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Unit 9. Acid-Base Chemistry

Most fundamental thing to remember about this chapter: Acids and Bases are opposites.

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Acids

- Ways you have dealt with/heard about acid before
  - health “acid indigestion”
  - gardening “pine trees like acid soil”
  - transportation “battery acid”
  - environment “acid rain”

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Properties of Acids

Sour taste
No distinctive feel (until it eats through skin)
React with metals to yield $H_2(g)$
React with base (both are neutralized)
Blue litmus turns to pink

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Properties of Bases

Bitter taste
Slippery to the touch
React with acid (both are neutralized)
Pink litmus turns to blue

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Definitions of Acids

Arrhenius acid- substance that *ionizes* or *dissociates* in water to yield hydrogen ions (protons)
Bronsted-Lowry acid- a proton donor
Lewis acid- electron pair acceptor

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Definitions of Bases

Arrhenius base- substance that ionizes in water to yield hydroxide ions
Bronsted-Lowry base- a hydrogen ion acceptor
Lewis base- electron pair donor

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Acidic and Basic Oxides

metal oxides are basic oxides - react with water to produce bases (e.g. MgO)

$$MgO + H_2O \longrightarrow Mg(OH)_2$$

nonmetal oxides are acidic oxides - acids form in water (e.g. CO_2)

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

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Conjugate Acid/Conjugate Base

Acid + Base $\longrightarrow$ Conjugate Acid + Conjugate Base

Conjugate Acid- the acid that is formed when a base accepts a proton.

Conjugate Base- the base that is formed when an acid donates a proton.

If acid is strong, conjugate base is weak

If base is strong, conjugate acid is weak

conjugate acid-base pairs differ only by one H^+

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All Neutralization Reactions are Similar

$$HCl + NaOH \longrightarrow H_2O + NaCl$$

$$HNO_3 + NaOH \longrightarrow H_2O + NaNO_3$$

$$HCl + KOH \longrightarrow H_2O + KCl$$

$$2\ HCl + Ca(OH)_2 \longrightarrow 2\ H_2O + CaCl_2$$

Acid + Base $\longrightarrow$ water + a *salt*

Salt- ionic compound formed from cation of base and anion of acid

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Acids and Bases *Dissociate* in Solution

Dissociate- break apart into ions when dissolved in water.

Total Ionic Equation

$$H^+ + Cl^- + Na^+ + OH^- \longrightarrow H_2O + Na^+ + Cl^-$$

Spectator ions- ions that are the same on both sides of the equation.

Net Reaction

$$H^+ + OH^- \longrightarrow H_2O$$

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Examples

- React 1 mol HF with 1 mol LiOH
  - what is the balanced reaction?
  - what is the total ionic reaction?
  - name the spectator ions.
  - what is the net reaction?
- React sulfuric acid with potassium hydroxide
  - what is the balanced reaction?
  - what is the total ionic reaction?
  - name the spectator ions.
  - what is the net ionic equation?

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Strong Acids/Weak Acids

How strong an acid is depends on how much it dissociates.

Strong acid- HCl, H_2SO_4, HNO_3

$$HCl + H_2O \longrightarrow Cl^- + H_3O^+$$

K_{eq}= infinity (big)

Weak acid- acetic acid CH_3COOH

$$CH_3COOH + H_2O \longrightarrow CH_3COO^- + H_3O^+$$

$K_{eq} = 1.82 \times 10^{-5}$ (small)

The Keq is a constant which you would be given

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Example

- React HNO_3 with NaOH
  - what is the balanced reaction?
  - identify the acid, base and conjugate acid and base.
  - what is the total ionic reaction?
  - name the spectator ions.
  - what is the net reaction?
  - are the acid, base, conjugate acid and base strong or weak?

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Molarity

mole

6.02×10^{23} molecules

molar mass in grams

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

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Sample Test Questions

- What is the molarity of a solution composed of 1.0 mol HCl in 0.5 L water?
- What is the molarity of a solution composed of 1.0 mol HCl in 750 mL water?
- What is the molarity of a solution composed of 0.357 mol HCl in 750 mL water?
- What is the molarity of a solution composed of 100 g HCl in 250 mL water?

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Normality

In water, $HCl \rightarrow H^+ + Cl^-$

But in water, $H_2SO_4 \rightarrow 2\ H^+ + SO_4^{2-}$

Refer to H_2SO_4 as having 2 *equivalents* H^+

$$\text{Normality} = \frac{\text{equivalents of solute}}{\text{liters of solution}}$$

$N=MX$

monoprotic acids, 1M=1N

diprotic acids, 1M=2N

triprotic acids, 1M=3N

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Sample Test Questions

- If you have 3.2 M HCl, what is the normality?
- If you have 3.2 M H_2SO_4, what is the normality?
- If you have 3.2 M H_3PO_4, what is the normality?

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Sample Test Questions

- How many moles of citric acid ($H_3C_6H_5O_7$) would you use to make 1.0 L of 3.25 M citric acid?
- How many grams of citric acid would you use to make 1.0 L of 3.25 M citric acid
- How many grams of citric acid would you use to make 0.75 L of 4.2 M citric acid?

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Molarity and Dilution

$(V_i)(C_i)=(V_f)(C_f)$

- How would you prepare 2.5 L of 2 M HCl from concentrated HCl (11.6 M)?
- Concentrated H_2SO_4 comes as a 18.0 M solution. How would you make a 2.0 N sol'n?

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Water Dissociates Slightly

$$H_2O \rightleftharpoons H^+ + OH^-$$

- $[H^+]$ is 1×10^{-7} M (measured experimentally)
- therefore, $[OH^-]$ is 1×10^{-7} M

Water is a weak acid

Water is also a weak base

- product is 1×10^{-14}
- this is the basis of the *pH scale*

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The pH Scale

scale of 0-14

low pH (pH 0 - pH 6) is acidic

pH 7 is neutral

high pH (pH 8 - pH 14) is basic

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pH Math

$pH = -\log[H_3O^+]$ or $pH = -\log [H^+]$

$[H_3O^+] [OH^-] = 1.0 \times 10^{-14}$

$pH + pOH = 14$

Because log scale, a difference of 1 pH unit means there are 10× as many protons.

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Sample Test Questions

- Is tomato juice (pH 4.0) acidic or basic?
- How many more/less protons are present in 2 than in 3?

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Amphiprotic Compounds

sodium dihydrogen phosphate: NaH_2PO_4

Amphiprotic- can accept or donate a proton depending on the environment.

Important in *buffers*

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Buffers

1. Why it is important to regulate pH.
2. Our blood is *buffered*.

Buffer- a molecule that prevents the pH from changing even when (small amounts) acid or base is added.

a. Proteins buffer our blood.

b. Amphiprotic compounds buffer our blood.

NaH_2PO_4 (minor),

$NaHCO_3$ (major).