

17.2 Buffers

Buffer pH – ICE

Calculate the pH of a buffer solution made from 1.00 L of a 0.133 M hydrofluoric acid and 0.243 mol of sodium fluoride.
 $K_a \text{ HF} = 7.2 \times 10^{-4}$

Shortest way to approach this is from the Buffer Acid equilibrium as this directly determines pH.

	HF(aq)	+ H ₂ O(l)	⇌	H ₃ O ⁺	+ F ⁻
I	0.133			0	0.243
C	-x			x	x
E	0.133 - x			x	0.243 + x

$$[\text{HF}]_i > 100(7.2 \times 10^{-4}), \quad 0.133 - x \approx 0.133$$

$$[\text{F}^-]_i > 100(7.2 \times 10^{-4}), \quad 0.243 + x \approx 0.243$$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{F}^-]}{[\text{HF}]}$$

$$7.2 \times 10^{-4} = \frac{x(0.243)}{0.133}$$

$$0.243x = 0.133(7.2 \times 10^{-4})$$

$$x = \frac{0.133(7.2 \times 10^{-4})}{0.243} = 3.94 \times 10^{-4} = [\text{H}_3\text{O}^+]$$

$$\text{pH} = -\log_{10}(3.94 \times 10^{-4}) = 3.40$$

17.2 Buffers

Buffer pH – The Henderson–Hasselbalch Equation

Calculate the pH of a buffer solution made from 1.00 L of a 0.133 M hydrofluoric acid and 0.243 mol of sodium fluoride.

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

$$\text{pH} = \text{p}K_a + \log_{10} \frac{[\text{Buffer Base}]}{[\text{Buffer Acid}]}$$

$[\text{Buffer Base}] = [\text{F}^-] = 0.243$; $[\text{Buffer Acid}] = [\text{HF}] = 0.133$

$$\text{pH} = -\log_{10}(7.2 \times 10^{-4}) + \log_{10} \left(\frac{0.243}{0.133} \right)$$

$$= 3.143 + \log_{10}(1.827)$$

$$= 3.143 + 0.262$$

$$= 3.40$$

17.2 Buffers Making Buffer Solutions

Preparing Buffer Solutions

[HCO₂H] [NaHCO₂]

HCO₂H/NaHCO₂

- H₂CO₃/NaHCO₃
- HOCl/NaOCl
- H₃BO₃/NaH₂BO₃
- NH₄Cl/NH₃
- NaHCO₃/Na₂CO₃

0.10 M = 0.10 M

[New Target](#)

See Class Web Site.

$$pH = pK_a + \log_{10} \frac{[\text{Buffer Base}]}{[\text{Buffer Acid}]}$$

But when [Buffer Base] = [Buffer Acid]

$$pH = pK_a + \log_{10}(1)$$

$$pH = pK_a$$

$$K_a = 1.8 \times 10^{-4} \quad pK_a = 3.74$$

$$K_a = 4.2 \times 10^{-7} \quad pK_a = 6.38$$

$$K_a = 3.5 \times 10^{-8} \quad pK_a = 7.46$$

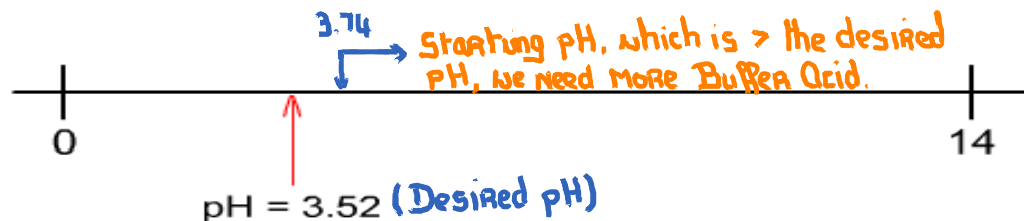
$$K_a = 7.3 \times 10^{-10} \quad pK_a = 9.14$$

$$K_a = 5.6 \times 10^{-10} \quad pK_a = 9.25$$

$$K_a = 4.8 \times 10^{-11} \quad pK_a = 10.32$$

1) Choose an acid/base combination whose acid pK_a is closest to the desired pH.

2) Adjust the acid or base concentration to get the desired pH.

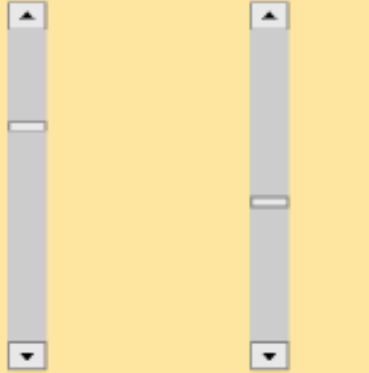


17.2 Buffers

Buffer Capacity

Preparing Buffer Solutions

[HCO₂H] [NaHCO₂]



0.73 M¹ 0.50 M²

- HCO₂H/NaHCO₂
- H₂CO₃/NaHCO₃
- HOCl/NaOCl
- H₃BO₃/NaH₂BO₃
- NH₄Cl/NH₃
- NaHCO₃/Na₂CO₃

New Target

$K_a = 1.8 \times 10^{-4}$	$pK_a = 3.74$
$K_a = 4.2 \times 10^{-7}$	$pK_a = 6.38$
$K_a = 3.5 \times 10^{-8}$	$pK_a = 7.46$
$K_a = 7.3 \times 10^{-10}$	$pK_a = 9.14$
$K_a = 5.6 \times 10^{-10}$	$pK_a = 9.25$
$K_a = 4.8 \times 10^{-11}$	$pK_a = 10.32$

Buffer Capacity

1. Maximum amount of OH⁻ that can be removed = [HCO₂H] = 0.73 M
2. Maximum amount of H₃O⁺ that can be removed = [HCO₂⁻] = 0.50 M

