بیوشیمی عمومی

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آب، اسید و باز

اشکال آب در بدن

- داخل سلولی (40% وزن بدن)
- خارج سلولی (20% وزن بدن)
  - آب میان بافتی (14 % وزن بدن)
  - پلاسما (5 % وزن بدن)
  - لنف، مایع نخاع، ... (1 % وزن بدن)

معادله هندرسون - هاسلباخ

$$pH = pK + Log\ \frac{[A^-]}{[HA]}$$

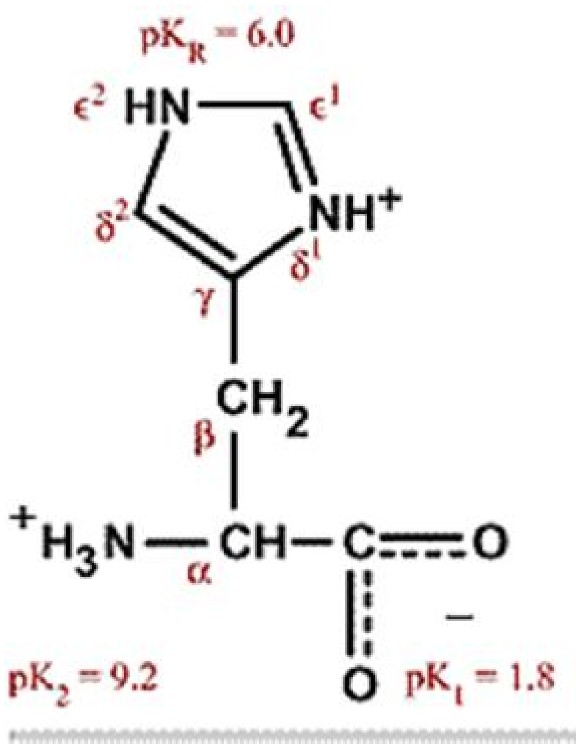
قدرت تامپونی

- غلظت اجزاء سازنده
- pK سیستم تامپونی

سیستم های تامپونی بدن

- سیستم بیکربنات
- سیستم فسفات
- هموگلوبین
- پروتئین
- سیستم آمونیاک

هیستیدین



علل اختلالات اسید و باز

- تنفسي
  - اسيدوز
    - كاهش تـهويه آلوئولي
    - پنومونـي شديد
    - انسداد ريه
  - آلكالوز
    - اضطراب
    - ترك اعتياد

علل اختلالات اسيد و باز

- **متابوليك**
  - اسيدوز
    - افزايش توليد اسيد (توليد اسيد لاكتيك)
    - كتو اسيدوز
    - اتيلن گليكول
    - افزايش دفع بيكربنات
  - آلكالوز
    - افزايش دفع اسيد (استفراغ)
      - كاهش كلر ادرار (آلكالوز پاسخ دهنده به كلر)
    - سندرم كوشينگ و هيپرآلدسترونيسم (تخليه پتاسيم و افزايش دفع يون آمونيوم)
      - افزايش كلر ادرار (آلكالوز مقاوم به كلر)
    - مصرف مواد قليايي

Reference ranges and points

Parameter	Reference range	Reference point
pH	7.35-7.45	7.40
PCO_2	33-44 mm Hg	40 mm Hg
PO_2	75-105 mm Hg	
HCO_3^-	22-28 mEq/L	24mEq/L
Anion gap	8-16 mEq/L	12 mEq/L
Osmolar gap	<10 mOsm/L	

The Hydration of Carbon Dioxide in Water

$$CO_2 + H_2O$$

$$\downarrow$$

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$

As carbon dioxide goes into solution, carbonic acid is formed, which partially dissociates, liberating protons (H^+) and thus causing the solution to become more acidic, i.e., *lowering* the pH.

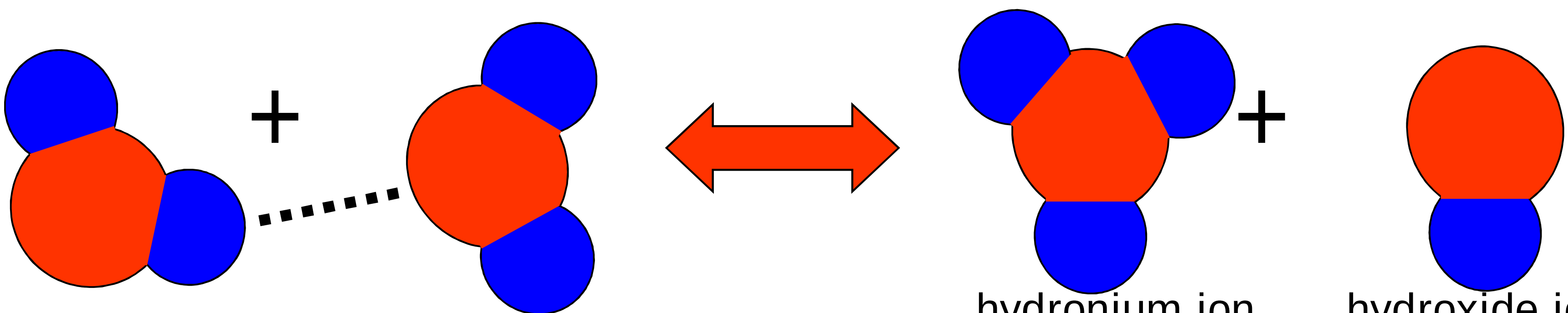
Weak acids thus are in equilibrium with their ionized species:

Governed by the Law of Mass Action, and characterized by an *equilibrium constant*:

$$HA \Longleftrightarrow H^+ + A^-$$

$$K_{eq} = \frac{[H^+][A^-]}{[HA]}$$

Water: A Very Weak Acid



hydronium ion hydroxide ion

$2\ H_2O$ H_3O^+ + OH^-

(an acid) (a base)

But this hardly happens at all: In fact, at equilibrium,

$[H^+] = [OH^-] = 0.0000001\ M = 10^{-7}\ M = pH\ 7$

Indeed, only two of every 10^9 (1 billion) molecules in pure water are ionized at any instant - *Can you confirm this?*

Comparative Equilibrium Constants

- Water: $K_{eq} = 1.8 \times 10^{-16}$
- Acetic acid $K_{eq} = 1.7 \times 10^{-5}$

A 100 billion-fold difference…

But still, of every 1000 acetic acid molecules in a 1 M solution of acetic acid, only 4 are ionized.

Can you figure out how to figure that out?

For biological systems:

- Ionization of a strong acid is TOO BIG!
- Ionization of water itself is way TOO LITTLE!
- Ionization of a weak acid is JUST RIGHT!

What if you could reverse this... by removing carbon dioxide?

$CO_2 + H_2O$

H_2CO_3

$HCO_3^- + H^+$

As carbon dioxide leaves the solution, carbonic acid is used up, which by the Law of Mass Action shifts the equilibrium to the left, using up protons (H^+) and thus causing the solution to become less acidic, i.e., *raising* the pH.

How Does This Work?

$CO_2 + H_2O$

$\uparrow$

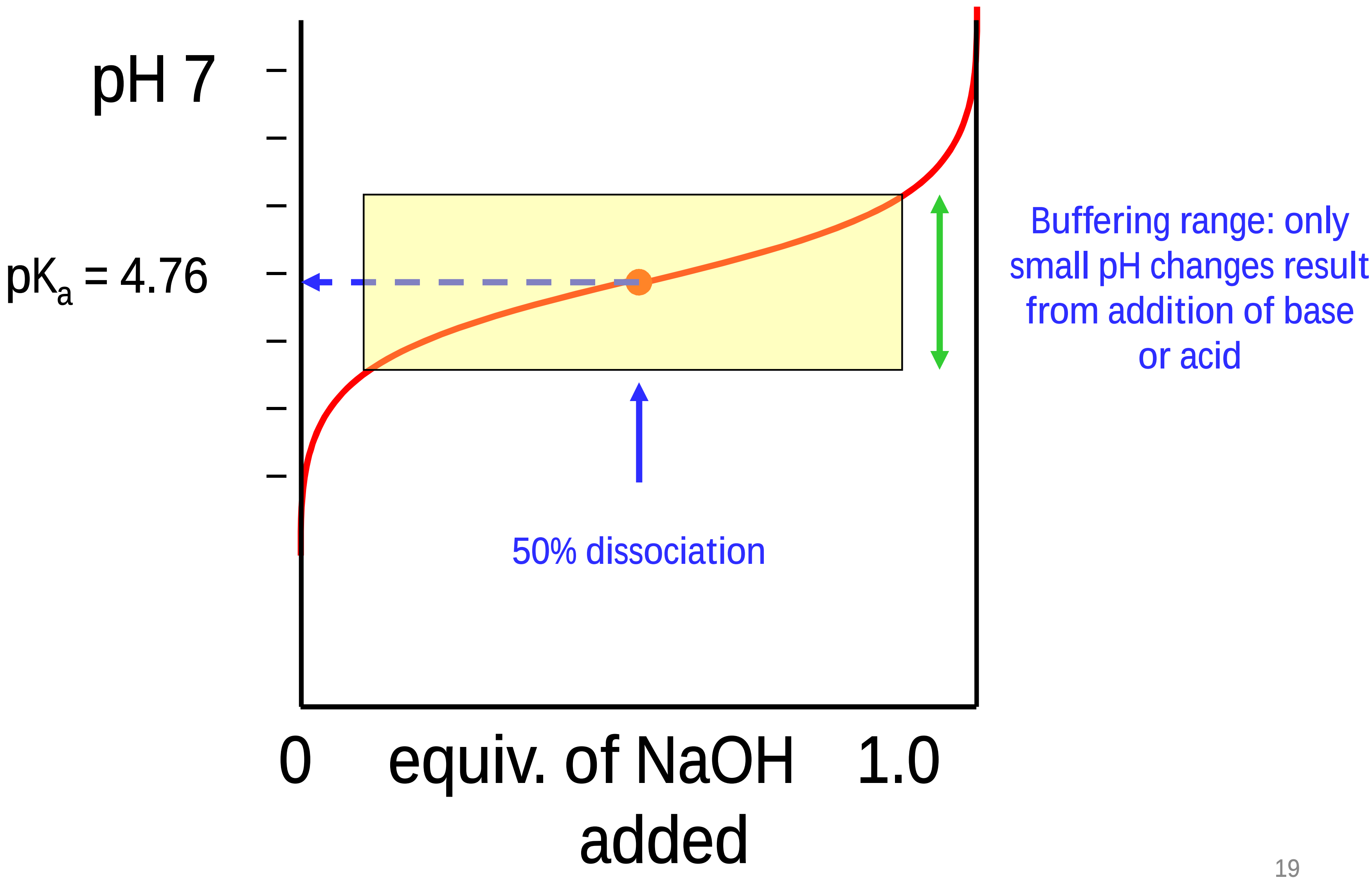
$H_2CO_3 \leftarrow HCO_3^- + H^+$

Here, the addition of excess bicarbonate will soak up many of the free protons, and drive the equilibrium to the left. This will *reduce* the acidity, *increasing* the pH, and the carbon dioxide produced will be blown off in the lungs. And make Molly feel MUCH better!

Weak acids, their conjugate bases, and buffers…

- Weak acids have only a modest tendency to shed their protons (definition of an acid).
- When they do, the corresponding negatively charged anion becomes a willing proton acceptor, and is called the *conjugate base.*
- The properties of a *buffer* rely on a balance between a weak acid and its conjugate base.
- And a titration curve looks like this…

Titration of acetic acid with sodium hydroxide



Insights for the Future

- pH control is important, as many enzymes have a narrow range in which they function optimally.
- Buffering capability is essential for the well-being of organisms, to protect them from unwelcome changes in pH.
- For example, your stomach is about pH 1, yet the adjacent portion of your intestine is near pH 7—think about (or look up) how that might happen [Hint: what is one function of the pancreas?].
- Many compounds and macromolecules in addition to bicarbonate can serve a buffering function—proteins comprise one of the major classes.