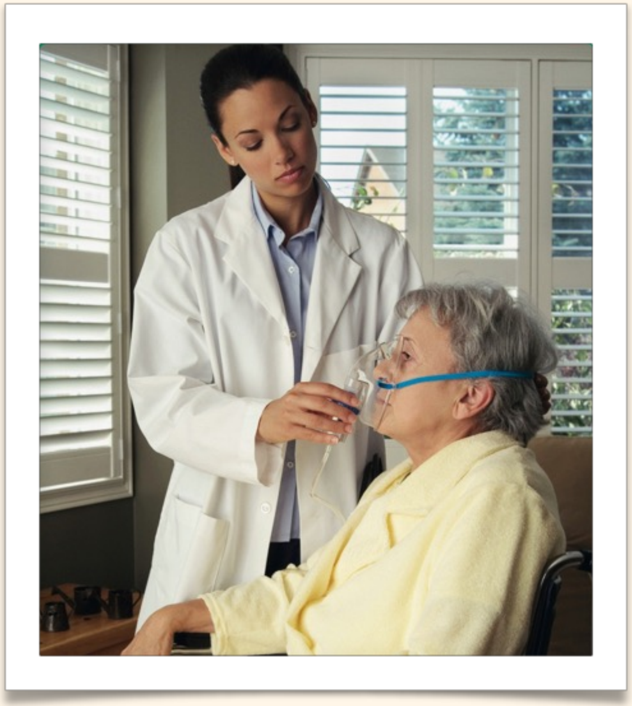
Chem 150, Spring 2015

Unit 4 - Acids & Bases

Introduction

- Patients with emphysema cannot expel CO_2 from their lungs rapidly enough.
  - This can lead to an increase of carbonic acid (H_2CO_3) levels in the blood and to a lowering of the *pH* of the blood by a process called respiratory acidosis.

$$CO_2 + H_2O \rightarrow H_2CO_3$$



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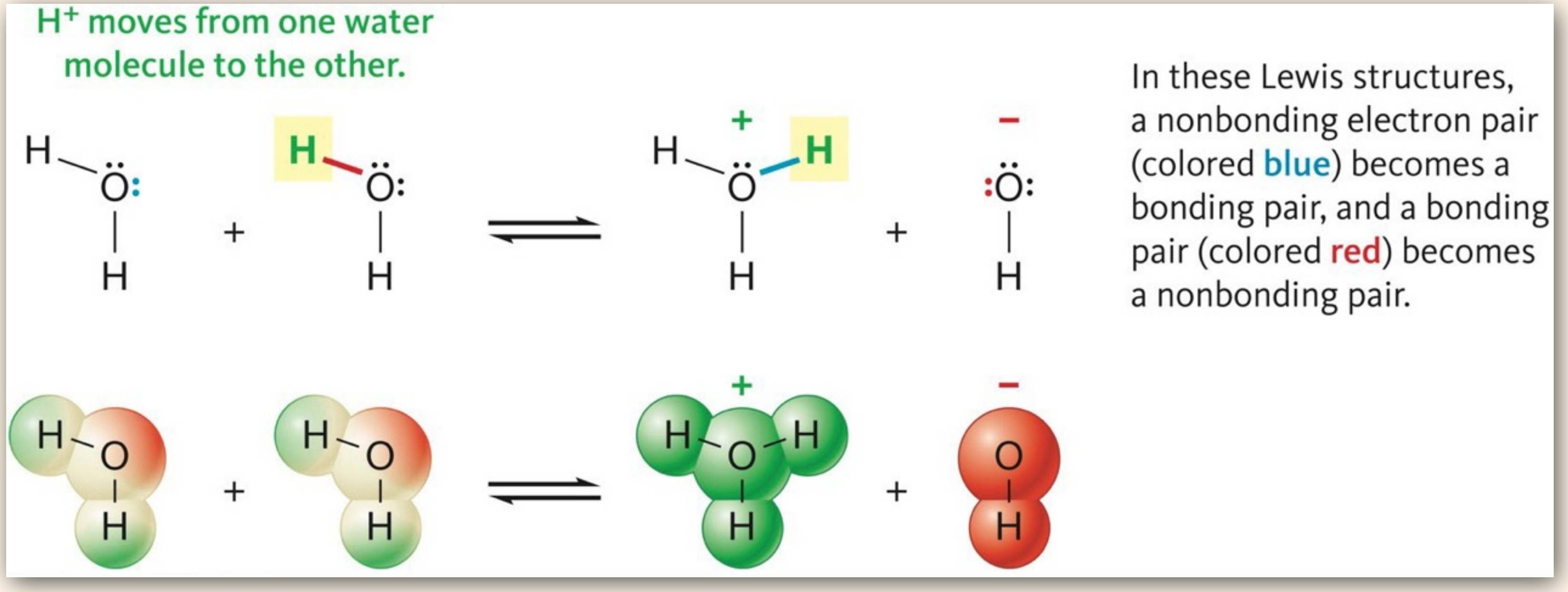
7.1 The Self-Ionization of Water

- When two water molecules are hydrogen bonded to one another, the acceptor (base) occasionally pulls a hydrogen ion away from the donor (acid). The products are a hydronium ion (H_3O^+) and a hydroxide ion.



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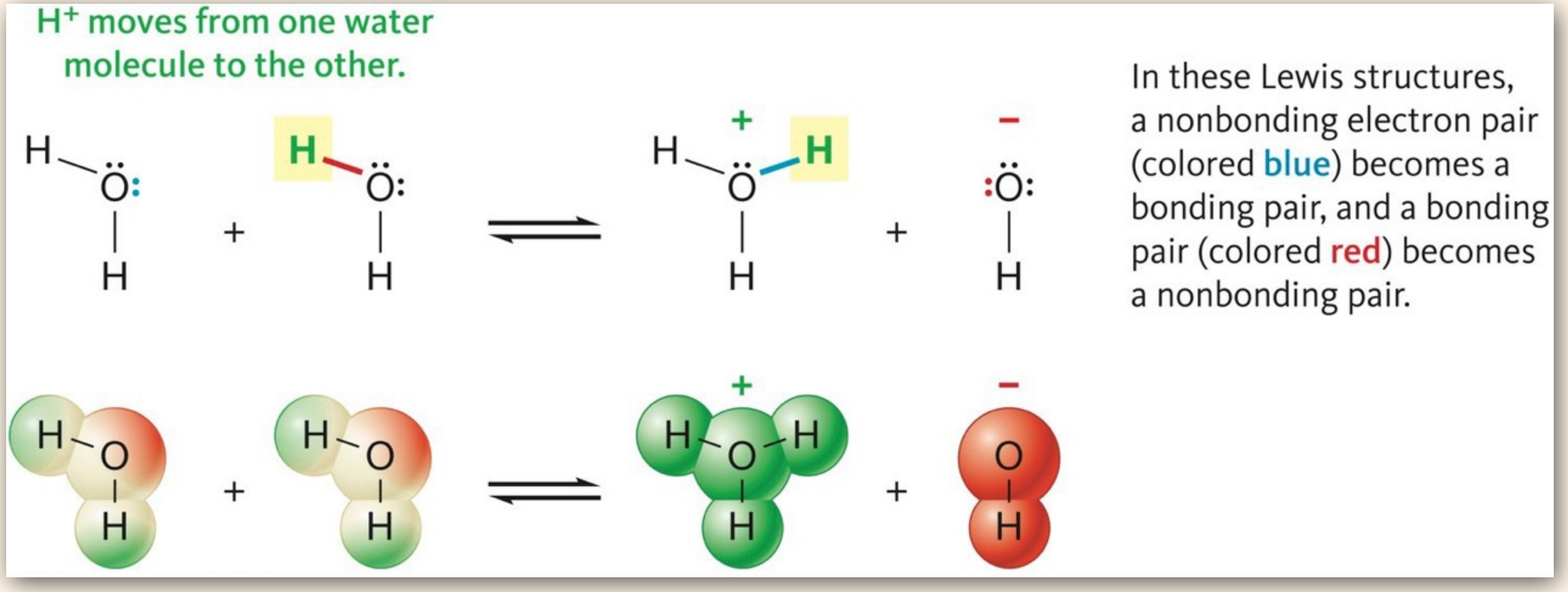

base acid

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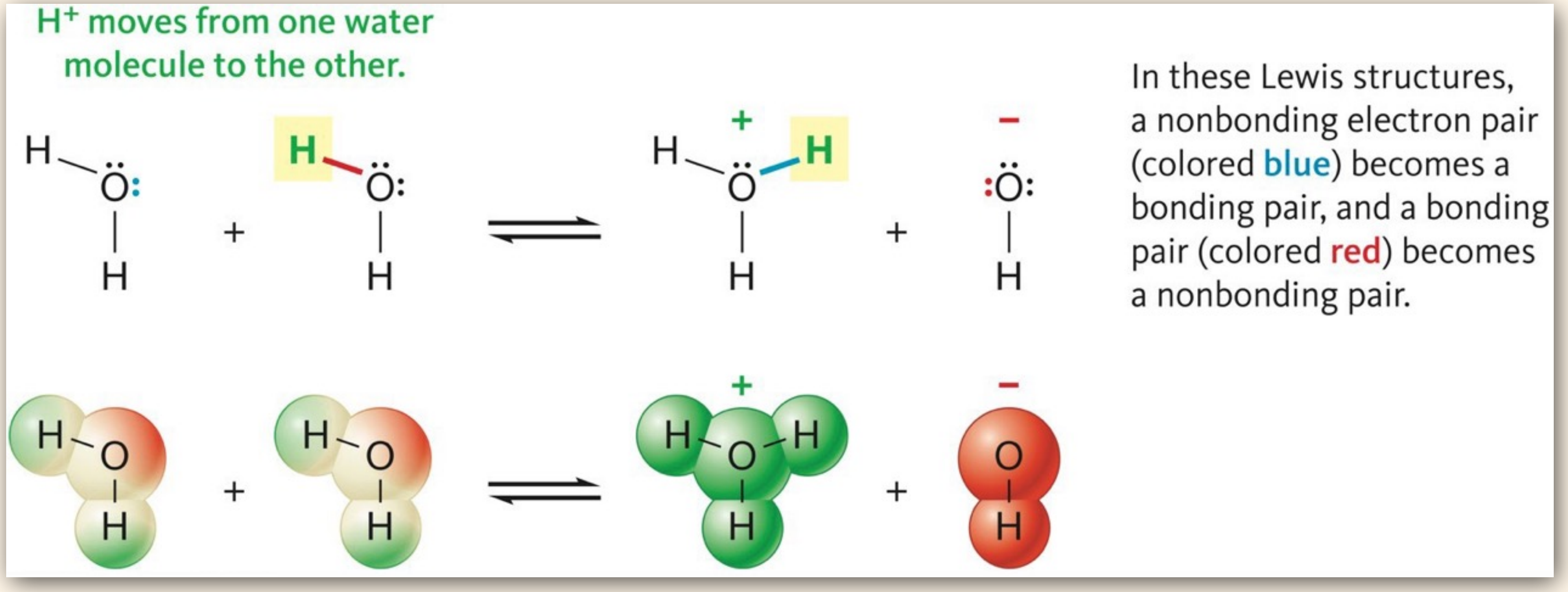

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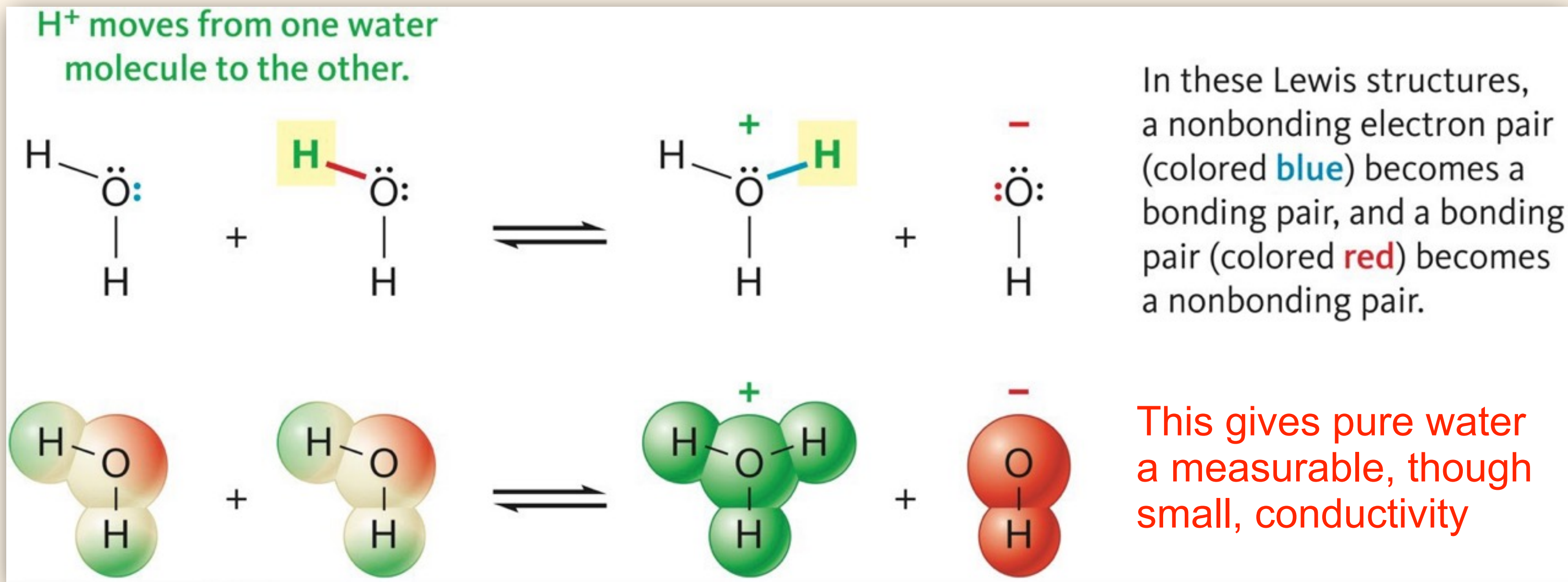

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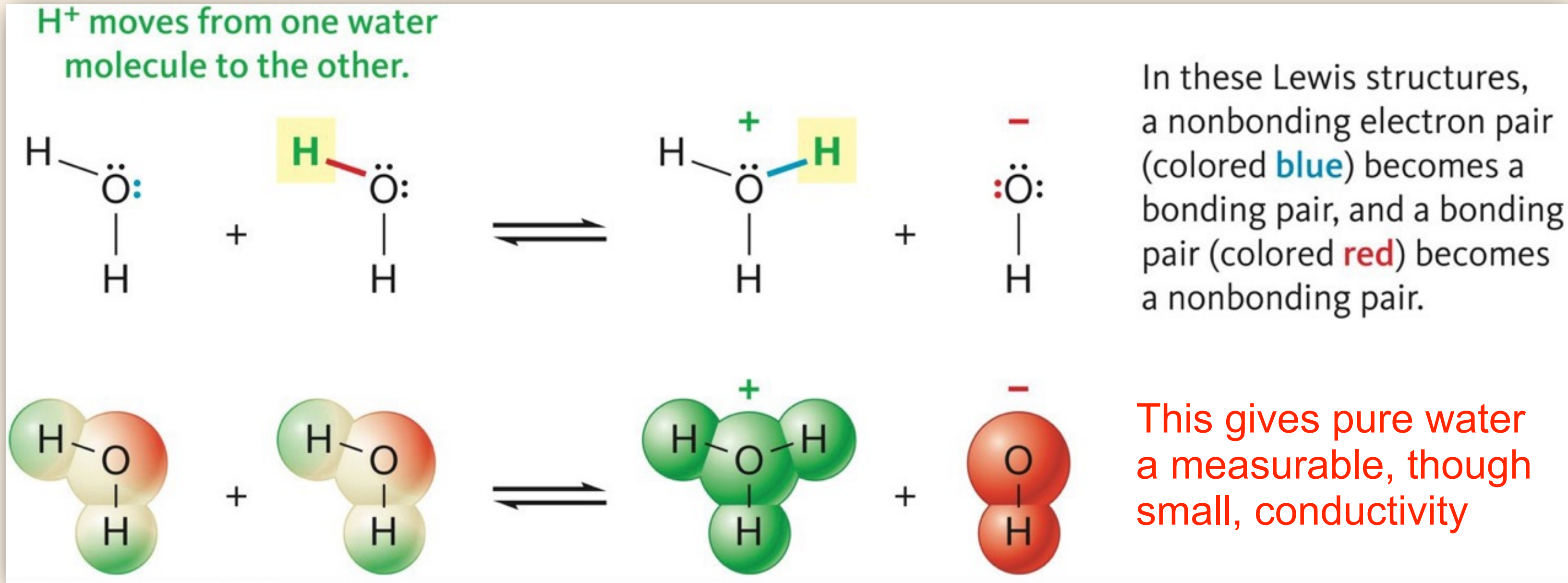

This gives pure water a measurable, though small, conductivity

base acid acid base

Just 1 ion (H_3O^+ or OH^-) per 280 million water molecules

Hydrogen Ion

- Since hydrogen atom contains one proton and one electron, a hydrogen ion (H^+) is simply a proton.
  - The terms *hydrogen ion* and *proton* are used interchangeably in chemistry.
- Although commonly represented as H^+, hydrogen ions do not exist as independent ions in an aqueous solution but instead are covalently bonded to water molecules.
  - The *hydronium ion* (H_3O^+) is also commonly used to represent a hydrogen ion.

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$H^+ = H_3O^+$

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- When dissolved in water, acids transfer or *donate* a proton to a water molecule.

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Hydrochloric acid

$$HCl_{(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$

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$$HNO_{3(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + NO_3^-{}_{(aq)}$$

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$$HNO_{3(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + NO_3^-{}_{(aq)}$$

Unlike pure water, the conductivity of hydrochloric acid and nitric acid solutions are very high, because both of these acids are strong acids and therefore strong electrolytes.

Bases

- Compounds that form hydroxide ions when they dissolve in water are bases.

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Examples:

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$$NaOH_{(s)} \xrightarrow{H_2O} Na^+_{(aq)} + OH^-_{(aq)}$$

Calcium Hydroxide

$$Ca(OH)_{2(s)} \xrightarrow{H_2O} Ca^{2+}_{(aq)} + 2\ OH^-_{(aq)}$$

Because both NaOH and $Ca(OH)_2$ are ionic compounds (salts), and therefore strong electrolytes that produce a high conductivity when dissolved in water.

The Ion Product of Water

- Any reaction that forms H_3O^+ or OH^- ions has an effect on the equilibrium in water between H_2O molecules and H_3O^+ and OH^- ions.

$$H_2O_{(l)} + H_2O_{(l)} \leftrightharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

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add acid

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shift equilibrium

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add acid lower OH^-

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$$H_2O_{(l)} + H_2O_{(l)} \leftrightharpoons H_3O^+_{(aq)} + \underset{\substack{\uparrow \\ \text{add base}}}{OH^-_{(aq)}}$$

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add base

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shift equilibrium

$$H_2O_{(l)} + H_2O_{(l)} \leftrightharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

lower H_3O^+ add base

The Ion Product of Water

- At equilbrium,

$$H_2O_{(l)} + H_2O_{(l)} \leftrightharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

$$K_w = [H_3O^+] \times [OH^-] = 1.0 \times 10^{-14}\ M^2$$

- K_w is called the ion product for water.

7.2 The pH Scale

- In most cases, $[H_3O^+]$ is very small can vary over a wide range of magnitudes, therefore, its concentration is often express in terms of *pH*..
- The *pH* is a logarithmic scale and it value is determine by taking the negative logarithm of the H_3O^+ concentration.
  - For exact powers of 10, it is just the negative value of the exponent:

If $[H_3O^+]$ =	**then, pH =**
10^{-4}	***4***
10^{-7}	***7***
10^{-11}	***11***

Acids, Bases, and pH

- If the *pH* of a solution is *below* 7, the solution is acidic, and,

$$\left[H_3O^+\right] > \left[OH^-\right] \quad \text{acidic}$$

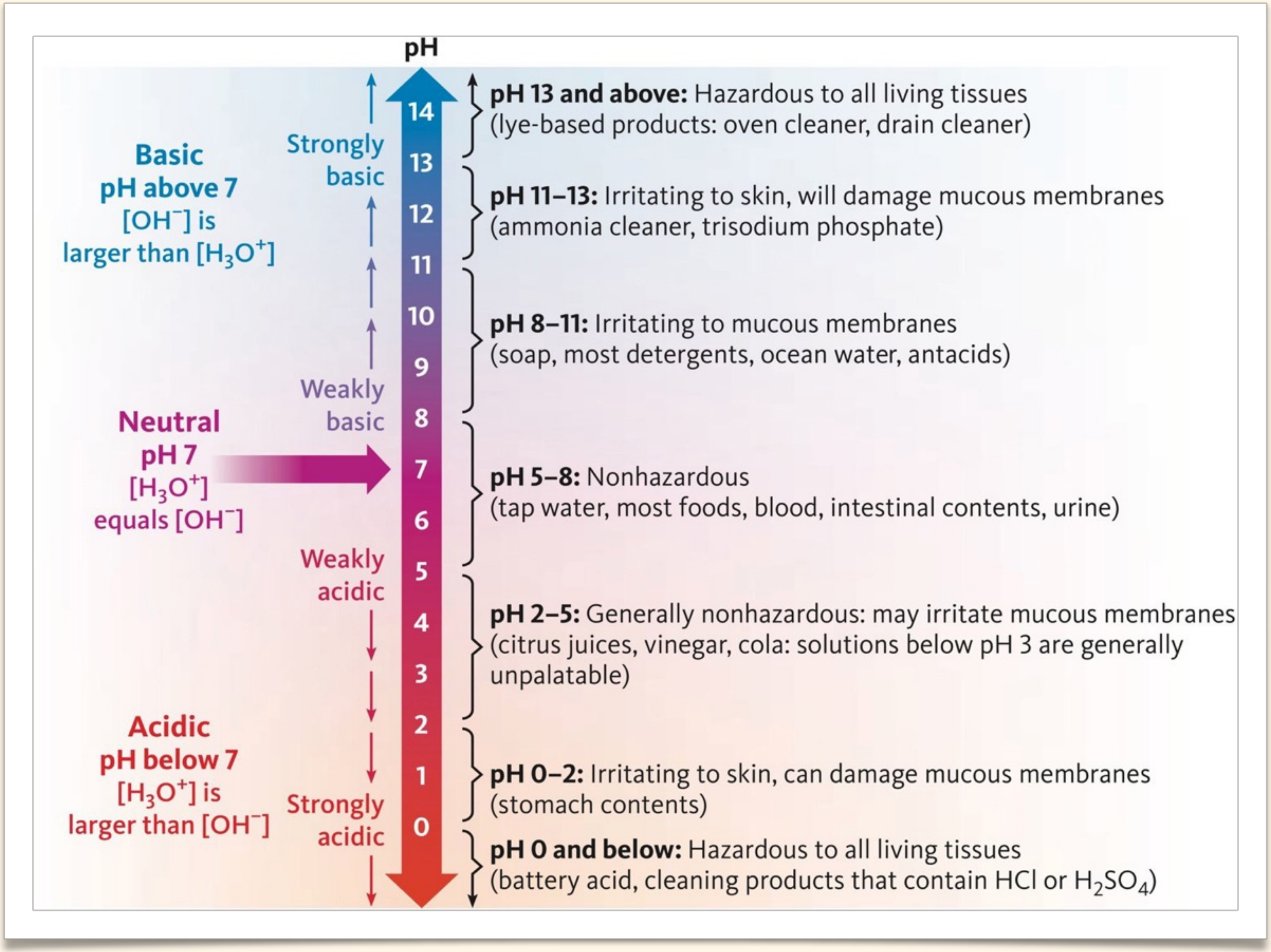
- If the pH of a solution is 7, the solution is neutral, and

$$\left[H_3O^+\right] = \left[OH^-\right] \quad \text{neutral}$$

- If the pH of a solution is *above* 7, the solution is basic or alkaline, and,

$$\left[H_3O^+\right] < \left[OH^-\right] \quad \text{basic or alkaline}$$

pH of Common Substances



Try It!

$[H_3O^+]$	$[OH^-]$	*pH*	Acid, Base, or Neutral
10^{-5} M			
	10^{-3} M		
			Neutral

Try It!

$[H_3O^+]$	$[OH^-]$	*pH*	Acid, Base, or Neutral
10^{-5} M	10^{-9} M		
	10^{-3} M		
			Neutral

Try It!

$[H_3O^+]$	$[OH^-]$	*pH*	Acid, Base, or Neutral
***10^{-5}* M**	*10^{-9}* M	*5*	
	***10^{-3}* M**		
			Neutral

Try It!

$[H_3O^+]$	$[OH^-]$	*pH*	Acid, Base, or Neutral
10^{-5} M	10^{-9} M	5	*Acid*
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10^{-11} M	***10^{-3} M***		
			Neutral

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10^{-5} M	10^{-9} M	*5*	*Acid*
10^{-11} M	**10^{-3} M**	*11*	*Base*
10^{-7} M	10^{-7} M	*7*	***Neutral***

pH, Logarithm, and Antilogarithm

- When $[H_3O^+]$ is not an exact power of 10, use the [Log] key on your calculator:

$$pH = -\log\left(\left[H_3O^+\right]\right)$$

- Example 1: If $[H_3O^+] = 7.3 \times 10^{-5}$, what is the pH?

  On a TI-83 calculator
  [(-)] [Log]   7.3 [EE] [(-)] 5 [Enter]

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$$pH = 4.14$$

pH, Logarithm, and Antilogarithm

- To calculate $[H_3O^+]$ from the *pH*, take 10 to the -*pH* power, do this using the the $[10^{-x}]$ key on you calculator.

$$\left[H_3O^+\right] = 10^{-pH}$$

- Example 2: If *pH* = 8.35, what is $[H_3O^+]$?

On a TI-83 calculator
$[10^{-x}]$ [(-)] 8.35 [Enter]

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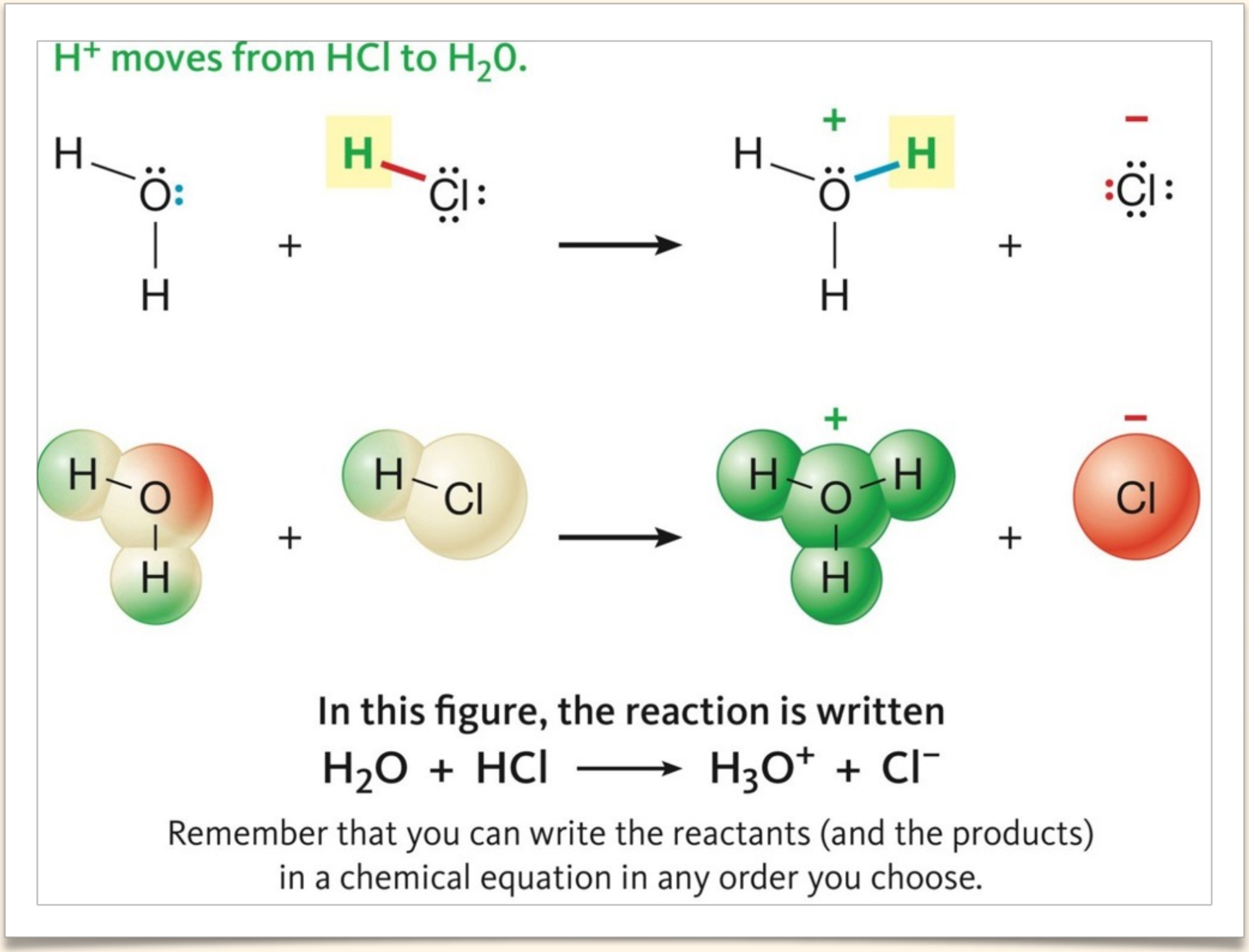
  [10^{-x}] [(-)]   8.35 [Enter]

$$\left[H_3O^+\right] = 4.5 \text{ x } 10^{-9} \text{ M}$$

7.3 Properties of Acids

- An acid is a compound that can lose a H^+ ion.
- Since a hydrogen ion is just a proton, acids are often called proton donors.



Common Acids

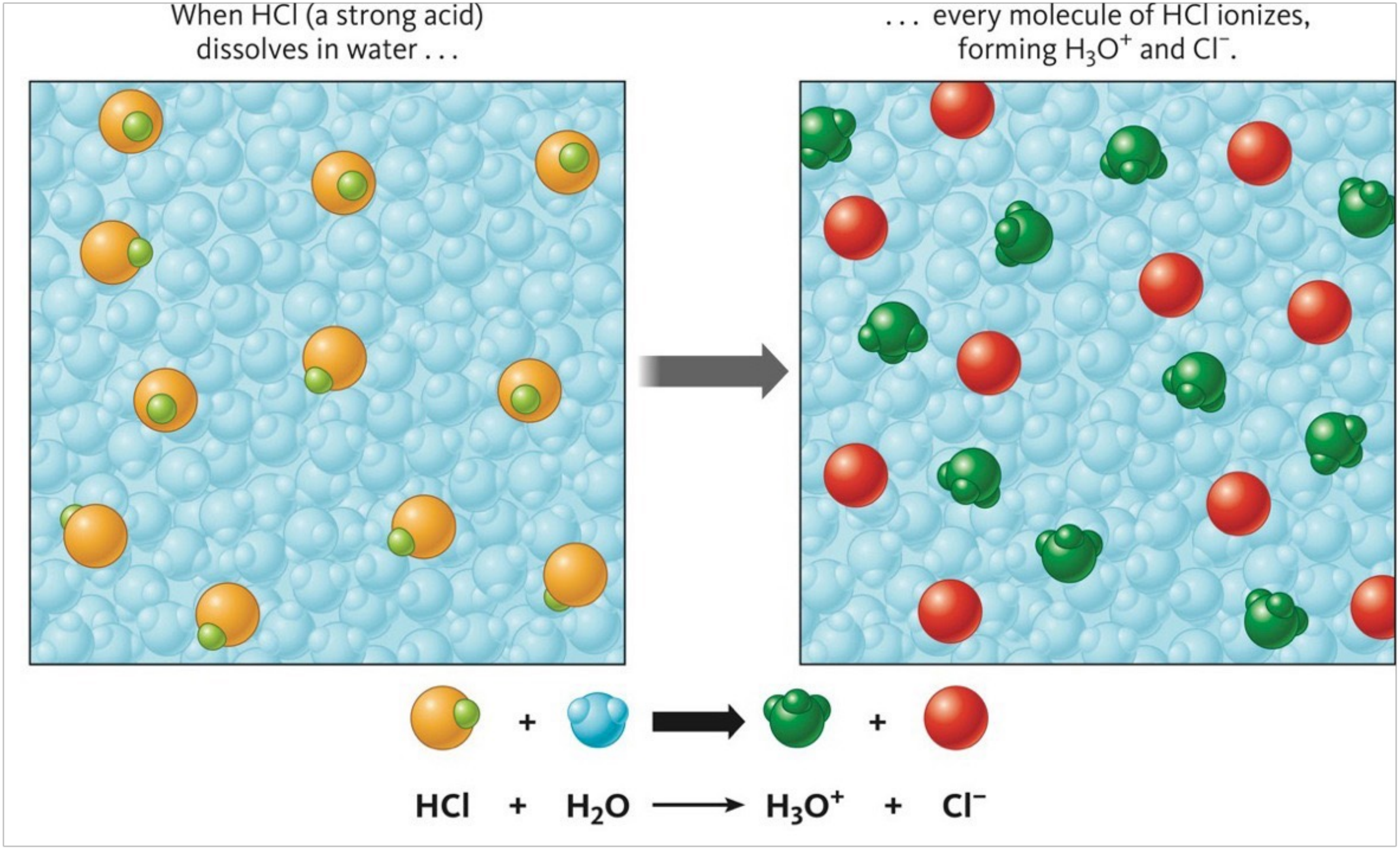
TABLE 7.2 Some Common Acids and Their Ionization Reactions

Formula	Name	Ionization Reaction
HCl	Hydrochloric acid	$HCl(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$
HNO_3	Nitric acid	$HNO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + NO_3^-(aq)$
H_2SO_4	Sulfuric acid	$H_2SO_4(aq) + H_2O(l) \rightarrow H_3O^+(aq) + HSO_4^-(aq)$
H_3PO_4	Phosphoric acid	$H_3PO_4(aq) + H_2O(l) \rightarrow H_3O^+(aq) + H_2PO_4^-(aq)$
H_2CO_3	Carbonic acid	$H_2CO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + HCO_3^-(aq)$
$HC_2H_3O_2$	Acetic acid	$HC_2H_3O_2(aq) + H_2O(l) \rightarrow H_3O^+(aq) + C_2H_3O_2^-(aq)$

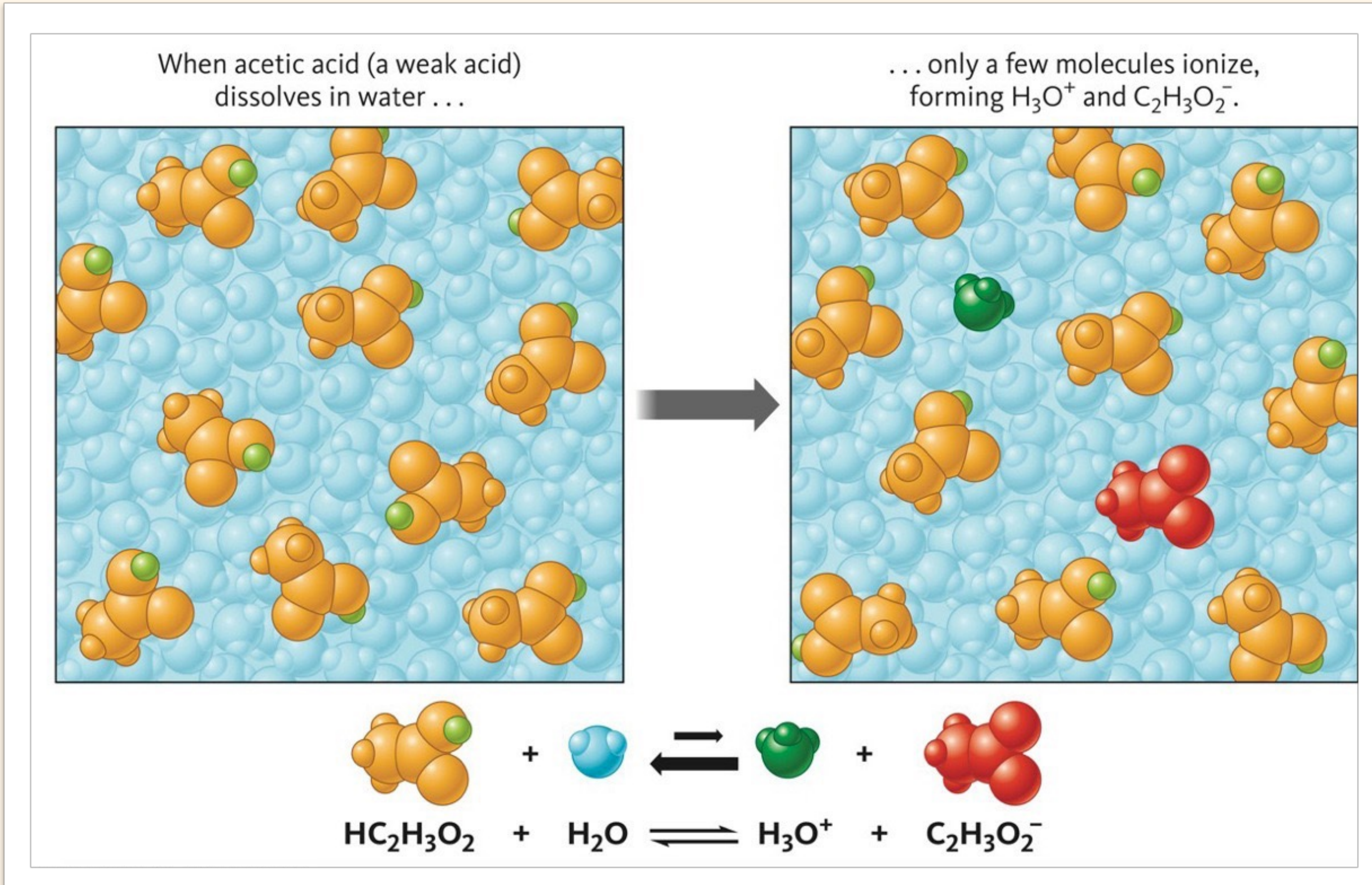
Acids: Strong or Weak Electrolytes

- All acids are electrolytes because they form ions when they dissolve in water.
- Any compound that *ionizes completely* in water is a strong electrolyte. An acid that is a strong electrolyte is classified as a strong acid.
- Any compound that ionizes to a limited extent when it dissolves in water is a weak electrolyte. An acid that is a weak electrolyte is classified as a weak acid.

Ionization of a Strong Acid



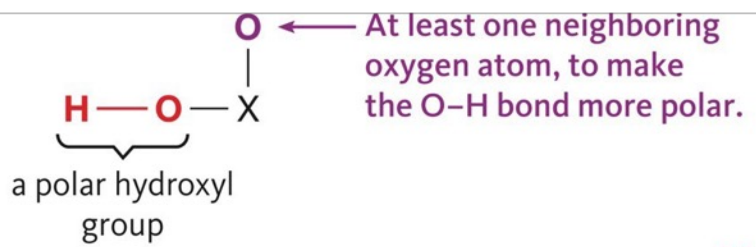
Ionization of a Weak Acid



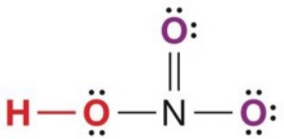
Common Structural Features of Acids

- We can recognize two structural features that are found in most acids:
  - Acids normally contain at least one hydroxyl (-OH) group.
  - The atom that is attached to the hydroxyl group is normally bonded to at least one other oxygen atom.
- In on convention, the chemical formulas of acids start with H, and the chemical formulas of compounds that are not acids start with some other element.

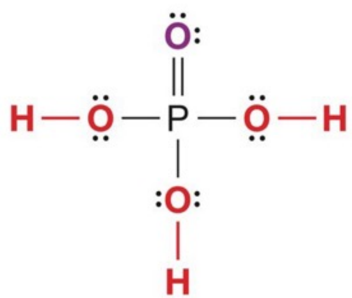
Structural Features



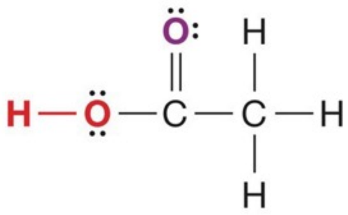
Structural features found in most acids.



Nitric acid (HNO_3)



Phosphoric acid (H_3PO_4)



Acetic acid ($HC_2H_3O_2$)

Each acid contains at least one hydroxyl group (shown in **red**). The hydrogen atoms in the hydroxyl groups are acidic and can be transferred to H_2O.

Oxygen atoms (shown in **purple**) also help to make these compounds acidic.

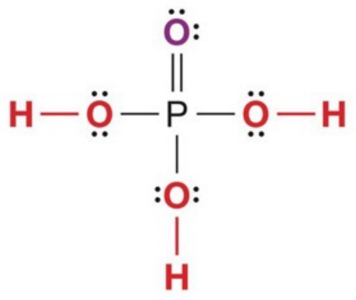
Try It!

Question:

Write the chemical equation for the ionization of *lactic acid* ($HC_3H_5O_3$) in aqueous solution.

Polyprotic Acids

- A monoprotic acid is only able to transfer one hydrogen ion to water.
- Polyprotic acids are capable of losing more than one hydrogen ion:



Phosphoric acid (H_3PO_4)

$$H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^-$$
$$H_2PO_4^- + H_2O \rightleftharpoons HPO_4^{2-} + H_3O^-$$
$$HPO_4^{2-} + H_2O \rightleftharpoons PO_4^{3-} + H_3O^-$$

- In most polyprotic acids, the second hydrogen is more difficult to remove than the first.

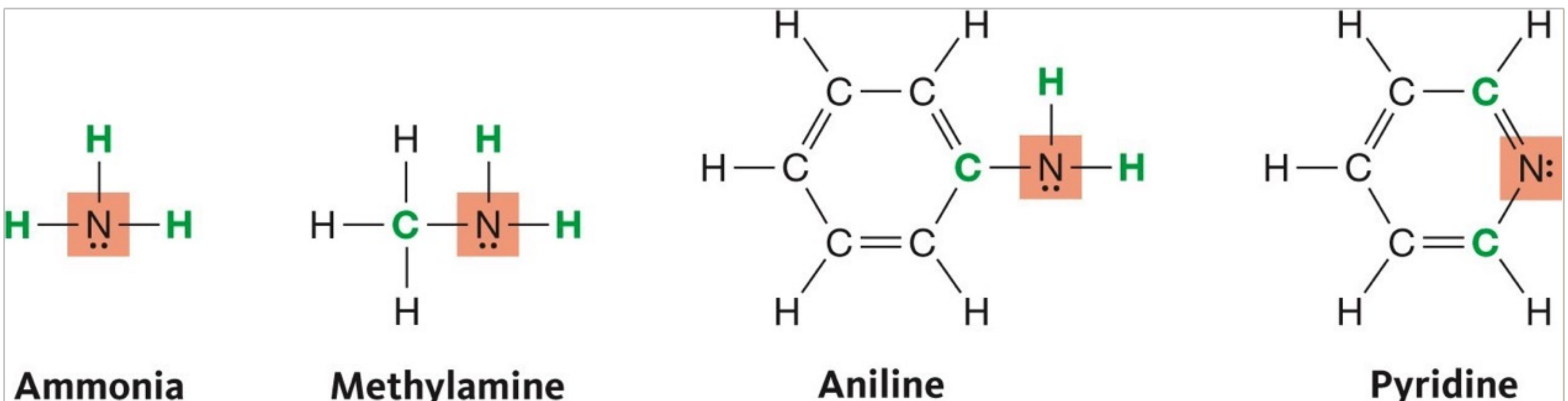
7.4 Properties of Bases

- Bases neutralize acids by forming a covalent bond to the hydrogen ion from the acid.
- A base is any compound that can bond to H^+.
- Since a hydrogen ion is a proton, bases are also called proton acceptors.
- When we mix a base with water, the base pulls a hydrogen ion away from a water molecule:

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Common Structural Features of Bases

- We can recognize two structural features that are common among bases:
  - ✦ Most anions are bases because opposite charges attract each other.
  - ✦ Most molecules that contain nitrogen covalently bonded to carbon, hydrogen, or both are bases.



Each of these bases contains nitrogen bonded to carbon or hydrogen.

Strong or Weak Bases

- Bases are classified as strong or weak based on how effective they are at removing hydrogen ions from water molecules.
- If every molecule of a substance removes a proton from a water molecule, the substance is a strong electrolyte and a strong base.
- Weak bases are weak electrolytes and react with water to produce hydroxide ions, but only to a limited extent.

Weak Bases

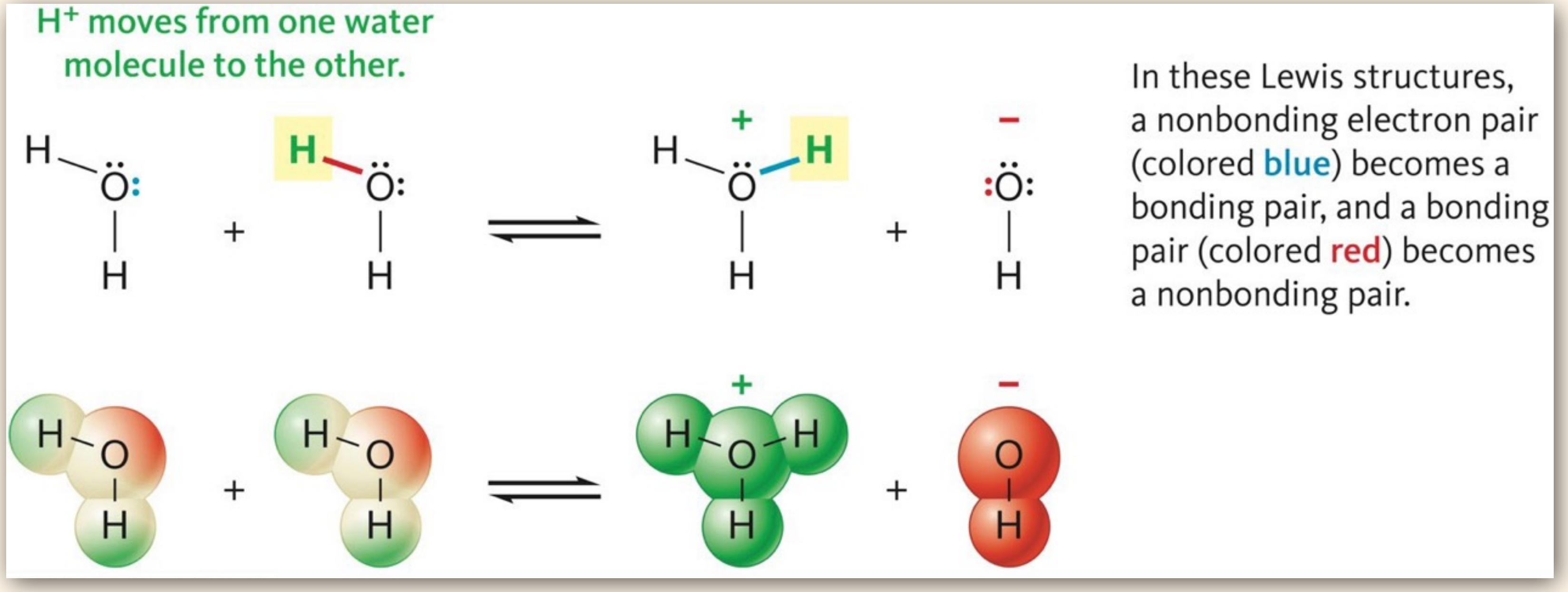
TABLE 7.3 Some Weak Bases and Their Reactions with Water

Formula	Name	Reaction with Water
C_5H_5N	Pyridine	$C_5H_5N(aq) + H_2O(l) \rightleftharpoons HC_5H_5N^+(aq) + OH^-(aq)$
N_2H_4	Hydrazine	$N_2H_4(aq) + H_2O(l) \rightleftharpoons N_2H_5^+(aq) + OH^-(aq)$
C_2H_7NO	Ethanolamine	$C_2H_7NO(aq) + H_2O(l) \rightleftharpoons HC_2H_7NO^+(aq) + OH^-(aq)$
$C_2H_3O_2^-$	Acetate ion	$C_2H_3O_2^-(aq) + H_2O(l) \rightleftharpoons HC_2H_3O_2(aq) + OH^-(aq)$
CO_3^{2-}	Carbonate ion	$CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$
PO_4^{3-}	Phosphate ion	$PO_4^{3-}(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + OH^-(aq)$

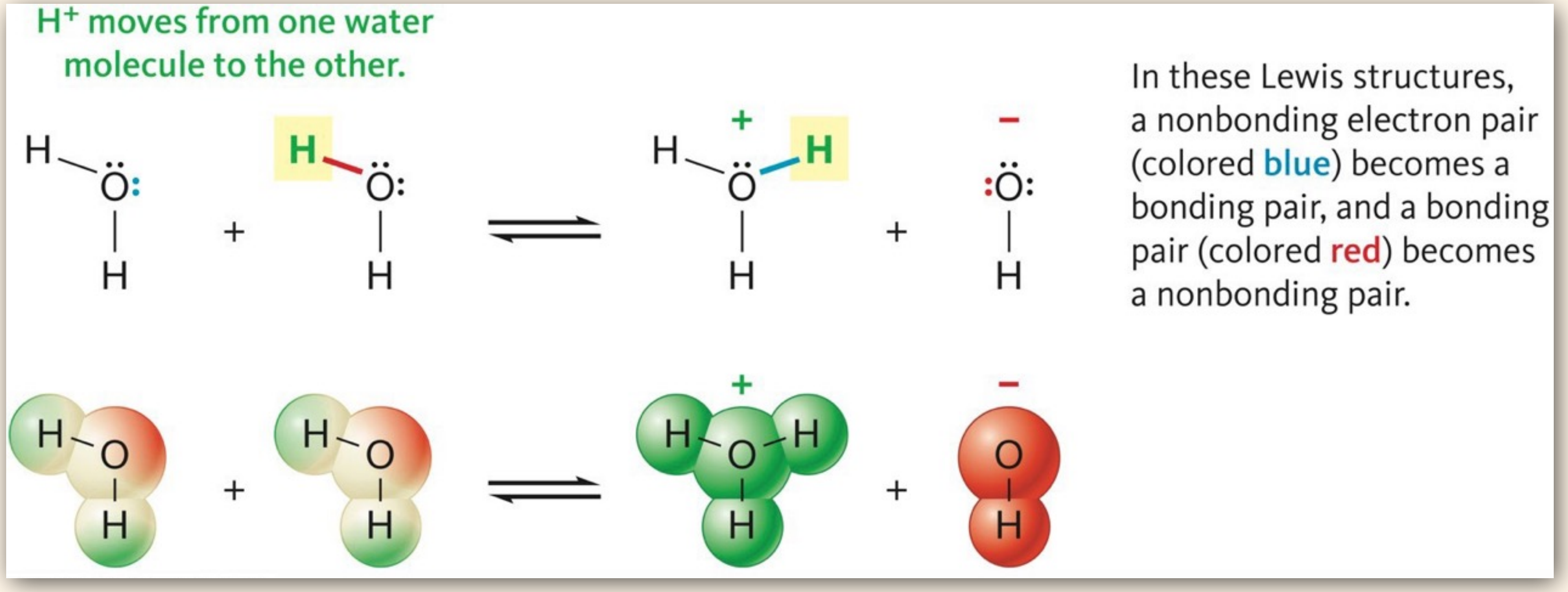
Conjugate Acids and Bases

- When an acid or a base reacts with water, the reactant and the product bear a special relationship with each other.
- In both cases, the formulas of the reactant and product differ by only one hydrogen ion.
- Two substances whose formulas differ by one hydrogen ion are called a conjugate pair.
- The substance with the hydrogen ion is the conjugate acid, and the substance that is missing the hydrogen ion is the conjugate base.

Conjugate Pairs

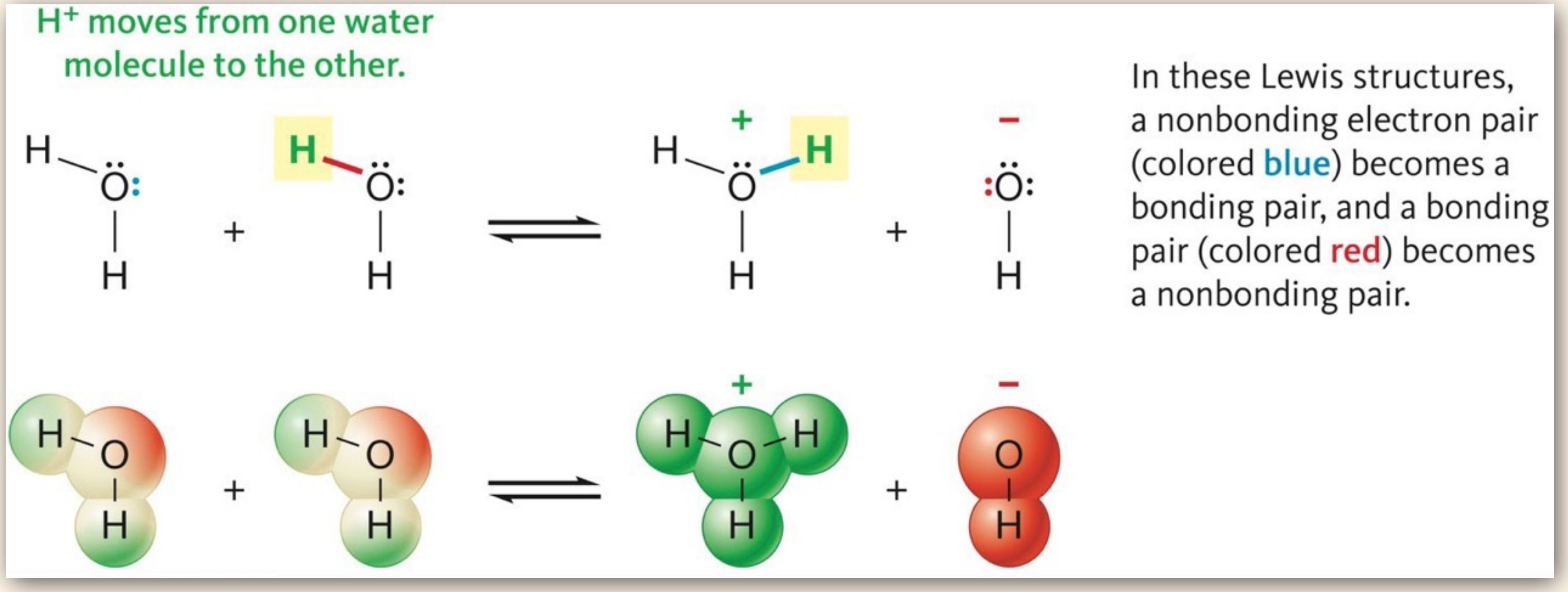


Conjugate Pairs



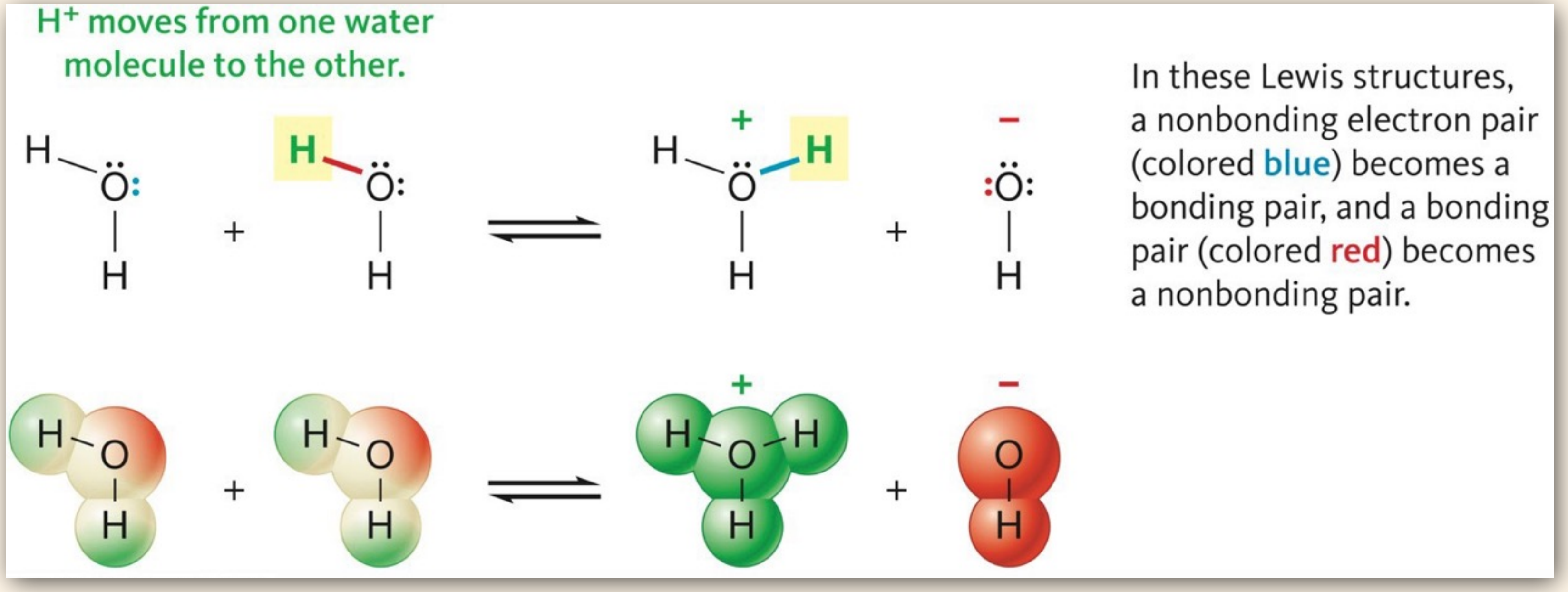
acid

Conjugate Pairs



acid → conjugate base

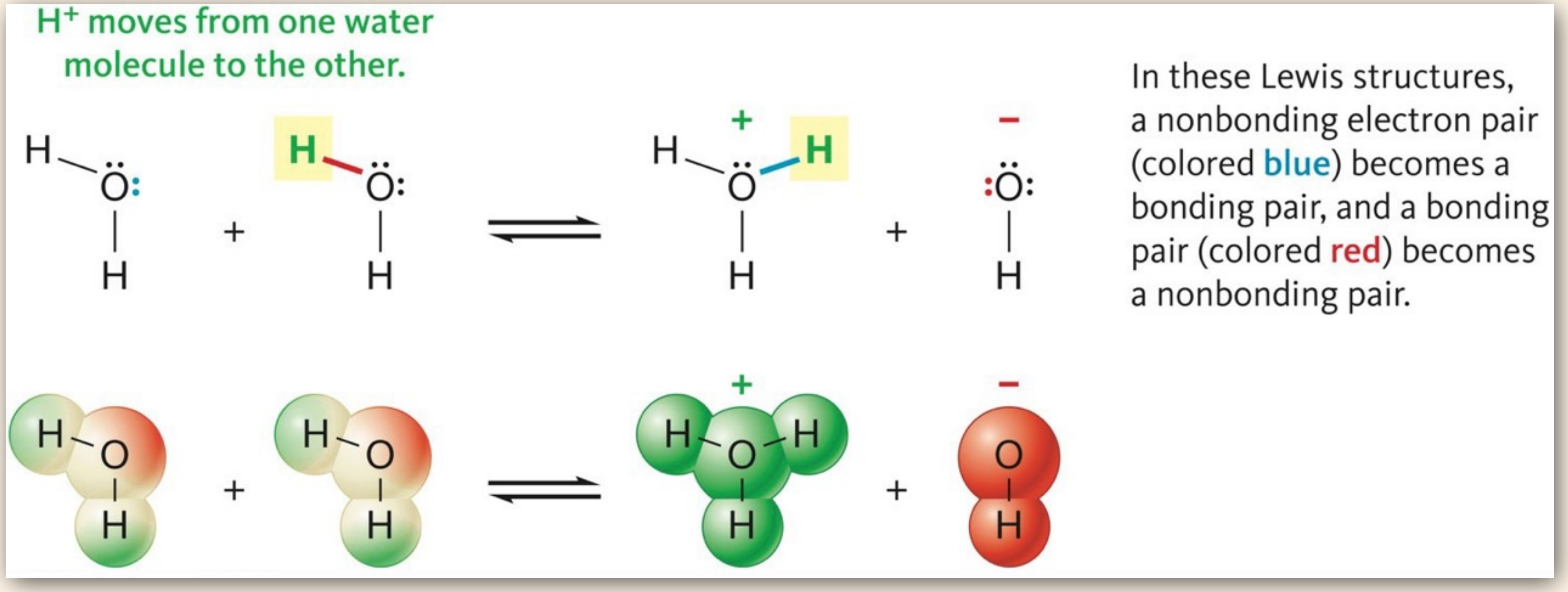
Conjugate Pairs



acid → conjugate base

base

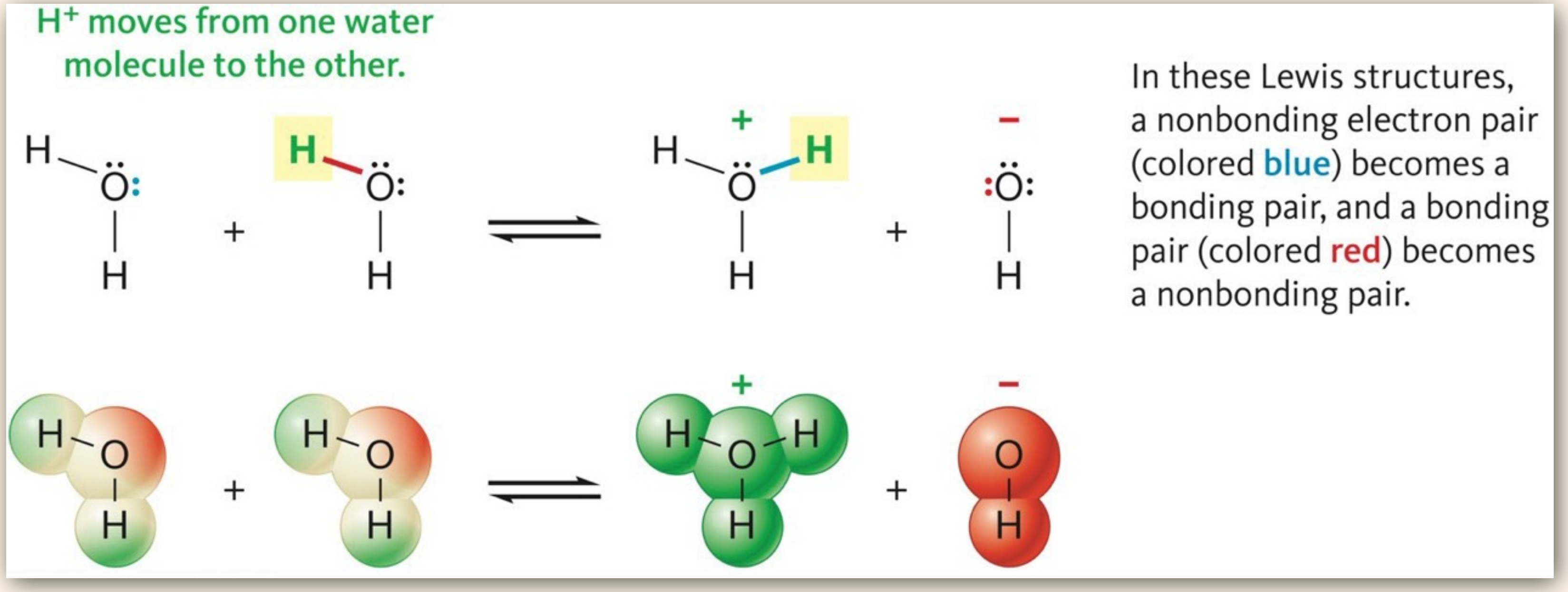
Conjugate Pairs



acid → conjugate base

base conjugate acid

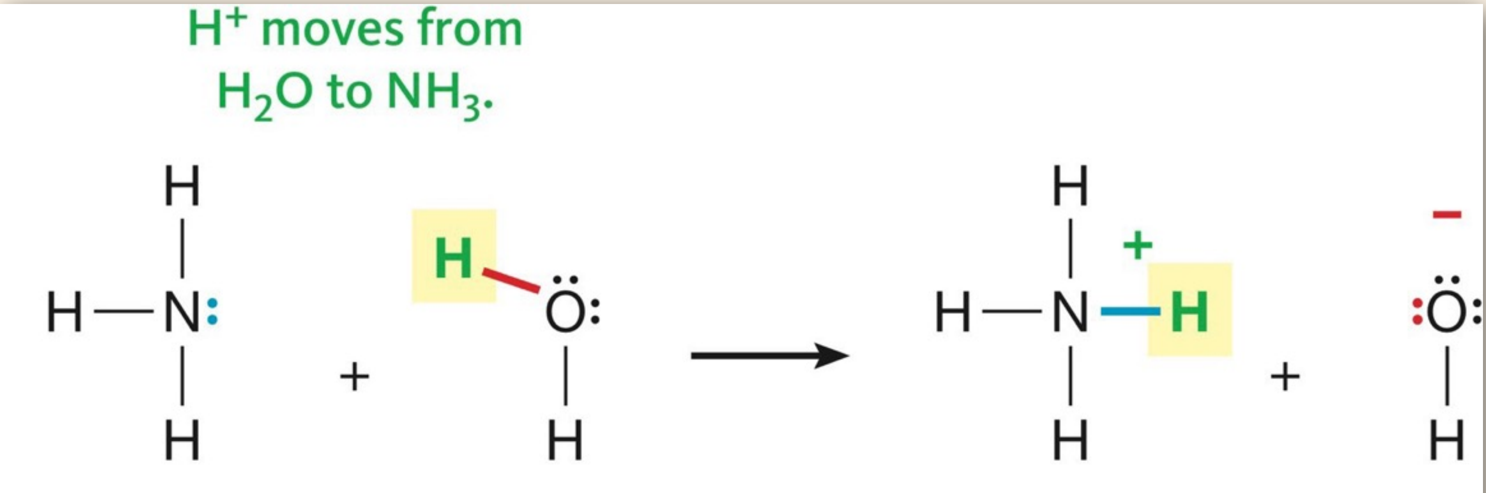
Conjugate Pairs



acid → conjugate base

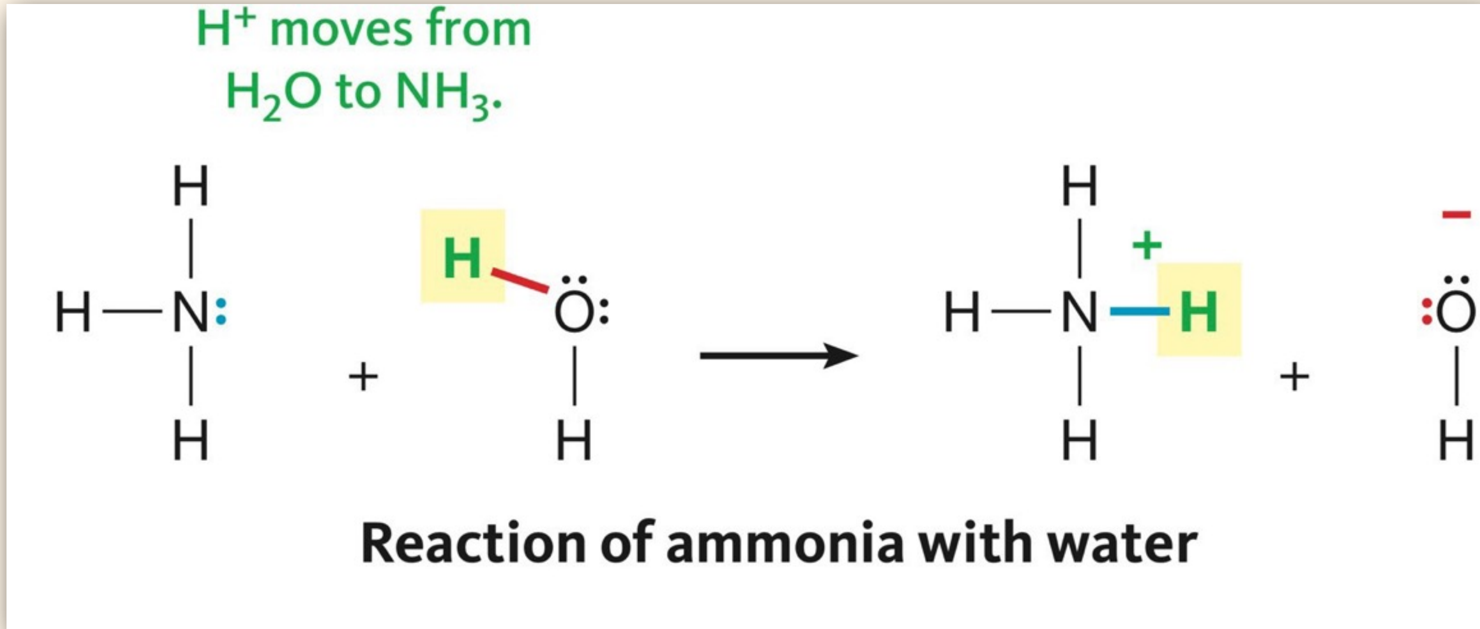
base → conjugate acid

Conjugate Pairs



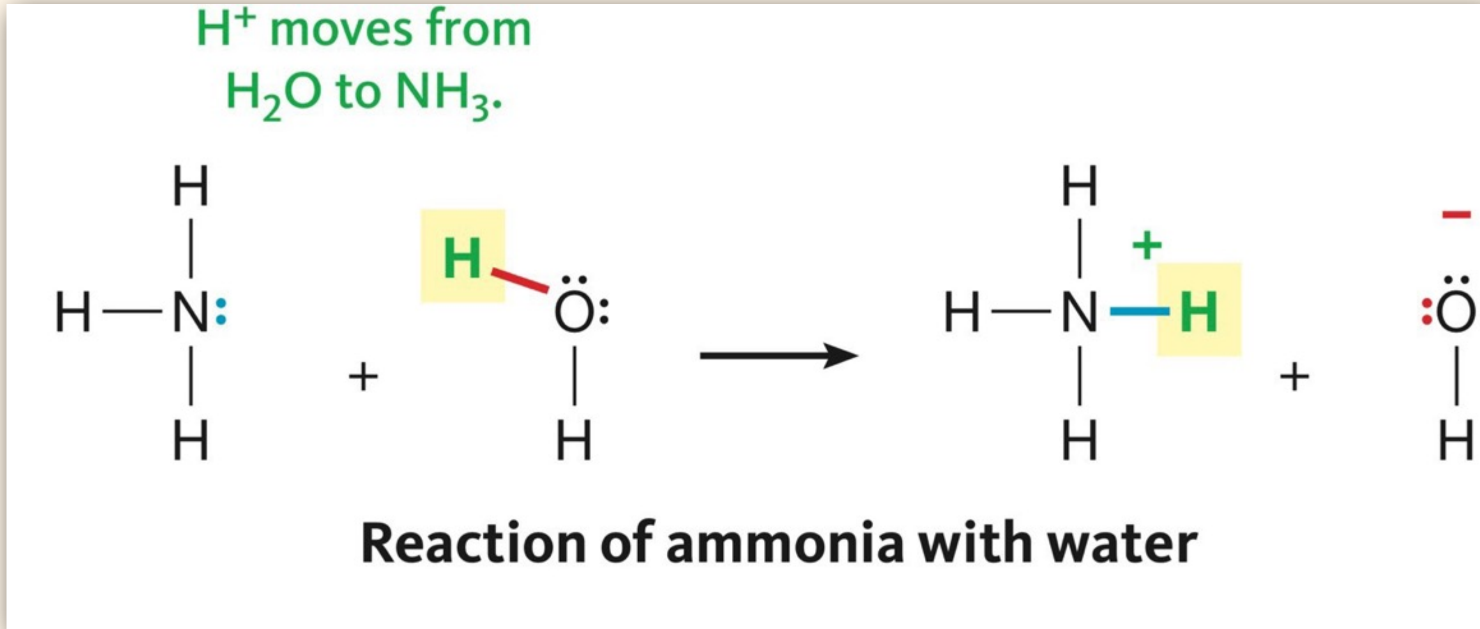
Reaction of ammonia with water

Conjugate Pairs



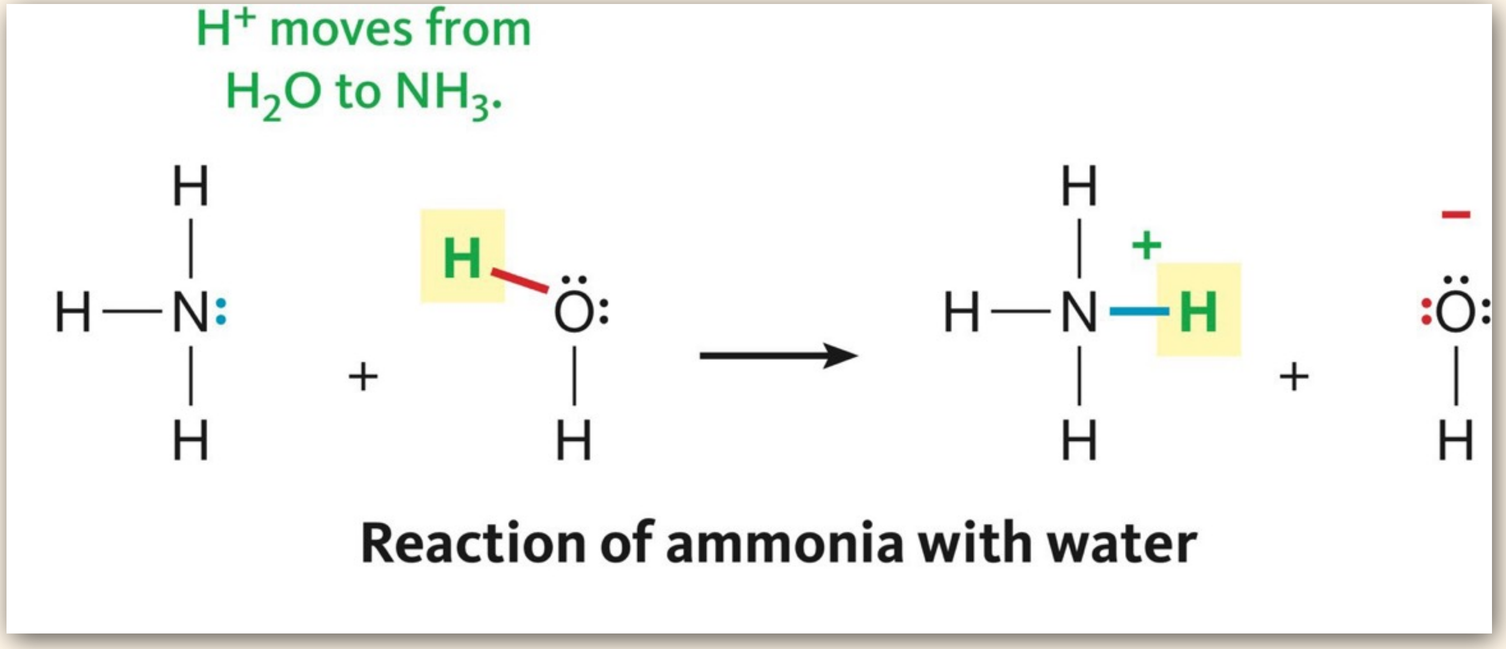
acid

Conjugate Pairs



acid → conjugate base

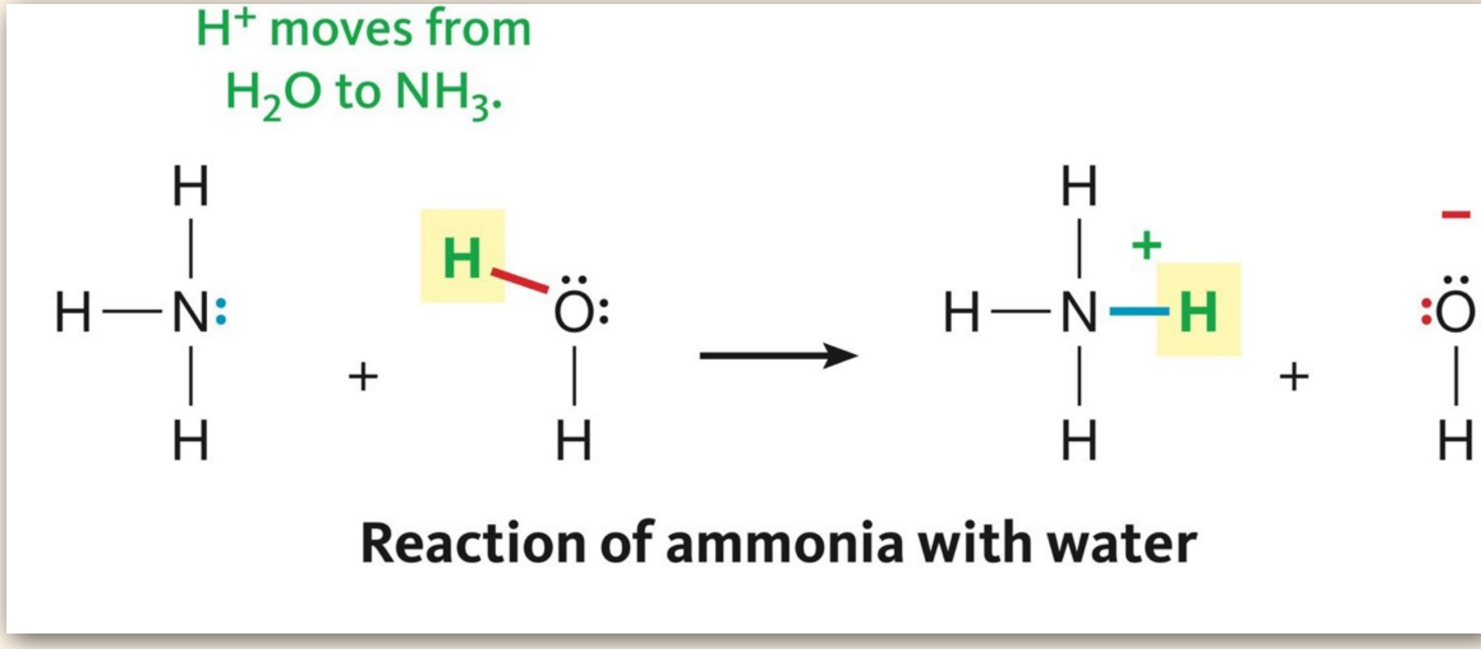
Conjugate Pairs



acid → conjugate base

base

Conjugate Pairs



acid → conjugate base

base → conjugate acid

Try It!

Question:

What is the conjugate base of the dihydrogen phosphate ($H_2PO_4^-$) ion?

A. H_3PO_4

B. $H_2PO_4^-$

C. HPO_4^{2-}

D. PO_4^{3-}

Try It!

Question:

What is the conjugate acid of the dihydrogen phosphate ($H_2PO_4^-$) ion?

A. H_3PO_4

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C. HPO_4^{2-}

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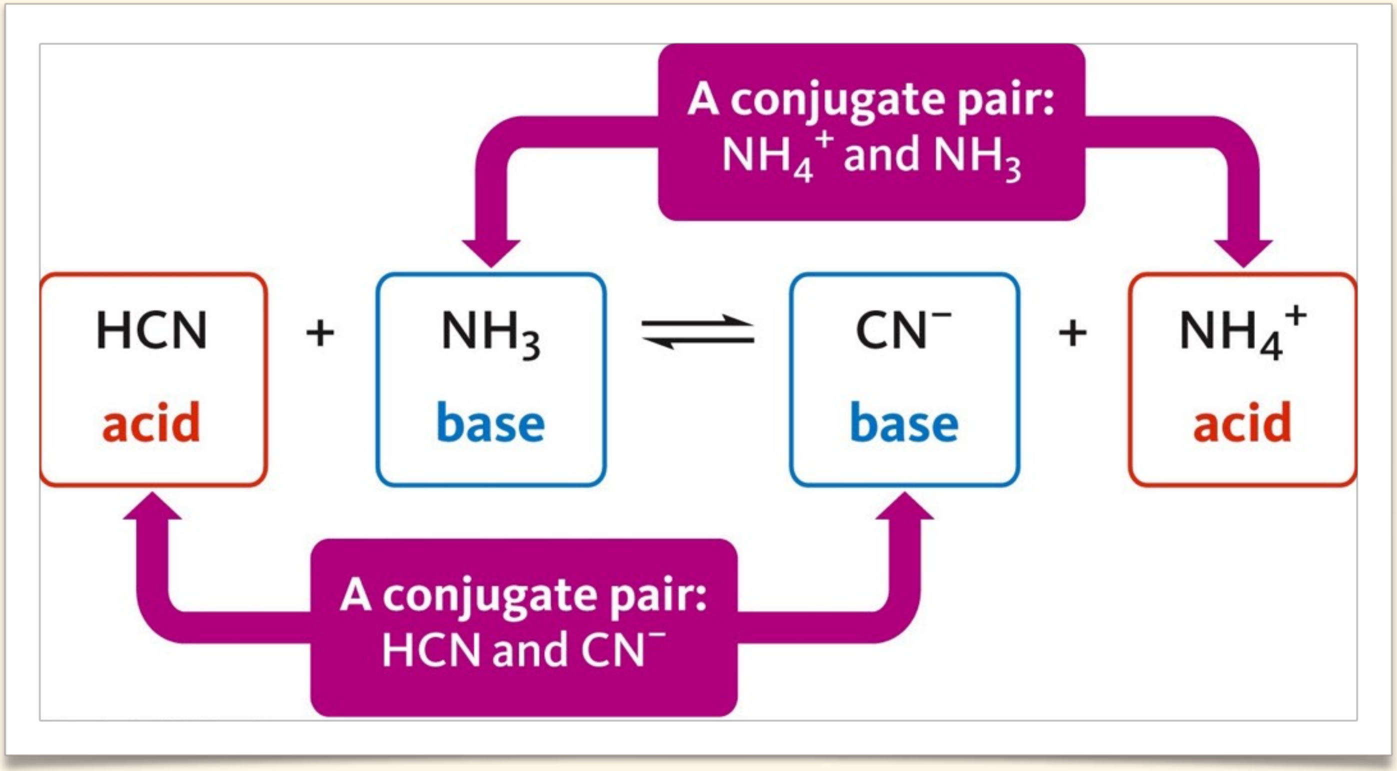
7.5 Acid-Base Reactions

- In an acid-base reaction, a proton moves from the acid to the base.
- Acid-base reactions involve two conjugate pairs.



7.5 Acid-Base Reactions

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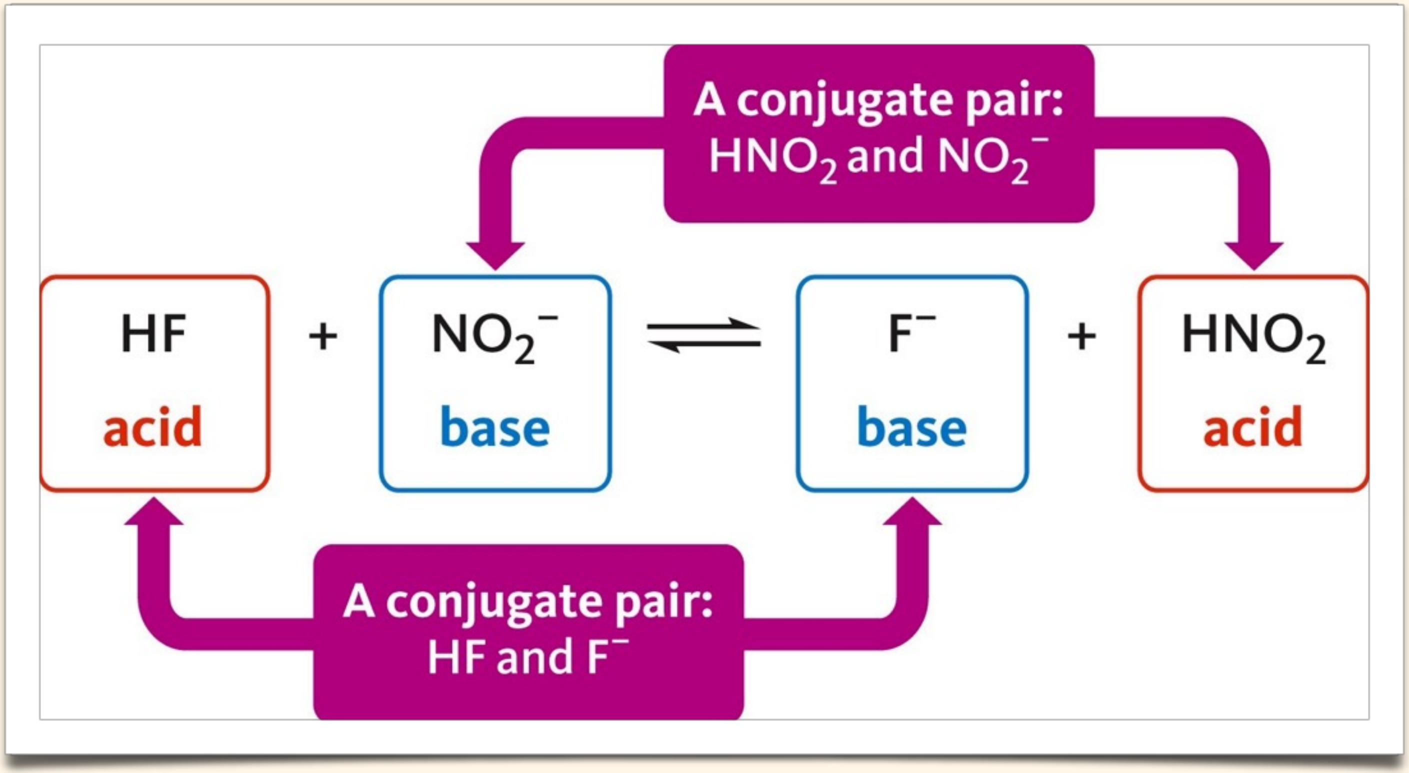

Polyprotic Acids React with Bases in Several Steps

- When a polyprotic acid reacts with a base, the base removes one hydrogen atom at a time.

$$H_3PO_4 + OH^- \rightarrow H_2O + H_2PO_4^-$$

$$H_2PO_4^- + OH^- \rightarrow H_2O + HPO_4^{2-}$$

$$HPO_4^{2-} + OH^- \rightarrow H_2O + PO_4^{3-}$$

Molecular and Net Ionic Equations

- We have been looking at net ionic equations where strong electrolytes are shown ionized without the counter ions that are not involved in the reaction (spectator ions).
- Molecular equations include spectator ions and do not make a distinction between weak, strong, and non-electrolytes.

$H_3O^+(aq) + OH^-(aq) \rightarrow 2\ H_2O(l)$ *(net ionic)*

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$ *(molecular)*

7.6 Amphiprotic Molecules and Ions

- Substances that can either gain or lose hydrogen ions are called amphiprotic.
- Water is an amphiprotic molecule since it can gain a proton to form a hydronium ion or lose a proton to form a hydroxide ion.
- Most negative ions that can lose hydrogen ions are amphiprotic
- Some molecular compounds are amphiprotic.

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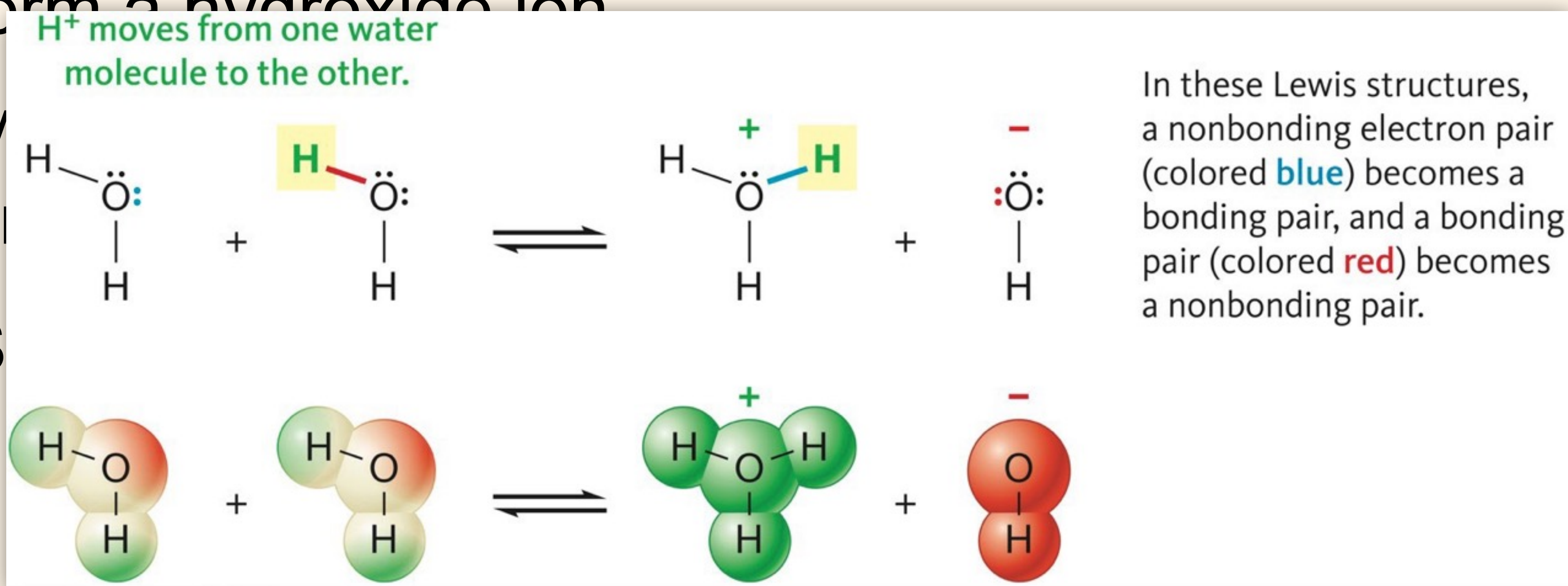
- M … e
  a…
- S…



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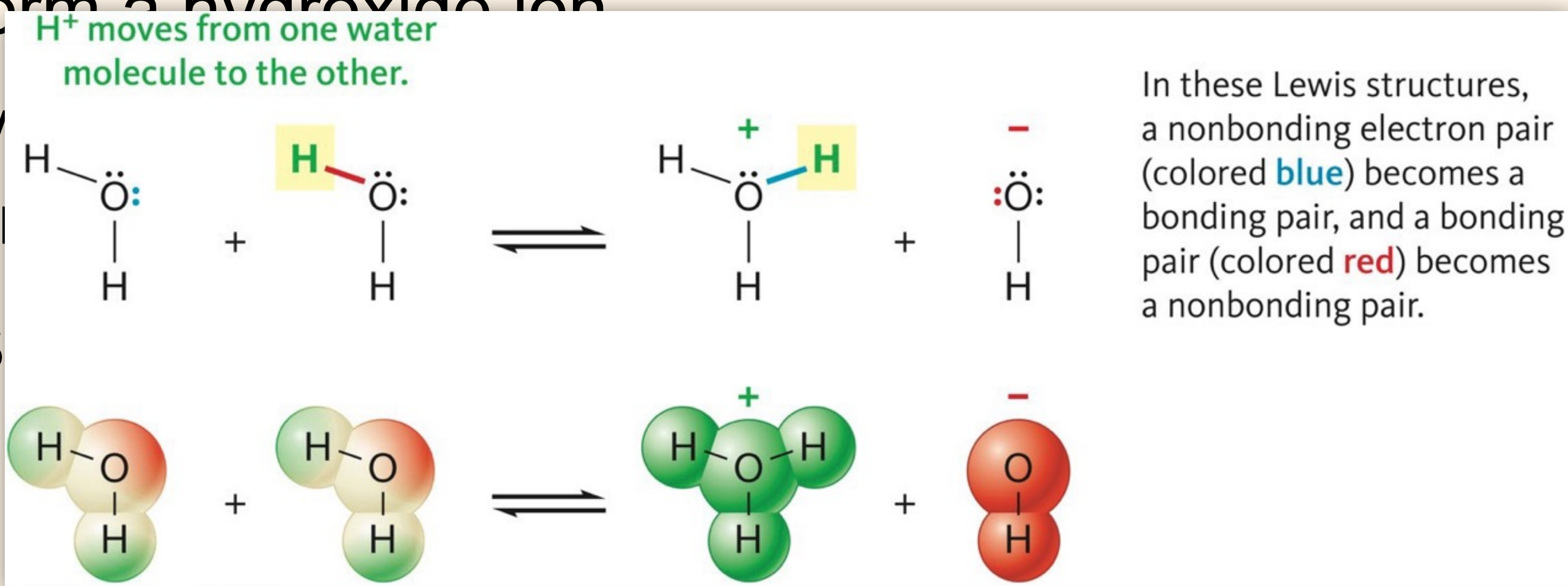

base acid

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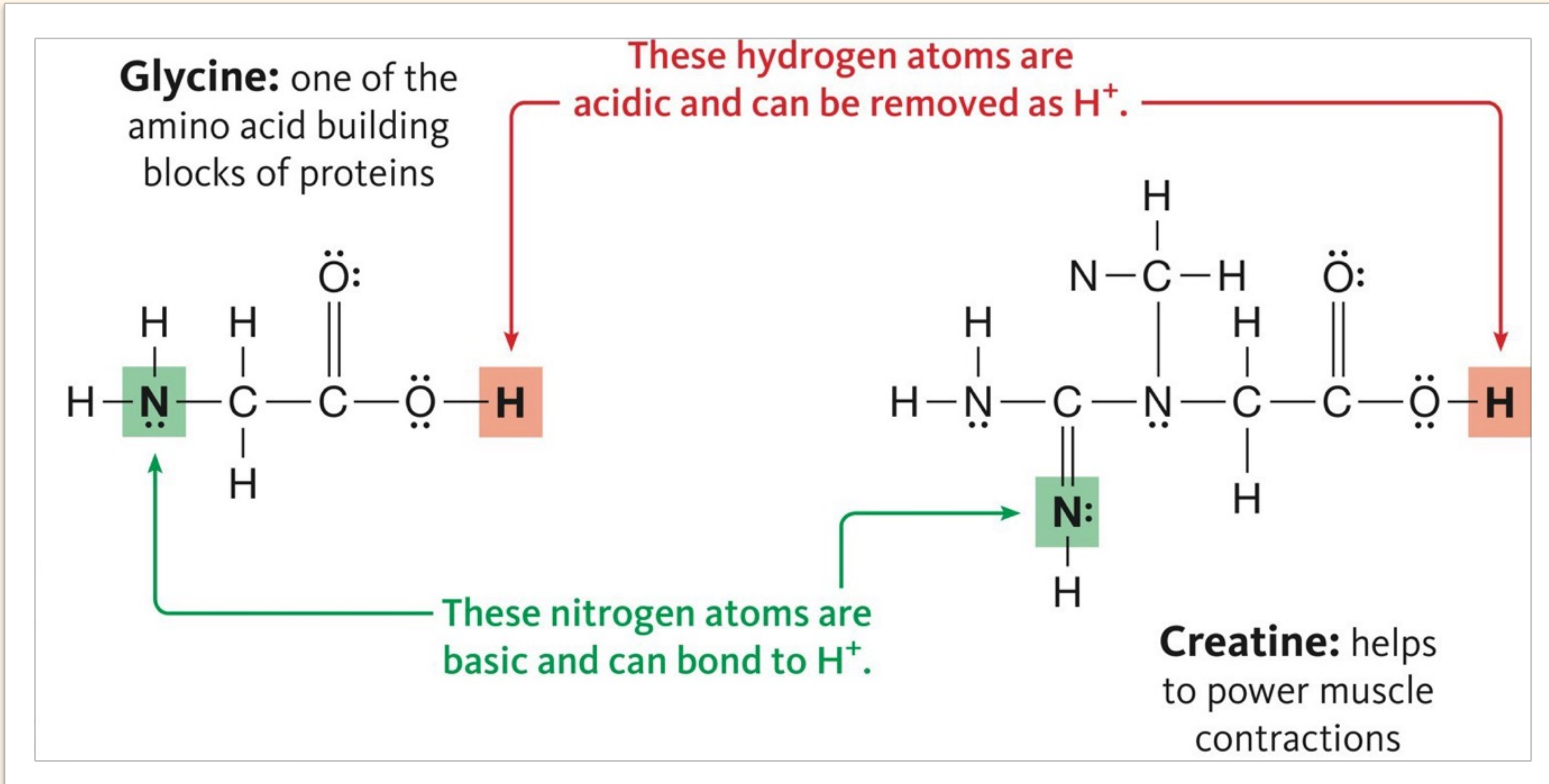
- Water is an amphiprotic molecule since it can gain a proton to form a hydronium ion or lose a proton to form a hydroxide ion.
- Most negative ions that can lose hydrogen ions are amphiprotic
- Some molecular compounds are amphiprotic.

Example of an Amphiprotic Ion

$HF(aq)$	+	$\boxed{HCO_3^-(aq)}$	$\longrightarrow$	$H_2CO_3(aq)$	+	$F^-(aq)$
acid (loses H^+)		**base** (gains H^+)				

$\boxed{HCO_3^-(aq)}$	+	$NH_3(aq)$	$\longrightarrow$	$NH_4^+(aq)$	+	$CO_3^{2-}(aq)$
acid (loses H^+)		**base** (gains H^+)				

Example of an Amphiprotic Molecular Compound



7.7 Buffers

- A buffer is a solution that resists a change in *pH* when acids and bases are added to them.
- A buffers is a solution that contain a mixture of a weak acid and its **conjugate base**.
- When the weak acid and its conjugate base are present at **equal concentrations**, the *pH* of a buffer is equal to the pK_a of the weak acid.
  - The *pH* of a buffer system can be fine-tuned by changing the proportions of acid and base in the solution.

Buffers and pH

- The *pK_a* is a measure of the strength of a weak acid
  - The *lower* the *pK_a*, the *stronger* the weak acid.

TABLE 7.4 Some Buffers and Their pH Values

Buffer Components	Source of the Conjugate Acid	Source of the Conjugate Base	Buffer pH (When the Molarities Are Equal)
$HC_2H_3O_2$ and $C_2H_3O_2^-$	$HC_2H_3O_2$ (acetic acid)	$NaC_2H_3O_2$ (sodium acetate)	4.74
H_3PO_4 and $H_2PO_4^-$	H_3PO_4 (phosphoric acid)	NaH_2PO_4 (sodium dihydrogen phosphate)	2.12
$H_2PO_4^-$ and HPO_4^{2-}	NaH_2PO_4 (sodium dihydrogen phosphate)	Na_2HPO_4 (sodium mono-hydrogen phosphate)	7.21
HPO_4^{2-} and PO_4^{3-}	Na_2HPO_4 (sodium mono-hydrogen phosphate)	Na_3PO_4 (sodium phosphate)	12.32
NH_4^+ and NH_3	NH_4Cl (ammonium chloride)	NH_3 (ammonia)	9.25

Buffers and pH

- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

Buffers and pH

- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

$HC_2H_3O_2$

weak
acid

Buffers and pH

- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

Buffer

$HC_2H_3O_2$

weak acid

$C_2H_3O_2^-$

weak base

Buffers and pH

- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

Buffer

$HC_2H_3O_2$ + OH^-

weak acid | strong base

$C_2H_3O_2^-$

weak base

Buffers and pH

- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

$$HC_2H_3O_2 + OH^- \longrightarrow C_2H_3O_2^- + HOH$$

$HC_2H_3O_2$: weak acid

OH^-: strong base

Buffer

$C_2H_3O_2^-$: weak base

Buffers and pH

- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

$$HC_2H_3O_2 + OH^- \longrightarrow C_2H_3O_2^- + HOH$$

$HC_2H_3O_2$	OH^-	$C_2H_3O_2^-$	HOH
weak acid	strong base	weak base	weak acid

Buffer

$C_2H_3O_2^-$
weak base

Buffers and pH

- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

Buffer

$$HC_2H_3O_2 + OH^- \longrightarrow C_2H_3O_2^- + HOH$$

$HC_2H_3O_2$	OH^-	$C_2H_3O_2^-$	HOH
weak acid	strong base	weak base	weak acid

$$C_2H_3O_2^- + H_3O^+$$

$C_2H_3O_2^-$	H_3O^+
weak base	strong acid

Buffers and pH

- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

Buffer

$$\underset{\text{weak acid}}{HC_2H_3O_2} + \underset{\text{strong base}}{OH^-} \longrightarrow \underset{\text{weak base}}{C_2H_3O_2^-} + \underset{\text{weak acid}}{HOH}$$

$$\underset{\text{weak base}}{C_2H_3O_2^-} + \underset{\text{strong acid}}{H_3O^+} \longrightarrow HC_2H_3O_2 + HOH$$

Buffers and pH

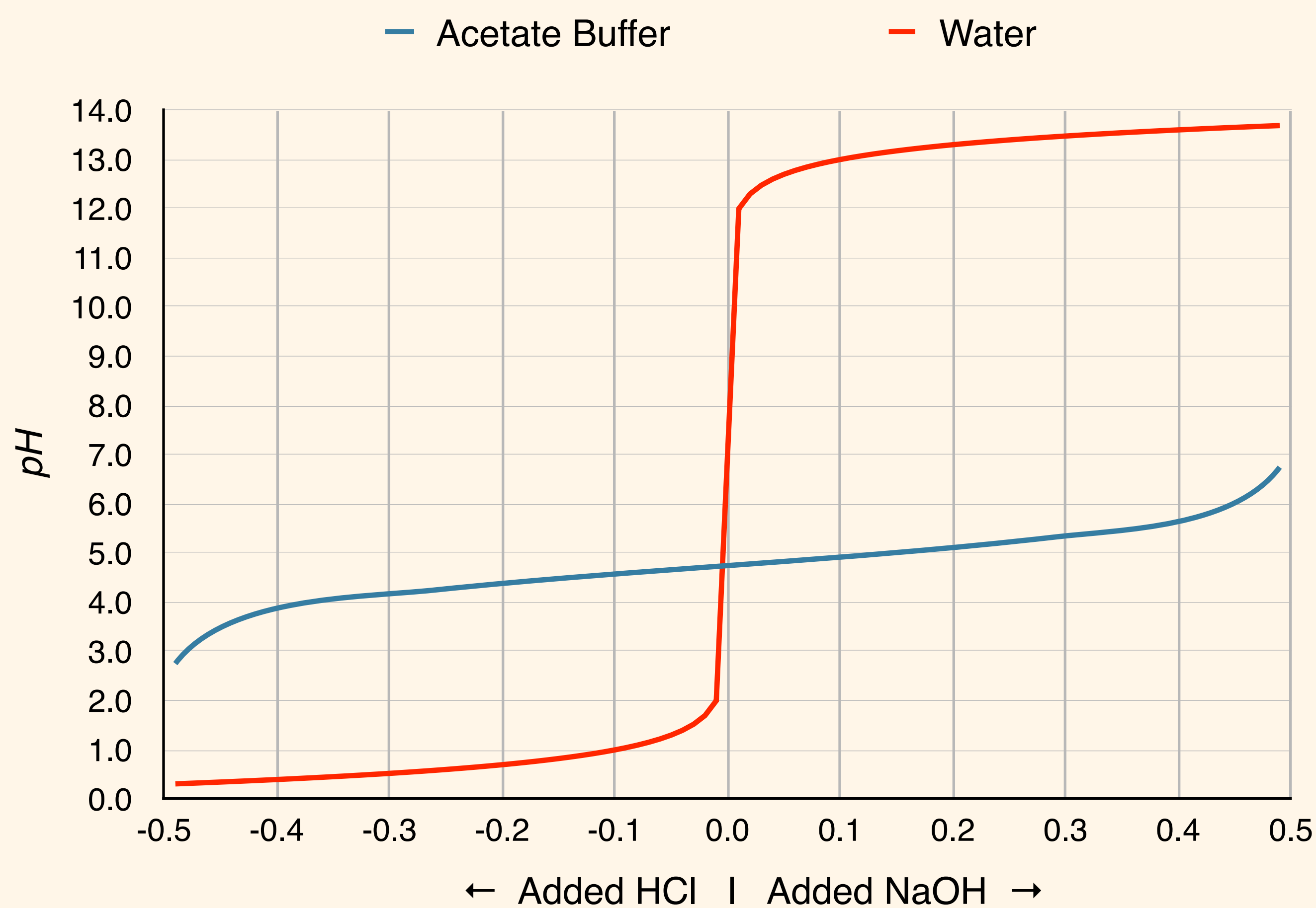
- Example: Acetic acid ($HC_2H_3O_2$) /Acetate ($C_2H_3O_2^-$) buffer (pK_a = 4.74)

Buffer

$HC_2H_3O_2$	+ OH^-	$\longrightarrow$	$C_2H_3O_2^-$	+ HOH
weak acid	strong base		weak base	weak acid
$C_2H_3O_2^-$	+ H_3O^+	$\longrightarrow$	$HC_2H_3O_2$	+ HOH
weak base	strong acid		weak acid	weak base

7.7 Buffers

- An acetate buffer will resist changes to the *pH* around *pH* 4.74, when either a strong acid (HCl) or base (NaOH) are added to the solution.



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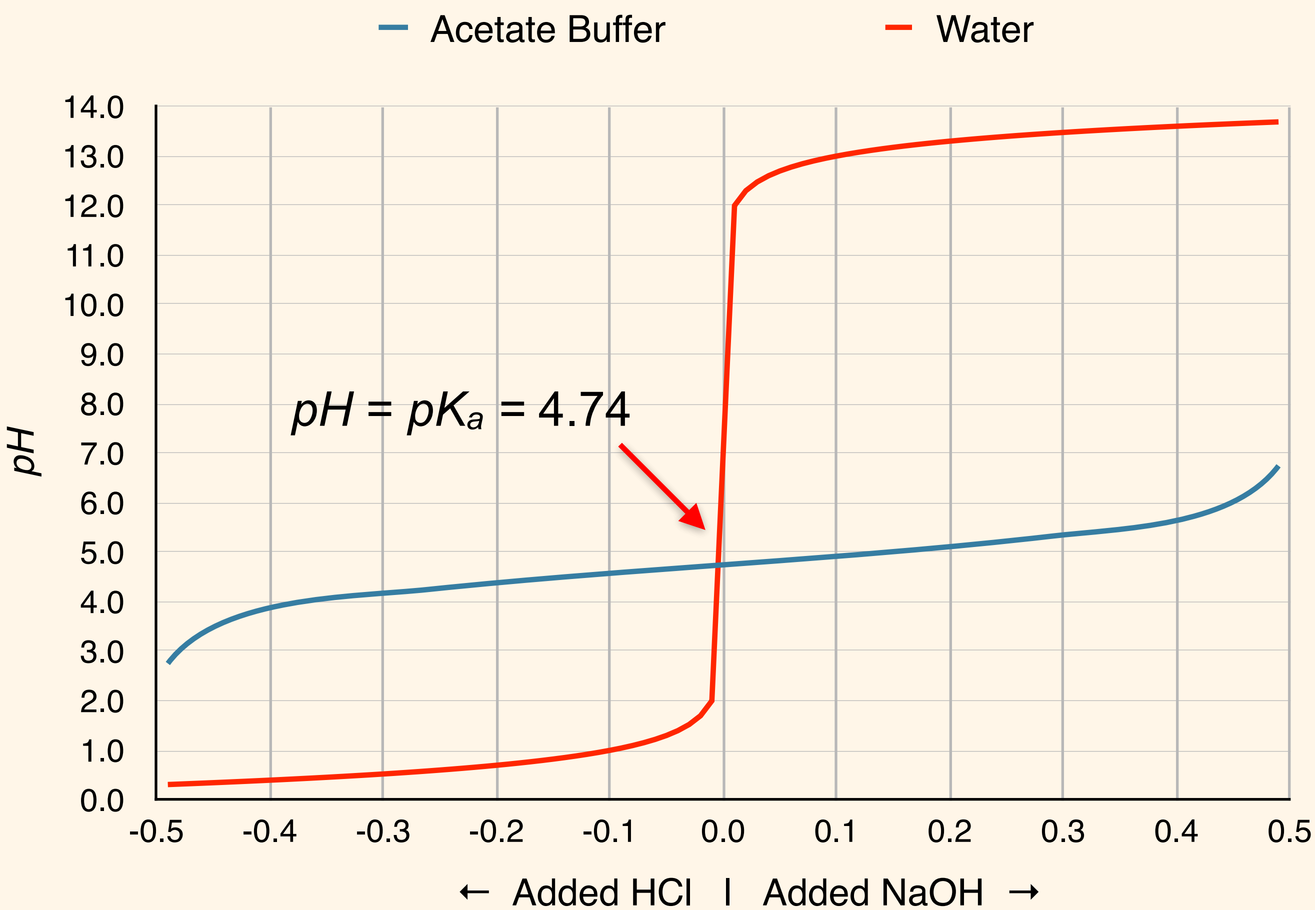

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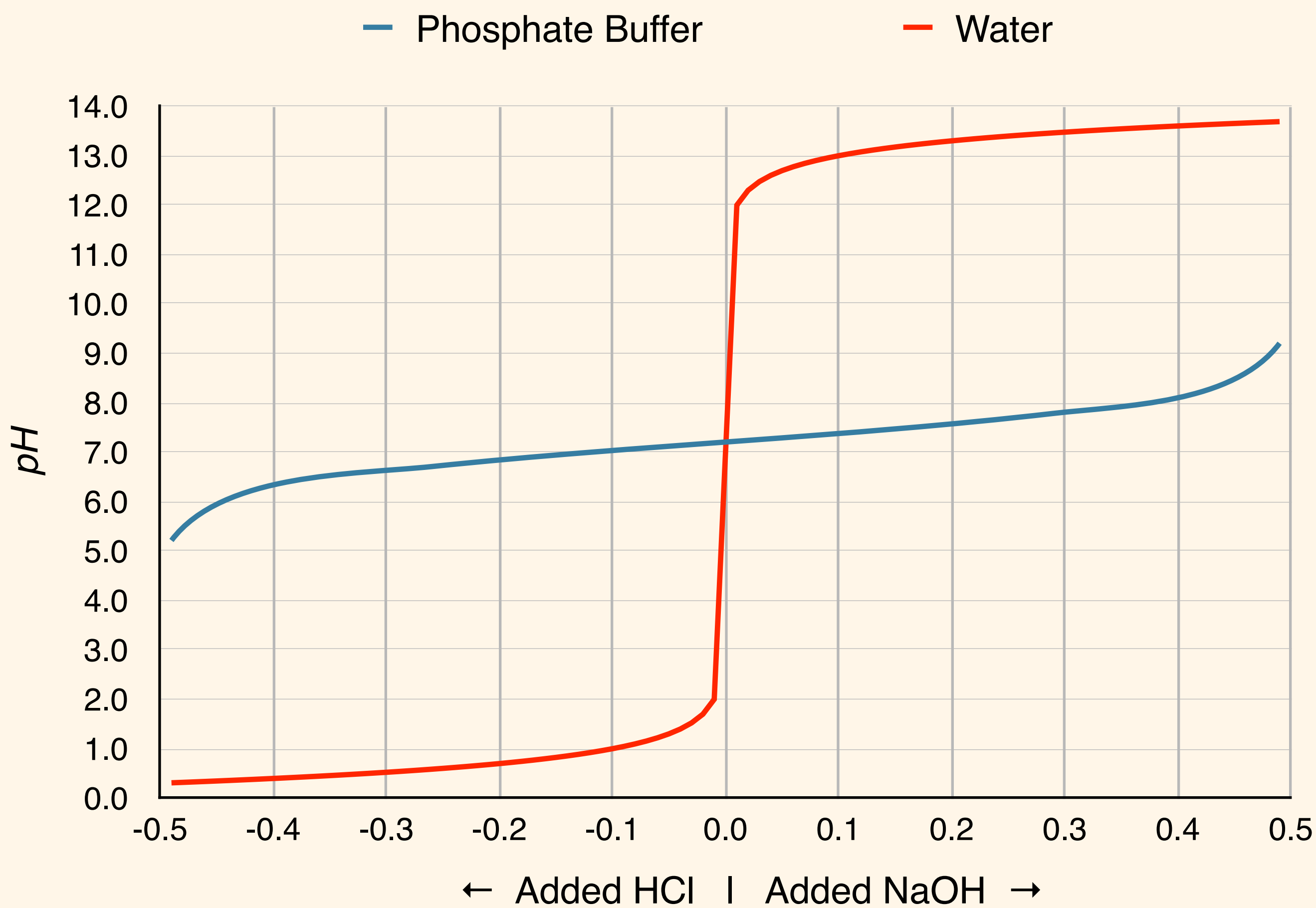

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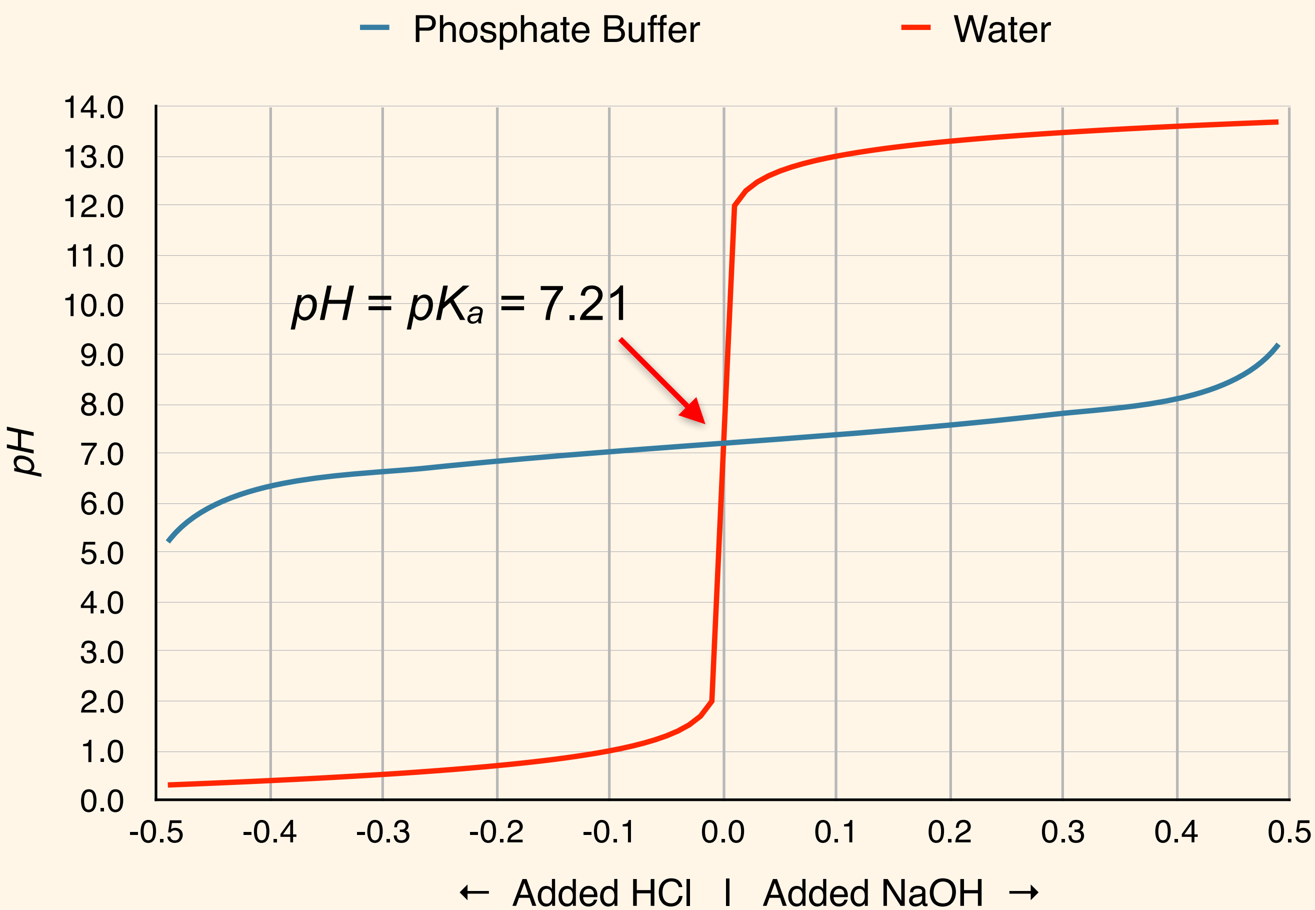
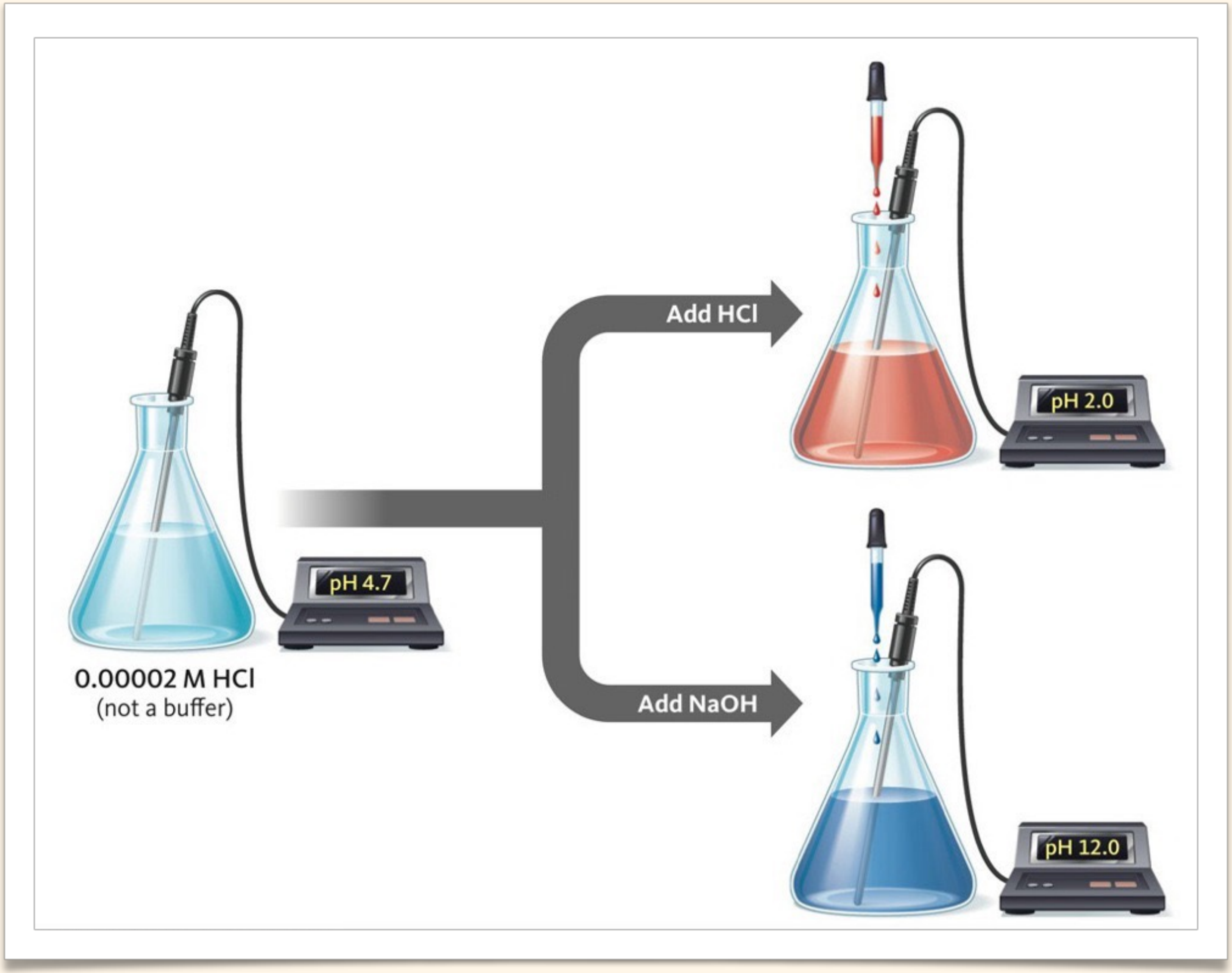
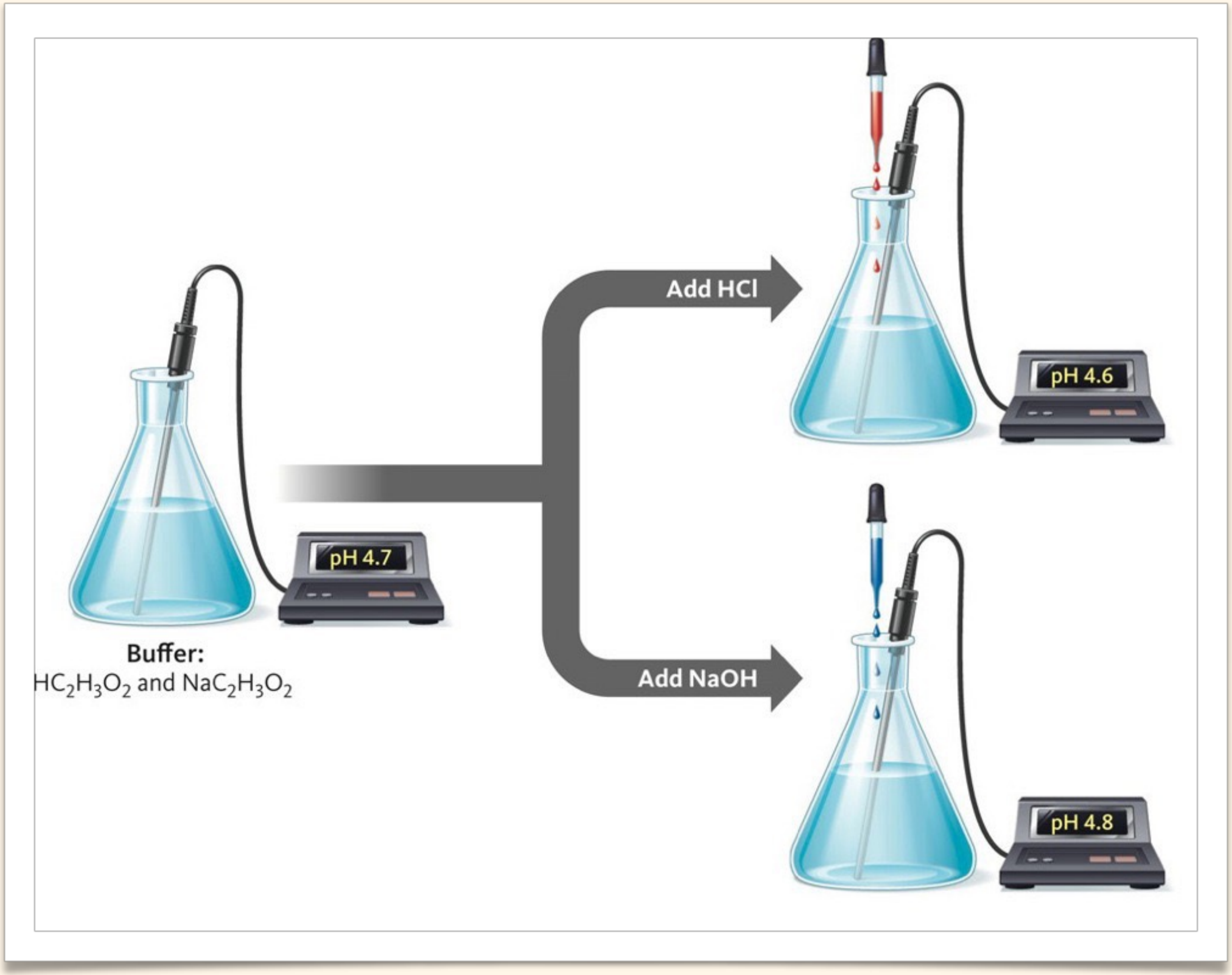


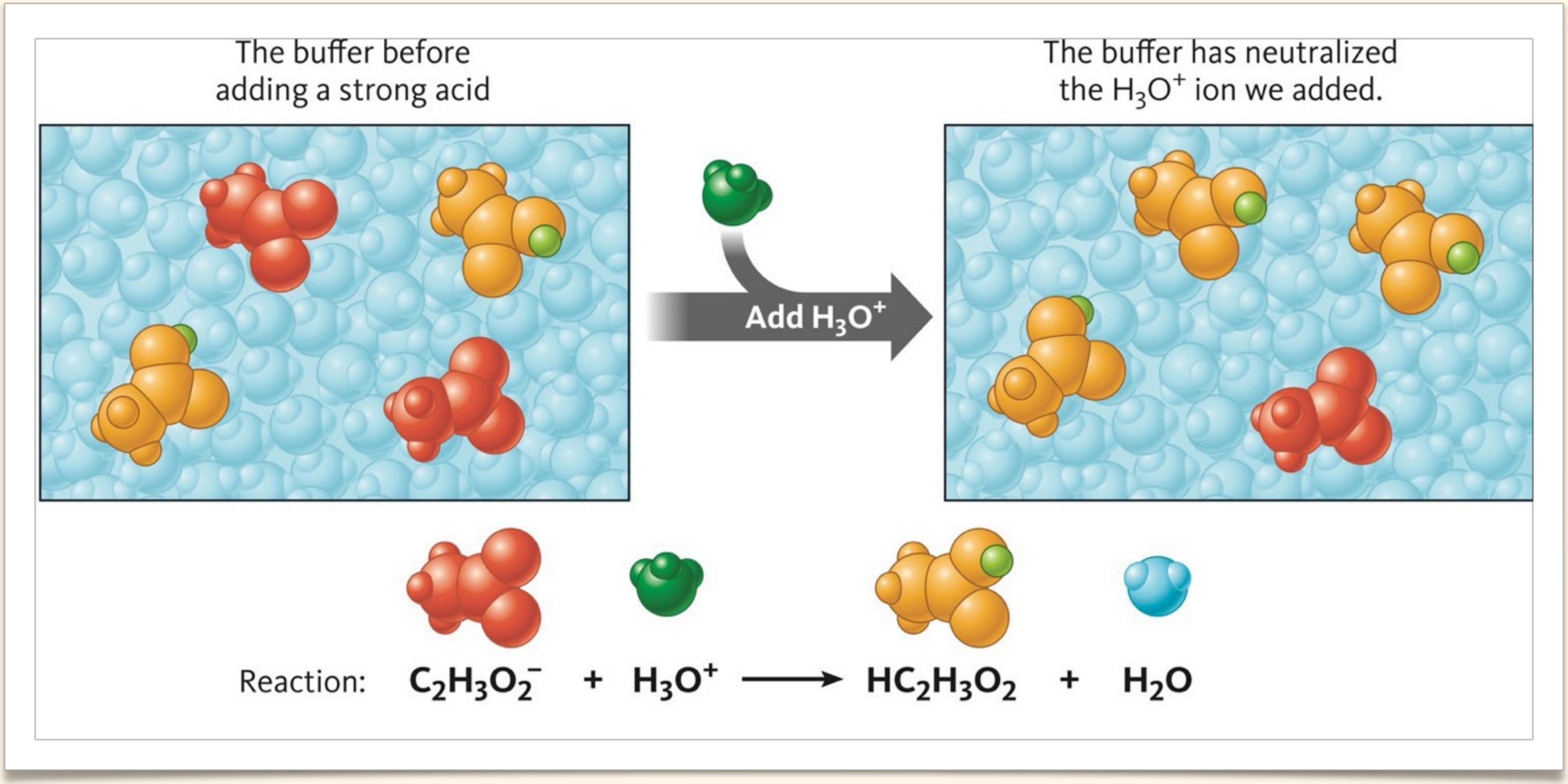
Significant pH Change (not buffered)



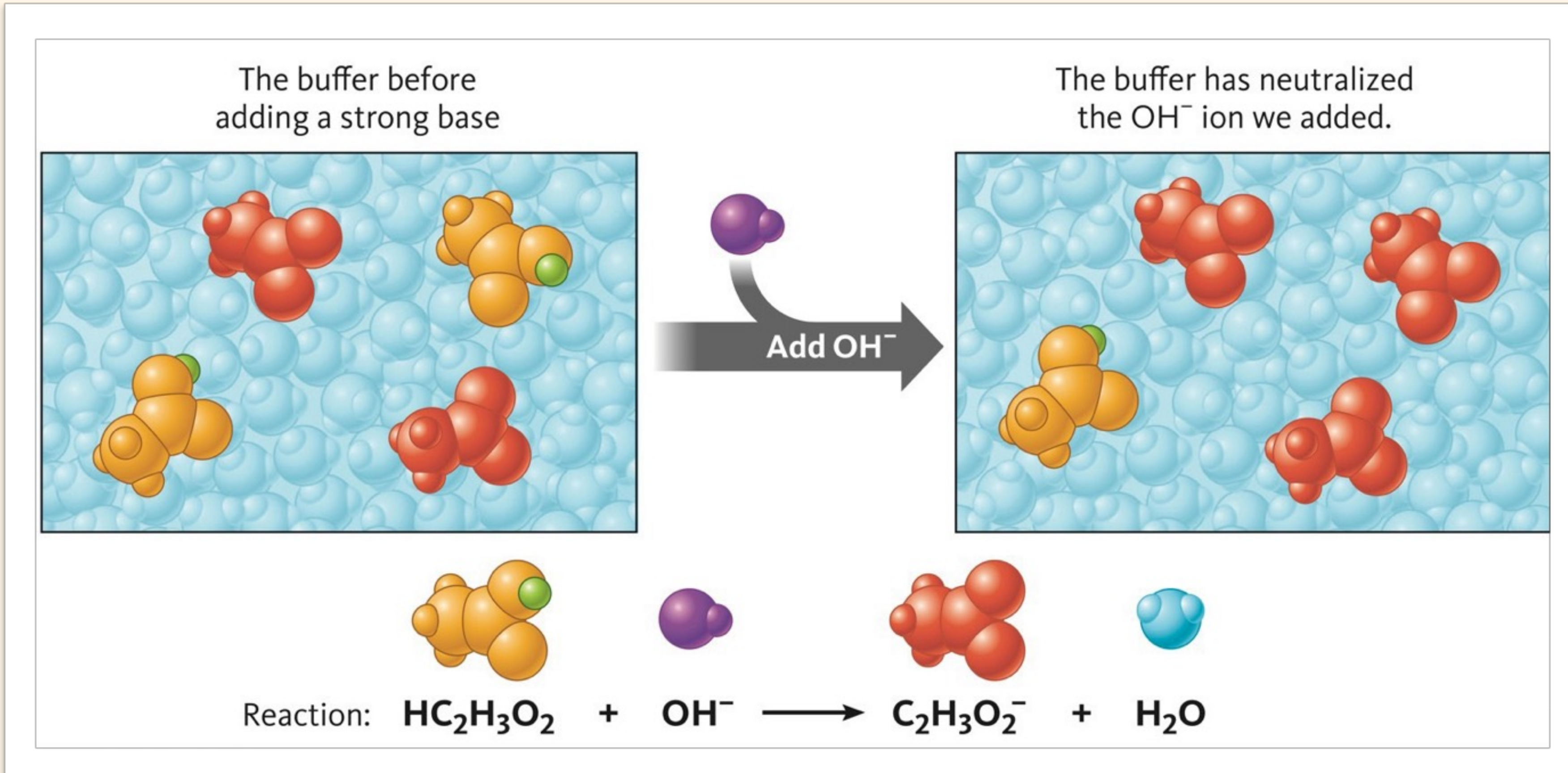
Buffer Solutions Resist Change in pH



Buffers Neutralize Acids



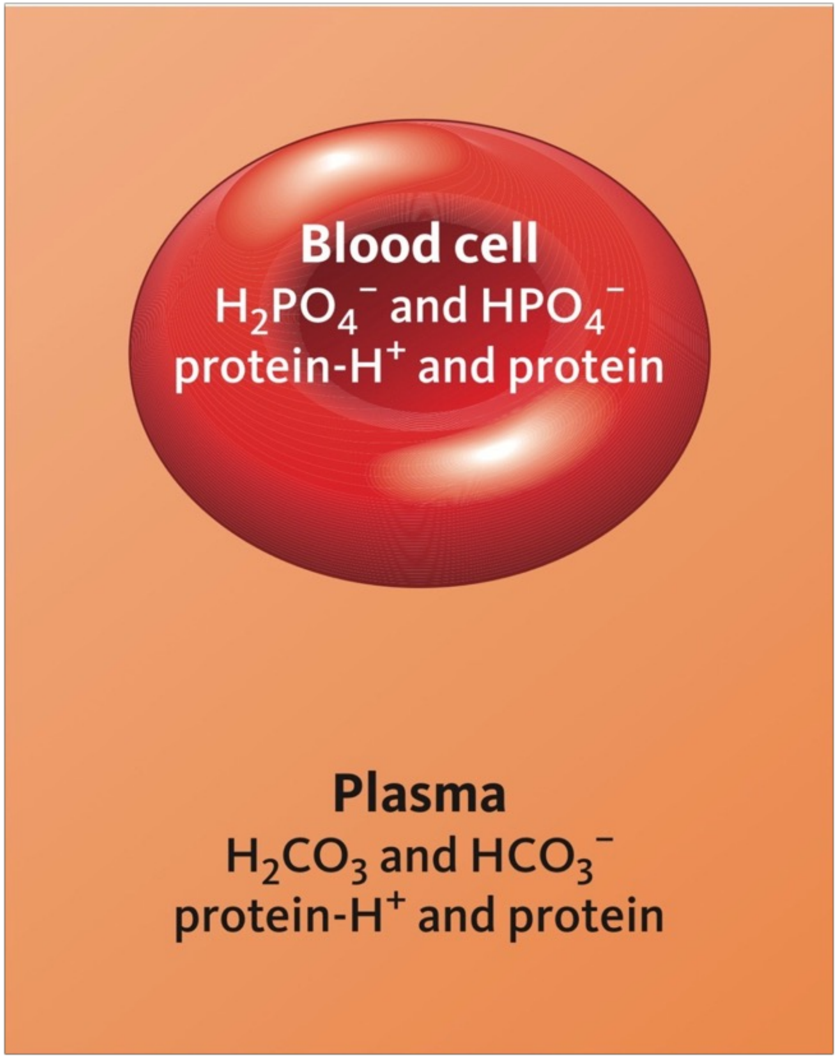
Buffers Neutralize Bases



7.8 The Role of Buffers in Human Physiology

- If blood *pH* drops below 7.35, you have acidosis.
- If blood *pH* rises above 7.45, you have alkalosis.
- There are three important buffers in the human body:
  1. Protein buffer system—proteins that contain amino acid that can serve as buffers.
  2. Phosphate buffer system—this system works with the protein buffer to maintain the *pH* of intercellular fluid.
  3. Carbonic acid buffer system (H_2CO_3) — the concentration of CO_2 in the blood can affect the plasma *pH*.

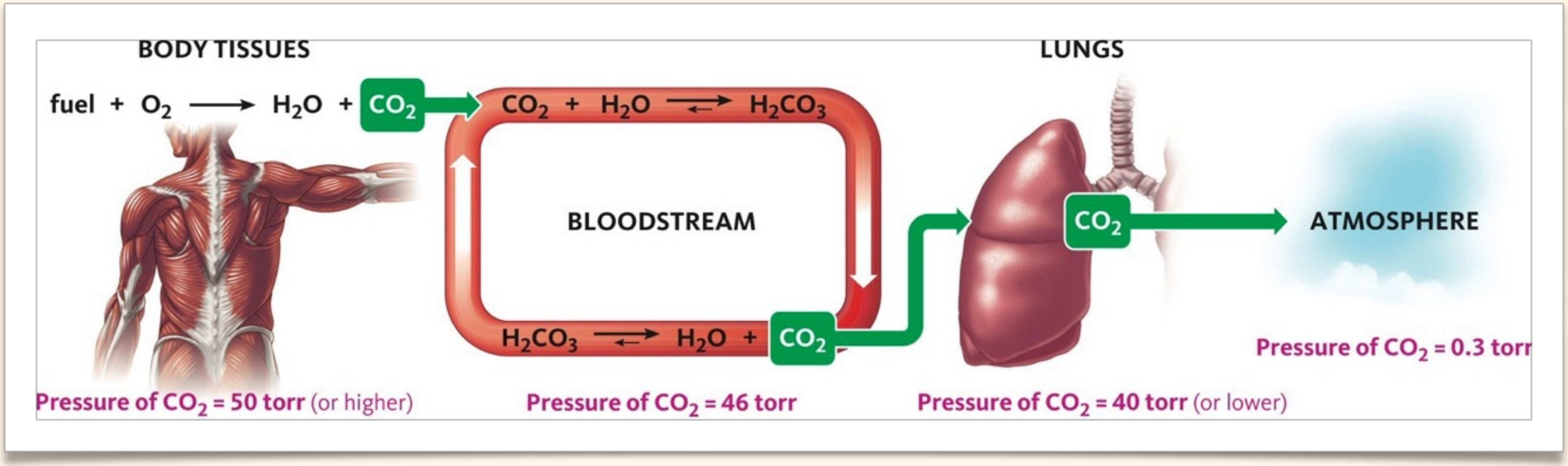
Buffers in Human Blood



Carbon Dioxide and the Carbonic Acid buffer

$$CO_2 + H_2O \leftrightharpoons H_2CO_3$$

- When CO_2 *increases*, the plasma pH goes *down*.
- When CO_2 *decreases*, the plasma pH goes *up*.



Carbon Dioxide and the Carbonic Acid buffer

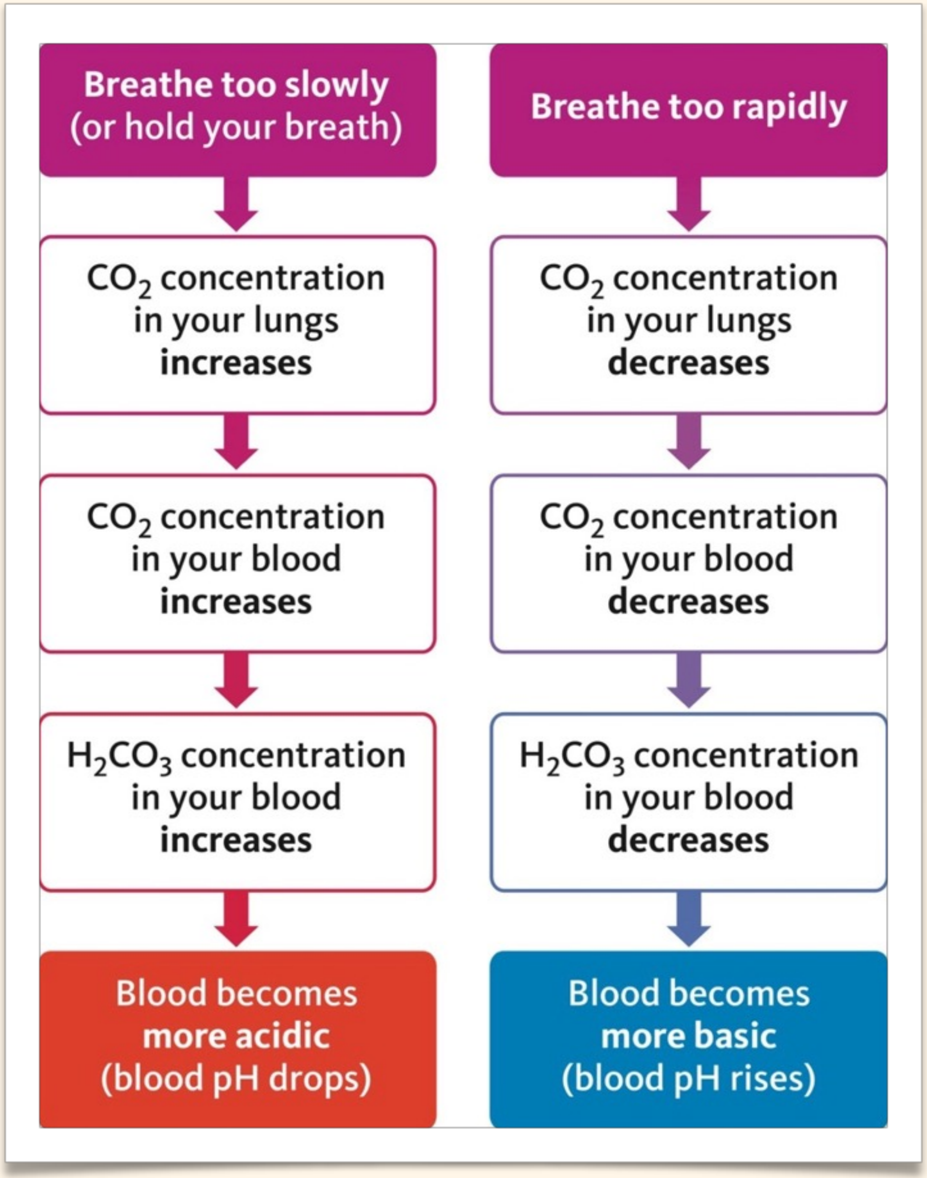
- Like combustions, the foods we eat for fuel are broken down to $CO_2 + H_2O$
  - The CO_2 dissolves in the plasma and is converted to carbonic acid

$$CO_2 + H_2O \leftrightharpoons H_2CO_3$$

- When CO_2 *increases*, the plasma pH goes *down*.
- When CO_2 *decreases*, the plasma pH goes *up*.

CO2 + H2O ⇋ H2CO3

Plasma pH and the Breathing Rate



Carbon Dioxide and the Carbonic Acid buffer

- The kidneys respond to elevated levels of CO_2 (H_2CO_3), by elevating the level of the conjugate base (HCO^-).

$$H_2CO_3 \;+\; H_2O \;\leftrightharpoons\; HCO_3^- \;+\; H_3O^+$$

Carbon Dioxide and the Carbonic Acid buffer

- The kidneys respond to elevated levels of CO_2 (H_2CO_3), by elevating the level of the conjugate base (HCO^-).

$$H_2CO_3 \; + \; H_2O \; \leftrightharpoons \; HCO_3^- \; + \; H_3O^+$$

excreted by
the kidneys

Kidneys Help Regulate Blood pH

TABLE 7.6 Acid–Base Regulation by the Kidneys

Substance Eliminated	Type of Substance	Result of Excretion	Comments
H_3O^+	Strong acid	Plasma pH *rises*	The kidneys make H_3O^+ by removing H^+ from H_2CO_3; the HCO_3^- is retained in the blood. This is the body's primary way to make HCO_3^- ions.
NH_4^+	Weak acid	Plasma pH *rises*	The kidneys make NH_4^+ by breaking down amino acids, so the body eliminates NH_4^+ only if the diet contains excess protein.
$H_2PO_4^-$	Weak acid*	Plasma pH *rises*	$H_2PO_4^-$ is only available if excess phosphate is present in the diet.
HCO_3^-	Weak base*	Plasma pH *drops*	This is the body's primary means of eliminating excess base.

* $H_2PO_4^-$ and HCO_3^- are amphiprotic ions, but $H_2PO_4^-$ functions as an acid and HCO_3^- functions as a base under physiological conditions.

Chapter 7—Key Health Science Notes

- *Respiratory acidosis* can be caused by
  - emphysema, pneumonia, asthma, pulmonary edema
  - drugs that suppress breathing
- *Metabolic acidosis*
  - hyperthyroidism and and sever diabetes which results in the over production of ketone bodies
  - Diarrhea, which disrupts the reabsorption of bicarbonate by the large intestine

Chapter 7—Key Health Science Notes

- *Respiratory alkalosis* can be caused by
  - hyperventilation brought on by anxiety
- *Metabolic alkalosis*
  - vomiting, which results in the loss of stomach acid

Next up

- Exam I on Thursday, 19. Feb.
  - Will cover Units 1 - 4