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BUFFER SOLUTIONS

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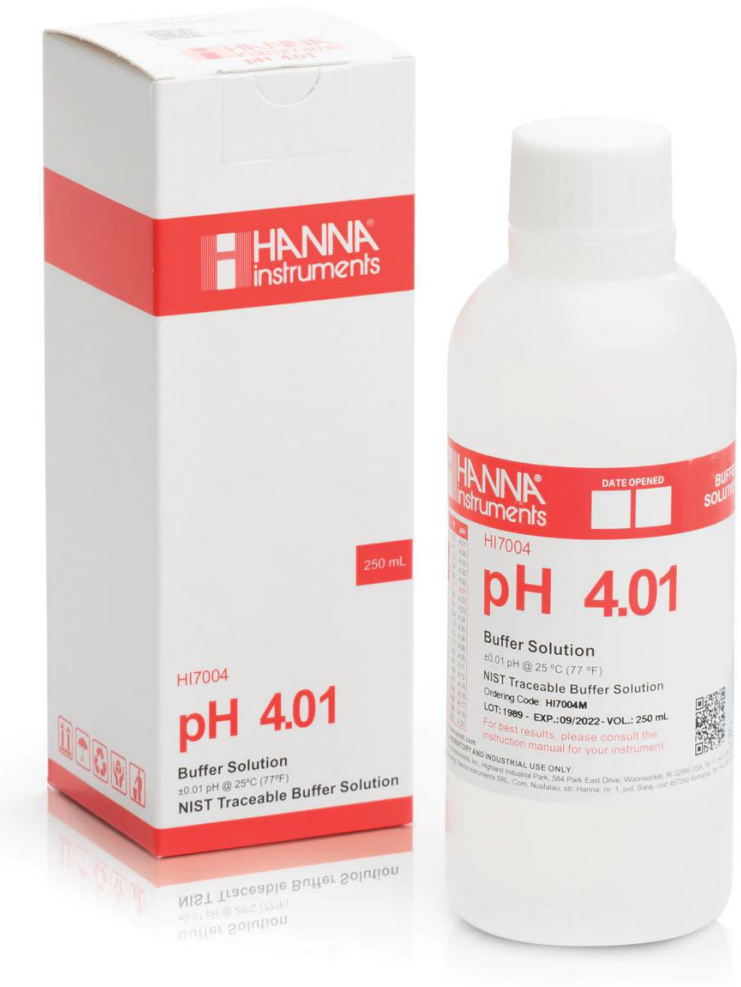

- **A solution that resists change in pH when <u>small</u> amounts of acid / alkali are added**
- **ACIDIC buffer pH < 7**
- **BASIC buffer pH > 7**

WHAT IS IN A BUFFER SOLUTION?

ACIDIC buffer solution

mixture of

- **weak acid (HA) +**
- **one of its salts (with A^-)**

e.g. mix CH_3COOH and CH_3COONa

e.g. mix excess CH_3COOH and NaOH

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

start	5	2	0	lots
change	–2	–2	+2	+2
end	3	0	2	lots

WHAT IS IN A BUFFER SOLUTION?

BASIC buffer solution

mixture of

- **weak base +**
- **one of its salts**

e.g. mix NH_3 and NH_4Cl

e.g. mix excess NH_3 and HCl

$$NH_3 + H^+ \longrightarrow NH_4^+$$

start	6	2	0
change	–2	–2	+2
end	4	0	2

Type of buffer	Acidic buffer		Basic buffer	
Components	Weak acid + one of its salts [acid] & [salt] >> [H^+]		Weak base + one of its salts [base] & [salt] >> [OH^-]	
Route 1	Mixture of weak acid and one of its salts	e.g. ethanoic acid + sodium ethanoate	Mixture of weak base and one of its salts	e.g. ammonia + ammonium chloride
Route 2	Mixture of an excess of weak acid and a strong base	e.g. excess ethanoic acid + sodium hydroxide	Mixture of an excess of weak base and a strong acid	e.g. excess ammonia + hydrochloric acid

HOW DO THEY WORK (ACIDIC)

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

[HA] and [A⁻] >> [H⁺]

e.g. buffer – mixture of CH_3COOH and CH_3COONa

$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$

add a little H^+

CH_3COO^- reacts with added H^+ to remove it, making more CH_3COOH

but as $[CH_3COOH]$ and $[CH_3COO^-] >> [H^+]$, then $\frac{[CH_3COOH]}{[CH_3COO^-]}$ and pH is roughly constant

HOW DO THEY WORK (ACIDIC)

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[HA] and [A⁻] >> [H⁺]

e.g. buffer – mixture of CH_3COOH and CH_3COONa

$$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$$

				$\frac{[HA]}{[A^-]}$		
start	0.100	0.001	0.200		$\frac{0.100}{V}$	$\frac{0.101}{V}$
change	+0.001	–0.001	–0.001		$\frac{0.200}{V}$	$\frac{0.199}{V}$
end	+0.101		–0.199			
					0.500	0.508

HOW DO THEY WORK (ACIDIC)

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

[HA] and [A⁻] >> [H⁺]

e.g. buffer – mixture of CH_3COOH and CH_3COONa

$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$

add a little OH^-

H^+ reacts with added OH^-

CH_3COOH reacts to replace H^+ (and forms some CH_3COO^-)

but as $[CH_3COOH]$ and $[CH_3COO^-] >> [H^+]$, so $\frac{[CH_3COOH]}{[CH_3COO^-]}$ and pH roughly constant

HOW DO THEY WORK (ACIDIC)

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

[HA] and [A⁻] >> [H⁺]

e.g. buffer – mixture of CH_3COOH and CH_3COONa

$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$

add H_2O

$\frac{[CH_3COOH]}{[CH_3COO^-]}$ and pH constant

HOW DO THEY WORK (BASIC)

[base] and [salt] >> [OH^-]

e.g. buffer – mixture of NH_3 and NH_4Cl

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

add a little OH^-

NH_4^+ reacts with added OH^- to remove it, making more NH_3

but as [NH_3] and [NH_4^+] >> [OH^-], then $\frac{[NH_3]}{[NH_4^+]}$ and pH is roughly constant

HOW DO THEY WORK (BASIC)

[base] and [salt] >> [OH^-]

e.g. buffer – mixture of NH_3 and NH_4Cl

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

add a little H^+

OH^- reacts with added H^+

NH_3 reacts to replace OH^-, making more NH_4^+

but as $[NH_3]$ and $[NH_4^+]$ >> $[OH^-]$, then $\frac{[NH_3]}{[NH_4^+]}$ and pH is roughly constant

HOW DO THEY WORK (BASIC)

[base] and [salt] >> [OH^-]

e.g. buffer – mixture of NH_3 and NH_4Cl

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

add H_2O

$\frac{[NH_3]}{[NH_4^+]}$ and pH is constant