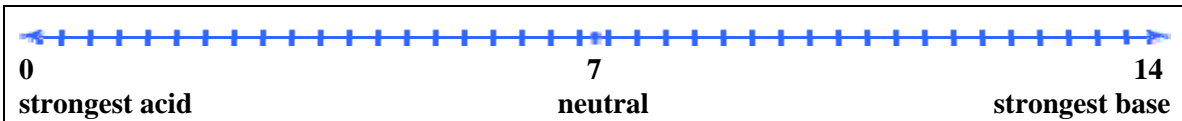
B. **pH** = the negative logarithm of the hydrogen ion concentration

$$pH = -\log [H^+]$$

C. pH is a measure of the acidity or basic quality (alkalinity) of a substance

D. pH values

acid $pH < 7$ **neutral** $pH = 7$ base $pH > 7$



E. other important equations

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

$$pH + pOH = 14$$

ENVIRONMENTAL EFFECTS OF pH

http://www.msichicago.org/ed/learninglabs/imgs/waters_ph_chart.jpg

Environmental Effects	pH Value	Examples
ACIDIC	pH = 0	Battery acid
	pH = 1	Sulfuric acid
	pH = 2	Lemon juice, Vinegar
	pH = 3	Orange juice, Soda
All fish die (4.2)	pH = 4	Acid rain (4.2-4.4) Acidic lake (4.5)
	pH = 5	Bananas (5.0-5.3) Clean rain (5.6)
Frog eggs, tadpoles, crayfish, and mayflies die (5.5)	pH = 6	Healthy lake (6.5) Milk (6.5-6.8)
	pH = 7	Pure water
NEUTRAL	pH = 8	Sea water, Eggs
	pH = 9	Baking soda
BASIC	pH = 10	Milk of Magnesia
	pH = 11	Ammonia
	pH = 12	Soapy water
	pH = 13	Bleach
	pH = 14	Liquid drain cleaner

F. examples

E1) If $[H^+]$ of a solution = 1.0×10^{-11} M...

- a) Find pH. b) Find pOH. c) Find $[OH^-]$. d) Acid, base, or neutral?

a) $[H^+] = 1.0 \times 10^{-11}$ M so $\boxed{pH = 11}$

b) $pH + pOH = 14$ $11 + pOH = 14$ $\boxed{pOH = 3}$

c) $[H^+] [OH^-] = 10^{-14}$ M $[10^{-11}] [OH^-] = 10^{-14}$ M $\boxed{[OH^-] = 10^{-3}$ M

d) base (pH = 11)

E2) If $[OH^-]$ of a solution = 1.0×10^{-9} M...

- a) Find pOH. b) Find pH. c) Find $[H^+]$. d) Acid, base, or neutral?

a) $[OH^-] = 1.0 \times 10^{-9}$ M so $\boxed{pOH = 9}$

b) $pH + pOH = 14$ $pH + 9 = 14$ $\boxed{pH = 5}$

c) $[H^+] [OH^-] = 10^{-14}$ M $[H^+] [10^{-9}] = 10^{-14}$ M $\boxed{[H^+] = 10^{-5}$ M

d) acid (pH = 5)