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World of CHEMISTRY

Chapter 16

- Acids and Bases

Overview

- Arrhenius and Bronsted-Lowry models for acids and bases
- Acid strength
- Relationship between acid strength and conjugate base
- Ionization of water
- pH and pOH
- Acid-base titration
- Buffered solutions

Acids (Arrhenius Model)

- *Produce hydrogen ions in aqueous solution*

$HCl(g) \rightarrow H^+(aq) + Cl^-(aq)$

- First recognized as substances that taste sour
  - Vinegar, citric acid
- Sulfuric acid
  - Most manufactured chemical
  - Used in fertilizers, detergents, plastics, storage batteries, pharmaceuticals, and metals
- Very important: make lemons sour, digest food, clean deposits out of coffee maker

Bases (Arrhenius model)

- *Produce hydroxide ions in aqueous solution*

$NaOH(s) \rightarrow Na^{+}(aq) + OH^{-}(aq)$

- Sometimes called alkalis
- Bitter taste and slippery feel
- Hand soaps, Drano (drain cleaners)
- (Arrhenius experimented with electrolytes and was one of first to recognize the nature of acids & bases)

Bronsted-Lowry Model

- Arrhenius concept limited because only recognized hydroxide ion as a base
- Acid = proton (H^+) donor
- Base = proton acceptor

$$HA(aq) + H_2O(l) \rightarrow H_3O^+(aq) + A^-(aq)$$

Acid *Base* *Conjugate* *Conjugate*

AcidBase

(Hydronium Ion)

Acid Strength

- *Strong acid*: the acid is completely ionized or completely dissociated
  - Conducts electricity better than weak acid
  - Forward reaction predominates
  - Contains a relatively weak conjugate base (low attraction for protons – weaker than water)
- *Weak acid*: dissociates (ionizes) only a small extent in aqueous solution
  - Contains relatively strong conjugate base (stronger than water)

Figure 16.1: Representation of the behavior of acids of different strengths in aqueous solution.

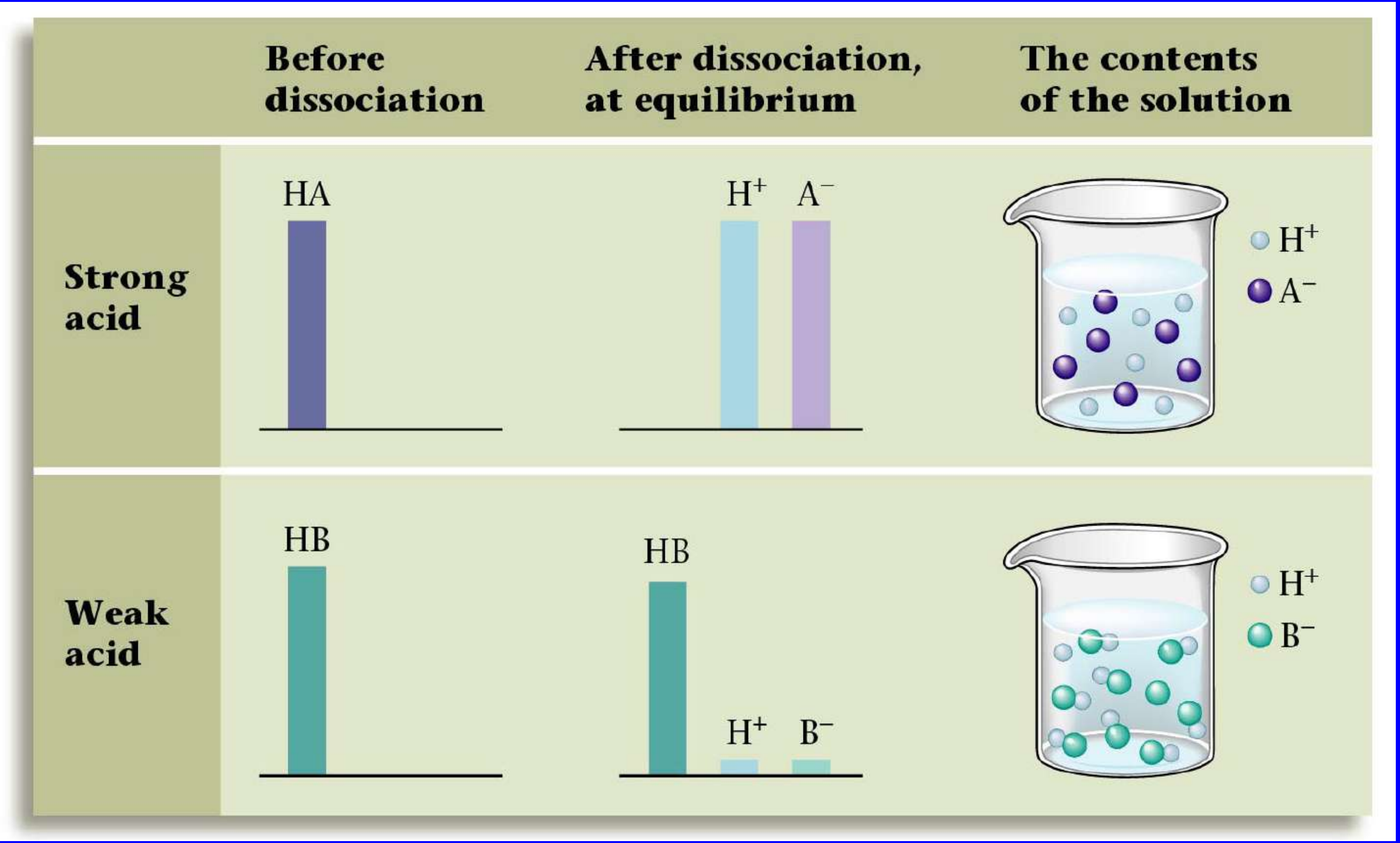
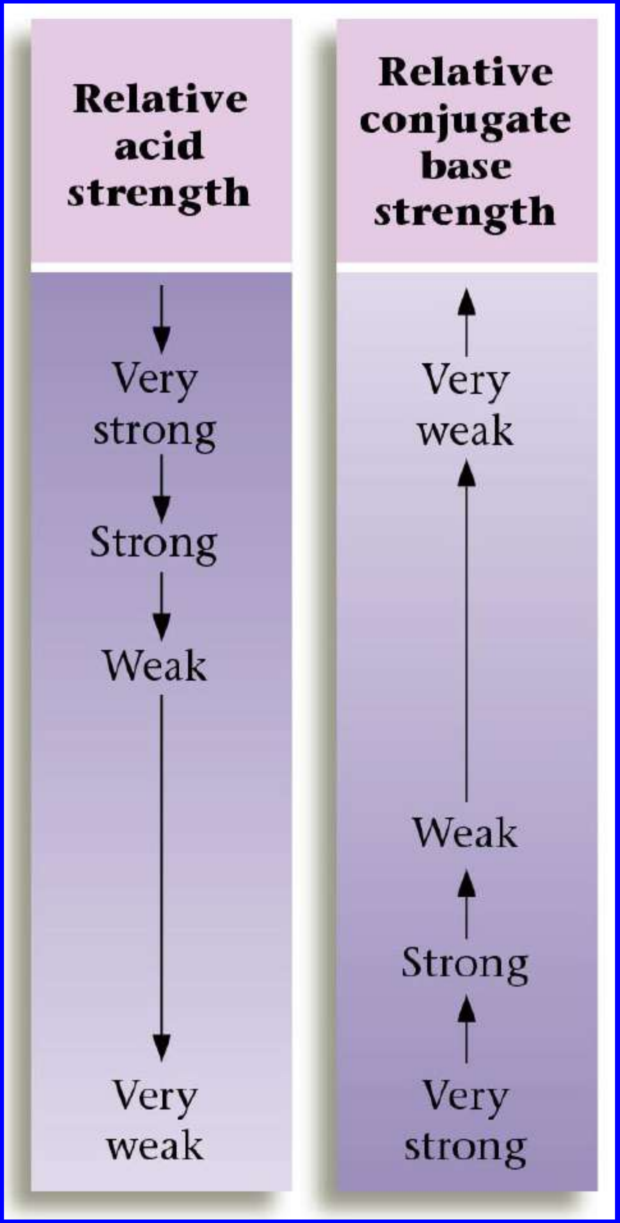


Figure 16.2: Relationship of acid strength and conjugate base strength for the dissociation reaction.



Types of Acids

- Oxyacids
  - Acidic hydrogen is attached to an oxygen atom
  - Usually strong: Phosphoric acid, nitrous acid
- Organic acids
  - Have a carbon-atom backbone (carboxyl group)
  - Usually weak: acetic acid
- Hydrohalic acids
  - Acidic proton attached to halogen
  - HCl – strong, HF - weak

Water: an acid and a base

- *Amphoteric substance*: can behave either as an acid or a base
  - Water = most common
  - Ionization of water

  $H_2O(l) + H_2O(l) \rightarrow H_3O^+(aq) + OH^-(aq)$
- K_w = ion-product constant (water)
- $K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$
  - in any aqueous solution at 25°C, no matter what it contains, must equal K_w

What type of solution?

- Neutral solution: $[H^+] = [OH^-]$
- Acidic solution: $[H^+] > [OH^-]$
- Basic solution: $[OH^-] > [H^+]$

- In each case $[H^+][OH^-] = 1.0 \times 10^{-14}$

The pH Scale

- To express small numbers, chemists use the "p scale" – based on common logarithms

pN = -log N = (-1) x log N

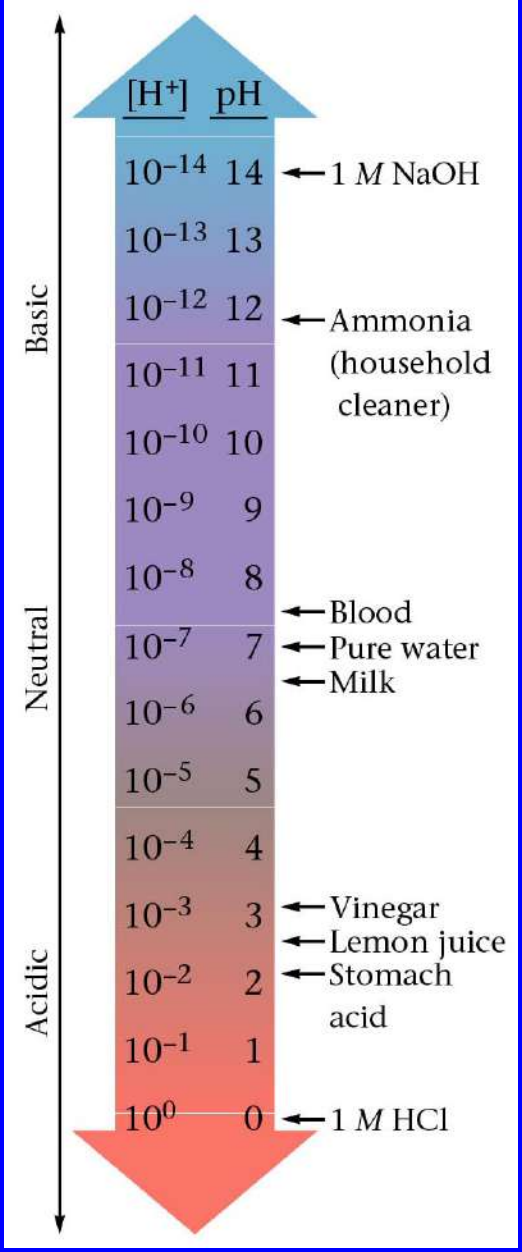
- pH scale: used to represent solution acidity

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

  So, if $[H+] = 1.0 \times 10^{-5}$ M

  $pH = -\log(1.0 \times 10^{-5}) = 5.00$

Figure 16.3: The pH scale.



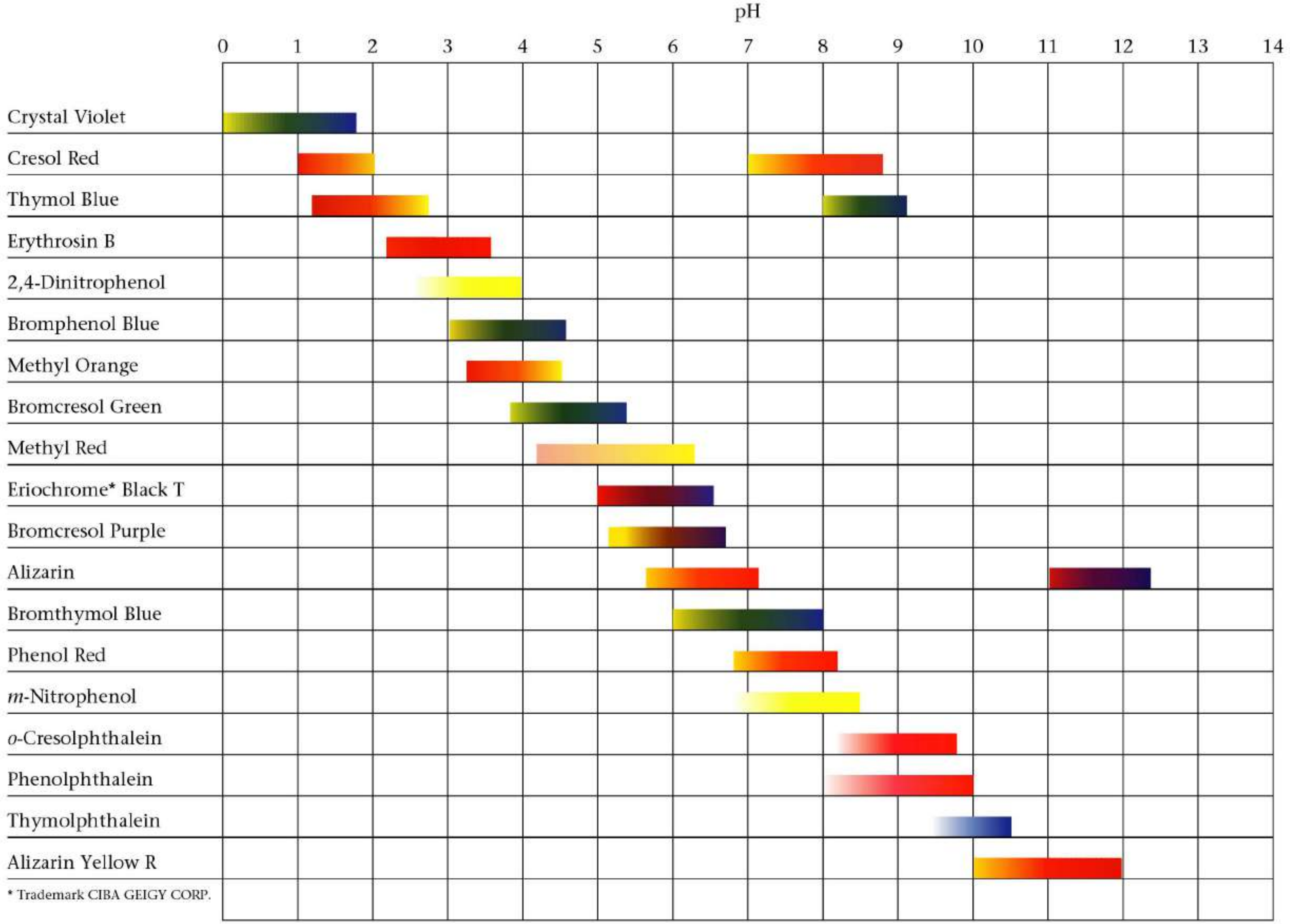
pOH

- Rarely used

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

$$pH + pOH = 14.00$$

Figure 16.4: Useful pH ranges for several common indicators.



The pH ranges shown are approximate. Specific transition ranges depend on the indicator solvent chosen.

Measuring pH

- Indicators: substances that exhibit different colors in acidic and basic solutions
- Indicator paper – strip of paper coated with a combination of indicators, turns a specific color for each pH value
- pH meter – electronically measures pH
  - Probe sensitive to $[H^+]$ in a solution
  - Produces voltage that appears as pH reading

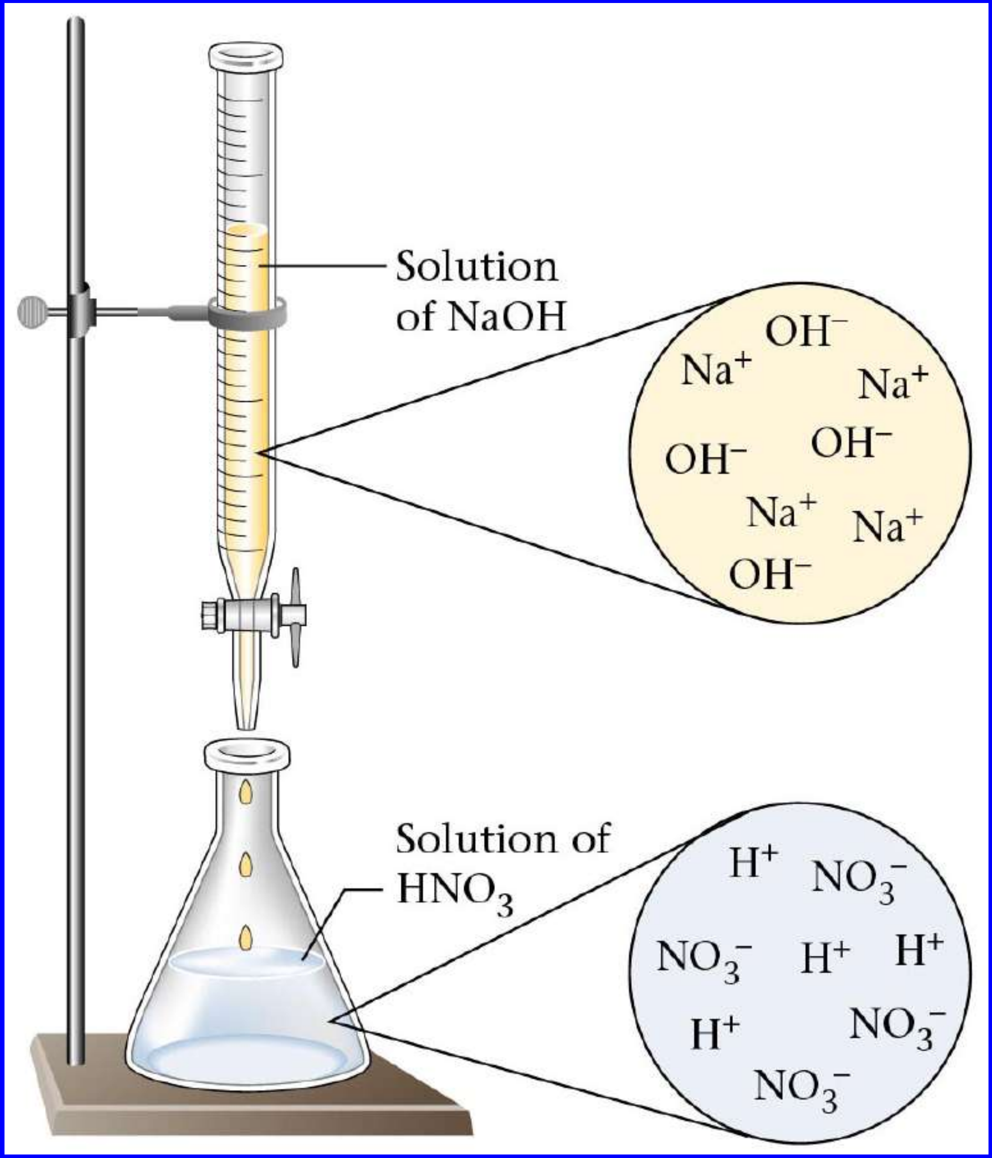
Acid-Base Titrations

- Neutralization reaction: equal amounts of H^+ and OH^- available for reaction, neutral solution is result

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

- Titration: delivery of a measured volume of a solution of a known concentration (titrant) into the solution being analyzed (analyte)
  – If you want to know how much base is in solution, titrate with a strong acid
  – Standard solution: solution of known concentration

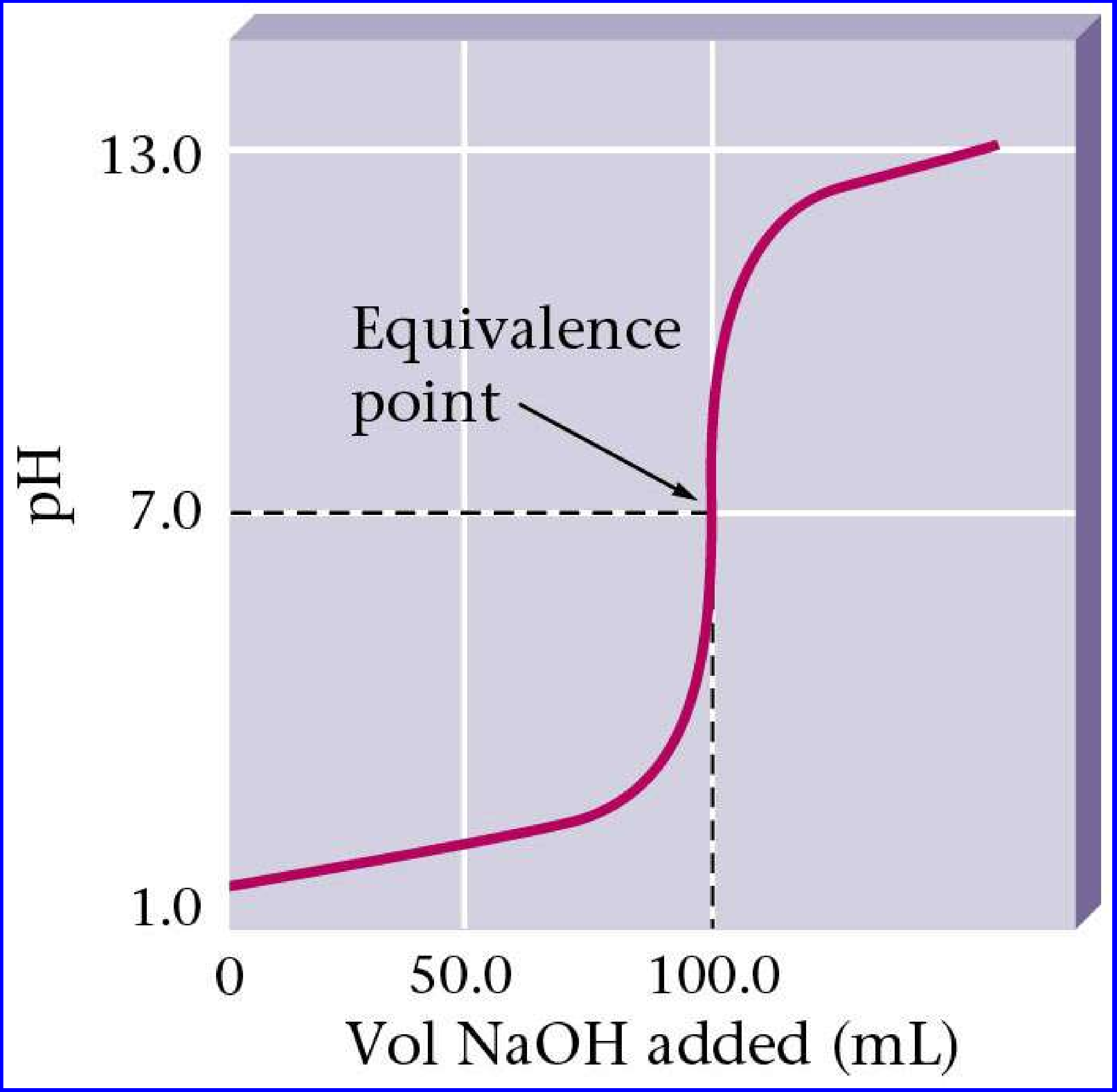
Figure 16.8: Microscopic picture of the solutions in the titration of 0.200 M HNO_3 with 0.100 M NaOH.



Acid-Base Titrations

- *Stoichiometric point/equivalence point*: when exactly enough titrant has been added to react with all of the analyte
  - For acid/base: when pH = 7.00
- Titration curve/pH curve: plot of data from titration (see next slide)

Figure 16.9: The pH curve for the titration of 50.0 mL of 0.200 *M* HNO_3 with 0.100 *M* NaOH.



Buffered Solutions

- *Solution that resists a change in its pH even when a strong acid or a strong base is added to it*
- Vitally important to living organisms whose cells can only survive in a small pH range (goldfish, human blood 7.35-7.45)
- Buffered by presence of a weak acid and its conjugate base
  – Resists change in pH by reacting with any added H^+ or OH^- so they do not accumulate