

Chapter Outline-1

Molecular Nature of Water

Noncovalent Bonding

Ionic interactions Hydrogen Bonds
van der Waals Forces

Thermal Properties of Water

Solvent Properties of Water

Hydrophilic, hydrophobic, and
amphipathic molecules

Osmotic pressure

3P2-1

Chapter Outline-2

Ionization of Water (**We are here.**)

Acids, bases, and pH

Buffers

Physiological buffers

3P2-2

3.5 (cont.) Monitoring Acidity

The **Henderson-Hasselbalch (HH) equation** is derived from the equilibrium expression for a weak acid.

$$\text{pH} = \text{pK}_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

3P2-3

Monitoring Acidity-2

The HH equation enables us to calculate the pH during a **titration** and to make predictions regarding **buffer solutions**.

What is a titration?

It is a process in which carefully measured volumes of a base are added to a solution of an acid in order to determine the acid concentration.

3P2-4

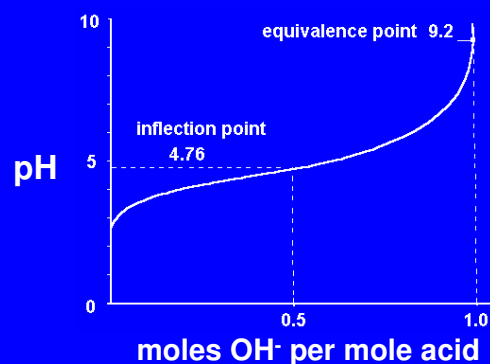
Monitoring Acidity-3

When chemically equal (equivalent) amounts of acid and base are present during a titration, the **equivalence point** is reached.

The equivalence point is detected by using an indicator chemical that changes color or by **following the pH of the reaction versus added base, ie. a titration curve**.

3P2-5

Titration Curve (HOAc with NaOH)



3P2-6

Titration Curve (HOAc with NaOH)-2

At the equivalence point, only the salt (NaOAc) is present in solution.

At the inflection point, equal moles of salt and acid are present in solution.

$$[\text{HOAc}] = [\text{NaOAc}]$$

$$\text{pH} = \text{pK}_a$$

3P2-7

Titration Curve (HOAc with NaOH)-3

The pK_a for acetic acid is 4.76.

1. Calculate the relative percents of acetic acid and acetate ion when the acid is titrated with 0.7 equivalents of NaOH.
2. Use the Henderson-Hasselbalch equation to calculate the pH at this point. (Click for answer.)

3P2-8

Titration Curve (HOAc with NaOH)-4

0.7 equivalents of NaOH neutralizes 0.7 eq of acid producing 0.7 eq of salt and leaving 0.3 eq of unneutralized acid.

pK_a of HOAc is 4.76

$$\text{pH} = 4.76 + \log \frac{[0.7]}{[0.3]}$$

30% acid and 70% salt. $\text{pH}=5.13$

3P2-9

Buffer Solutions

Buffer: a solution that resists change in pH when small amounts of strong acid or base are added.

A buffer consists of:

- a weak acid and its conjugate base
or
- a weak base and its conjugate acid

3P2-10

Buffer Solutions-2

Maximum buffer effect occurs at the pK_a for an acid.

Effective buffer range is ± 1 of the pK value for the acid or base.

eg. $\text{H}_2\text{PO}_4^-/\text{HPO}_4^{2-}$, $\text{K}_a=7.20$
buffer range 6.20-8.20 pH

3P2-11

Buffer Solutions-3

High concentrations of acid and conjugate base give a high buffering capacity.

Buffer systems are chosen to match the pH of the physiological situation, usually around pH 7.

3P2-12

Buffer Solutions-4

Within cells the primary buffer is the phosphate buffer: $\text{H}_2\text{PO}_4^- / \text{HPO}_4^{2-}$

The primary blood buffer is the bicarbonate system: $\text{HCO}_3^- / \text{H}_2\text{CO}_3$.

Proteins also provide buffer capacity. Side chains can accept or donate protons.

3P2-13

Buffer Solutions-5

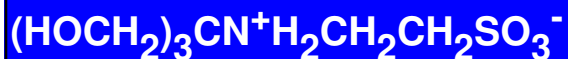
A zwitterion is a compound with both positive and negative charges.

Zwitterionic buffers have become common because they are less likely to cause complications with biochemical reactions.

3P2-14

Buffer Solutions-6

N-tris(hydroxymethyl)methyl-2-aminoethane sulfonate (TES) is a zwitterion buffer example.



3P2-15

Buffer Solutions-7

Buffers work by chemically tying up acid and base. Eg.:



3P2-16

Buffer Solutions-8

Calculate the ratio of lactic acid to lactate in a buffer at pH 5.00. The pK_a for lactic acid is 3.86

$$5.00 = 3.86 + \log \frac{[\text{lactate}]}{[\text{lactic acid}]}$$

$$5.00 - 3.86 = \log \frac{[\text{lactate}]}{[\text{lactic acid}]}$$

$$\text{antilog } 1.14 = \frac{[\text{lactate}]}{[\text{lactic acid}]} = 13.8$$

3P2-17