Buffers

Sections 9.10

Buffers

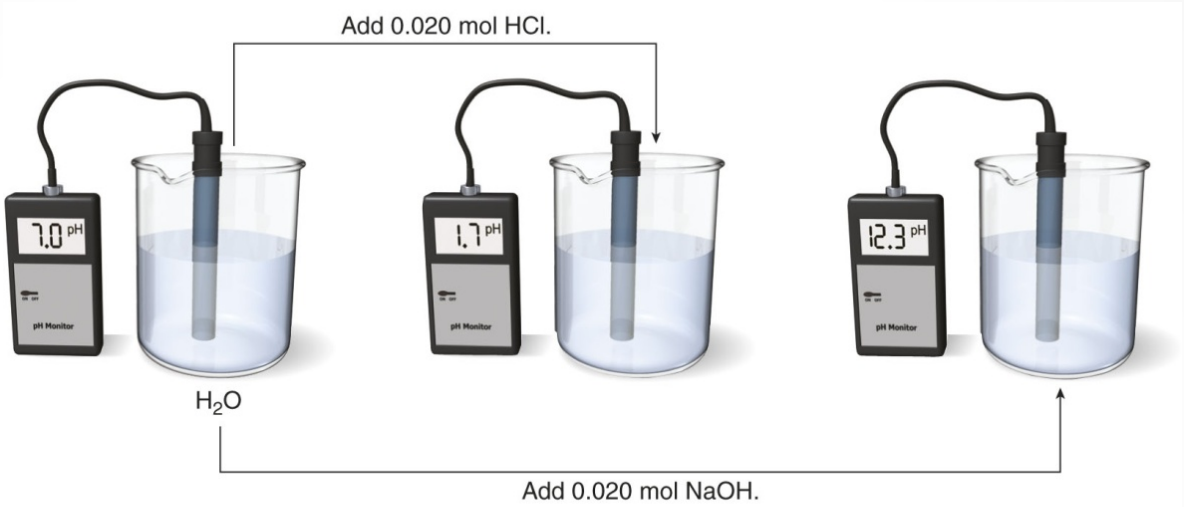
- A solution that is resistant to changes in pH
- Needs to be able to neutralize any added acid or base
- Must contain both an acid and a base
- **Most are solutions made up of a weak acid and the salt of its conjugate base**
- Usually in equal amounts

Buffers

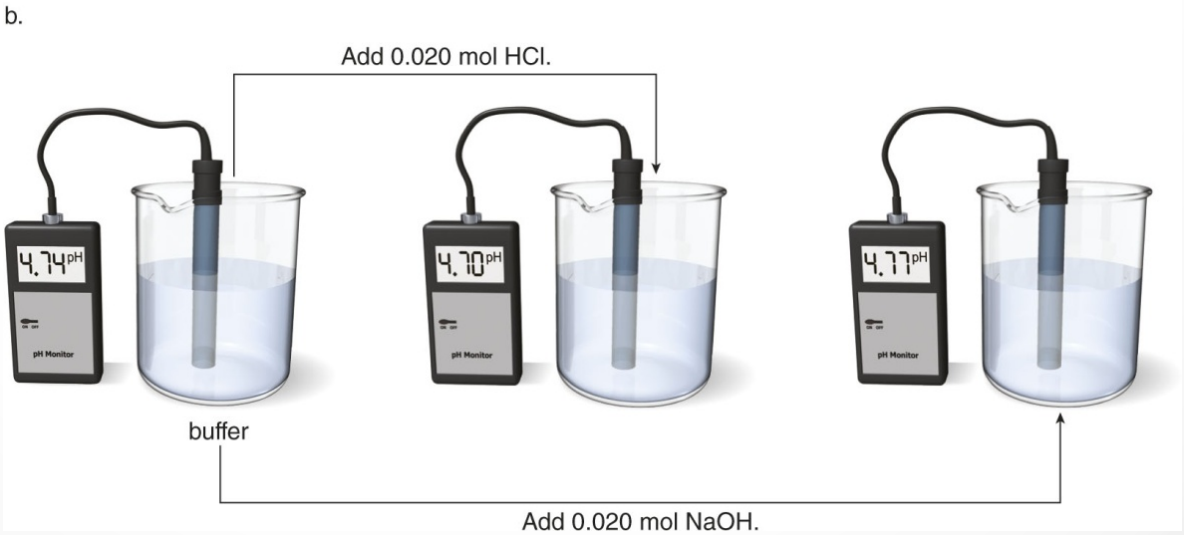
- Weak acid component reacts with any added base, OH^-
- Conjugate base component reacts with any added acid, H_3O^+

Buffers

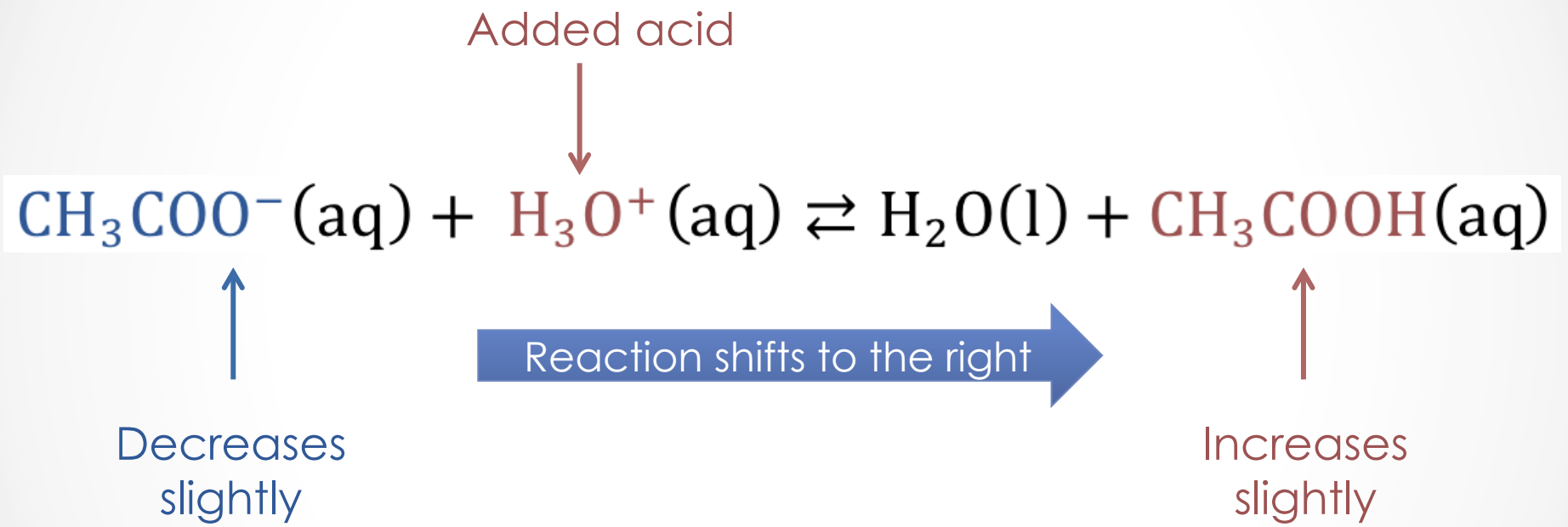
Water
(not a buffer)



Acetic acid
buffer



Adding Acid

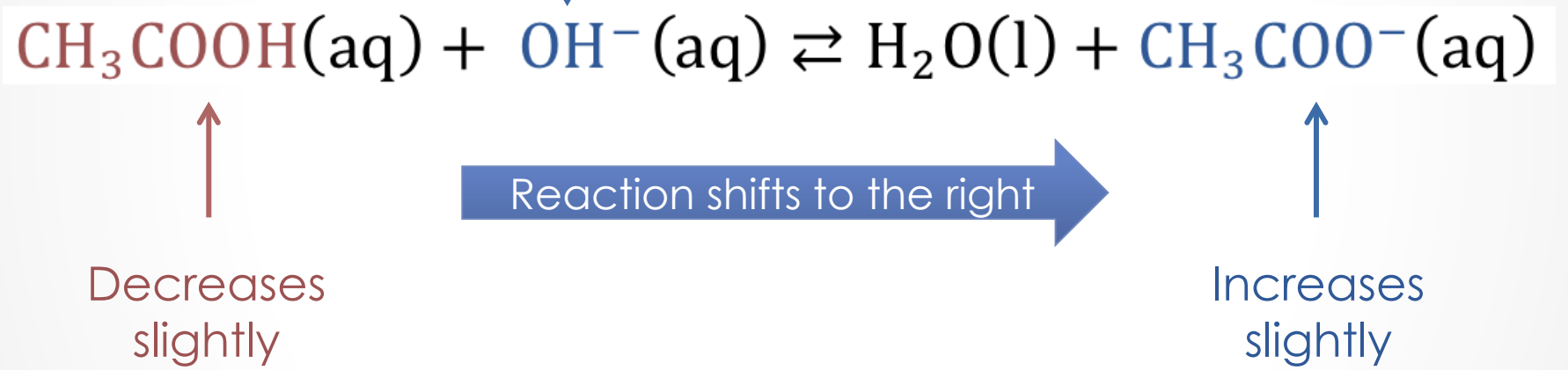


$$\frac{[CH_3COOH]}{[CH_3COO^-]} \leftarrow$$

- The ratio does not change much
- $[H_3O^+]$ does not change much

Adding Base

Added base



$$\frac{[CH_3COOH]}{[CH_3COO^-]} \leftarrow$$

- The ratio does not change much
- $[H_3O^+]$ does not change much

Common Buffer Systems

Buffer	Weak Acid	Conjugate Base	K_a
Acetic acid/ acetate	CH_3COOH	CH_3COO^-	1.8×10^{-5}
Bicarbonate/ carbonate	HCO_3^-	CO_3^{2-}	5.6×10^{-11}
Dihydrogen phosphate/ hydrogen phosphate	$H_2PO_4^-$	HPO_4^{2-}	6.2×10^{-8}
Hydrogen phosphate/ phosphate	HPO_4^{2-}	PO_4^{3-}	2.2×10^{-13}

Example #1

Determine whether a solution containing each of the following substances is a buffer. Explain your reasoning.

a. KBr and HBr

b. HF and NaF

c. CH_3COOH alone

Example #1 Solved

a. KBr and HBr: **not a buffer**, HBr is a strong acid

b. HF and NaF: **buffer**, HF is a weak acid, NaF is the salt of the conjugate base F^-

c. CH_3COOH alone: **not a buffer**, needs to contain the conjugate base in salt form (ex. $NaCH_3COO$)

Calculating pH of a Buffer

- Based on the ratio of weak acid concentration to the conjugate base concentration
- Also dependent on the K_a of the weak acid

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$[H_3O^+] = K_a \times \frac{[HA]}{[A^-]}$$

determines the buffer pH

Example #2

Calculate the pH of a dihydrogen phosphate/ hydrogen phosphate buffer prepared with 0.10 M NaH_2PO_4 and 0.10 M Na_2HPO_4.

Example #2 Solved

- 0.10 M NaH_2PO_4 and 0.10 M Na_2HPO_4
- HA: $H_2PO_4^-$, A^-: HPO_4^{2-}, $K_a = 6.2 \times 10^{-8}$
- Formula: $[H_3O^+] = K_a \times \frac{[HA]}{[A^-]}$

$$[H_3O^+] = K_a \times \frac{[H_2PO_4^-]}{[HPO_4^{2-}]} = 6.2 \times 10^{-8} \times \frac{[0.10]}{[0.10]} = 6.2 \times 10^{-8}\, M$$

- Formula: $pH = -\log[H_3O^+]$

$$pH = -\log[6.2 \times 10^{-8}] = 7.21$$

Example #3

Determine whether a solution containing each of the following substances is a buffer. Explain your reasoning.

a. HCN and KCN

b. HCl and NaOH

c. K_2HPO_4 and $H_2PO_4^-$

Example #4

Calculate the pH of a carbonic acid/hydrogen bicarbonate buffer prepared with 0.55 M H_2CO_3 and 0.45 M $NaHCO_3$.

(You will need to look up the K_a for carbonic acid)