Chapter 17

Acid – Base Equilibria
&
Solubility Equilibria

Buffer Solutions (Buffers)

Solutions that resist changes in pH when small amounts of acid or base are added

- Must contain a <u>weak</u> acid or base **<u>and</u>**
- The <u>conjugate</u> (salt) of the weak acid or base
- i.e. Contain a weak conjugate acid/base pair
- pH is controlled by equilibrium [K_a (or K_b)]

$$HA + H_2O \rightleftharpoons H_3O^+ + A^-$$

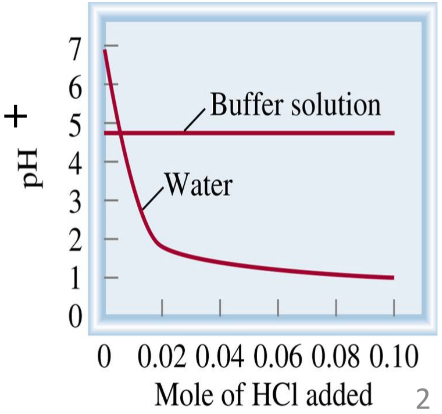
When small amounts of a strong acid or base are added:

- Acidic species in buffer neutralizes added OH^-

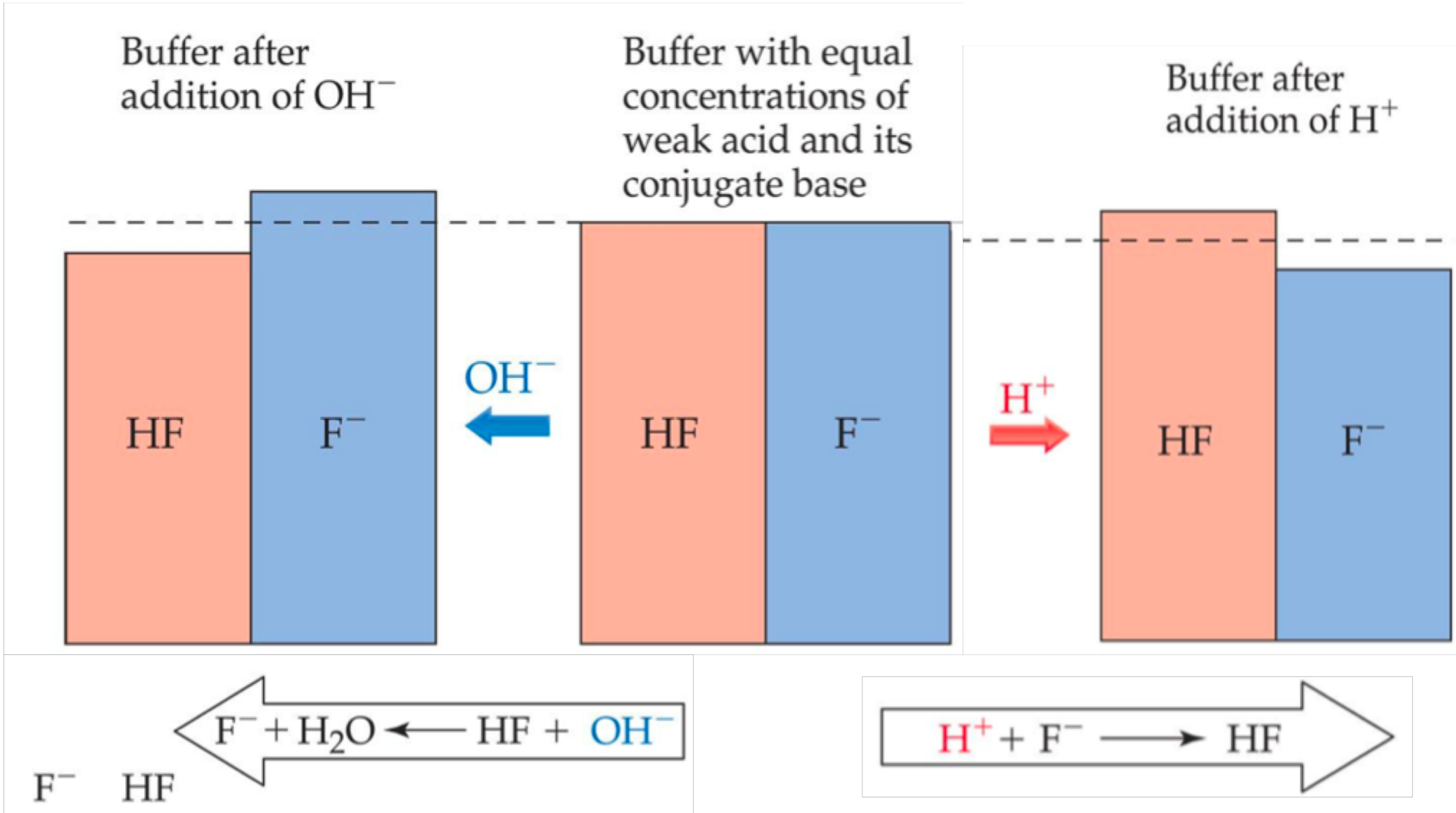
$$HA + OH^- \rightleftharpoons H_2O + A^-$$

- Basic species in buffer neutralizes added H^+

$$A^- + H_3O^+ \rightleftharpoons H_2O + HA$$



How Buffers Work – Le Châtelier's Principle



$$HF \rightleftharpoons H^+ + F^-$$

- Add OH^-, reduce H^+, shift equilibrium toward conj. Base
  - OH^- will react with H^+ to form water
- Add H^+, shift equilibrium toward undissociated acid

Henderson–Hasselbalch Equation

$$\boxed{\mathbf{pH = pK_a + \log \frac{[A^-]}{[HA]}}}$$

Comes from the equilibrium expression for: $HA \rightleftharpoons H^+ + A^-$

$$K_a = \frac{[H^+][A^-]}{[HA]} \Rightarrow K_a = [H^+]\frac{[A^-]}{[HA]}$$

Take the –log of both sides:

$$\underbrace{-\log K_a}_{pK_a} = \underbrace{-\log [H^+]}_{pH} + -\log \frac{[A^-]}{[HA]}$$

Conj. base

acid

Therefore:

$$pK_a = pH + -\log \frac{[A^-]}{[HA]}$$

For bases:

$$pOH = pK_b + -\log \frac{[BH^+]}{[B]}$$

Rearrange to get Henderson-Hasselbalch

Using the Henderson–Hasselbalch Equation

1. A 1.00L buffer solution is prepared that contains 0.150M nitrous acid and 0.200M sodium nitrite. What is its pH?
$K_a = 7.2x10^{-4}$

Ice Table Method

pH = 3.27

Using the Henderson–Hasselbalch Equation

1. A 1.00L buffer solution is prepared that contains 0.150M nitrous acid and 0.200M sodium nitrite. What is its pH?

$K_a = 7.2 \times 10^{-4}$

H-H equation method:

pH = 3.27

Using the Henderson–Hasselbalch Equation

2. How many grams of sodium lactate ($CH_3CH(OH)COONa$) should be added to 1.0L of a 0.150M lactic acid ($CH_3CH(OH)COOH$) to form a buffer solution with pH=4.00? $K_a = 1.4\times10^{-4}$; molar mass of sodium lactate = 112.1g/mol

A: 24g