

Exercise walk-through

# 8.9

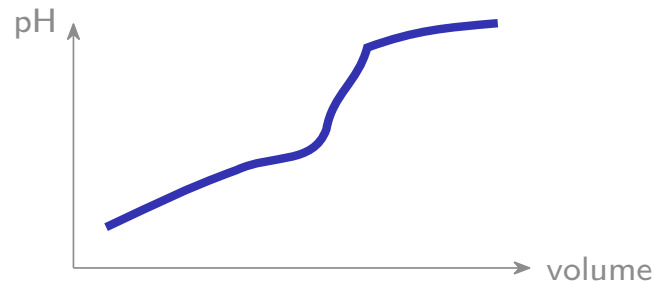
## Henderson-Hasselbalch Equation

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AP Chemistry

# What we will cover

- 1 Bronsted-Lowry and pH
- 2 Strong acids and bases
- 3 Weak acid and base equilibria
- 4 Buffers and Henderson-Hasselbalch
- 5 Acid-base titrations
- 6 Structure and pKa



# Buffers and Henderson-Hasselbalch

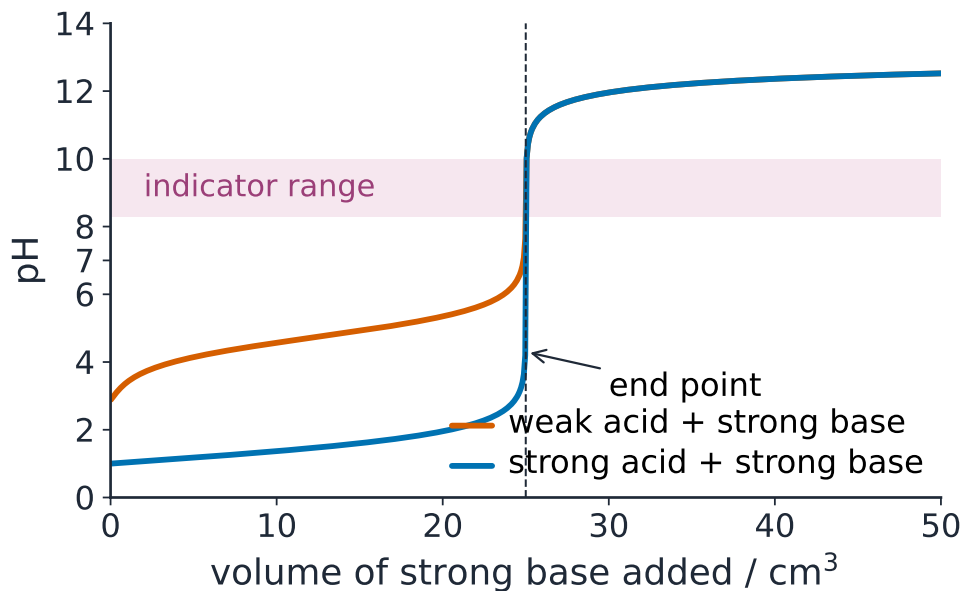
- A **buffer** holds pH steady with **both** a weak acid and its conjugate base:
- added acid  $\Rightarrow$  conjugate base soaks up  $\text{H}^+$
  - added base  $\Rightarrow$  weak acid soaks up  $\text{OH}^-$

## Henderson-Hasselbalch

$$\text{pH} = \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

Equal amounts  $\Rightarrow \text{pH} = \text{p}K_a$ .  
**Capacity** grows with total concentration.

# A titration curve has a steep jump



A titration curve has a steep jump near the equivalence point

## Exercises 2.1·2.3

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**2.1** Write the Henderson-Hasselbalch equation.

[1]

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**2.2** A buffer has  $\text{p}K_a = 4.7$  with equal acid and base. Find the pH.

[1]

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**2.3** Find the pH of a buffer with  $\text{p}K_a = 5.0$  and  $\frac{[\text{A}^-]}{[\text{HA}]} = 10$ .

[2]

## Exercises 2.1-2.3

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**2.1** Write the Henderson-Hasselbalch equation.

[1]

**2.1**

- $$\text{pH} = \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

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**2.2** A buffer has  $\text{p}K_a = 4.7$  with equal acid and base. Find the pH.

[1]

**2.2**

- $$\text{pH} = 4.7$$

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**2.3** Find the pH of a buffer with  $\text{p}K_a = 5.0$  and  $\frac{[\text{A}^-]}{[\text{HA}]} = 10$ .

[2]

**2.3**

- $$\text{pH} = 5.0 + \log 10 = 5.0 + 1 = 6.0$$

## Exercise 3.1

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**3.1** When  $[A^-] = [HA]$ , the Henderson-Hasselbalch equation gives  $\text{pH} =$  [1]

☐

**A** 0

**B** 7

**C**  $\text{p}K_a$

**D**  $\text{p}K_a + 1$

## Exercise 3.1

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**3.1** When  $[A^-] = [HA]$ , the Henderson-Hasselbalch equation gives  $\text{pH} =$  [1]

☐

**A** 0

**B** 7

**C**  $\text{p}K_a$

**D**  $\text{p}K_a + 1$

**3.1 C**

- $\text{pH} = \text{p}K_a$

## Exercise 3.2 (a)

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**3.2** A buffer uses an acid with  $\text{p}K_a = 4.74$ , with  $[\text{HA}] = 0.30 \text{ M}$  and  $[\text{A}^-] = 0.15 \text{ M}$ .

(a) Find the ratio  $\frac{[\text{A}^-]}{[\text{HA}]}$ .

[1]

## Exercise 3.2 (a)

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**3.2** A buffer uses an acid with  $\text{p}K_a = 4.74$ , with  $[\text{HA}] = 0.30 \text{ M}$  and  $[\text{A}^-] = 0.15 \text{ M}$ .

(a) Find the ratio  $\frac{[\text{A}^-]}{[\text{HA}]}$ .

[1]

(a)

- $\frac{0.15}{0.30} = 0.5$

## Exercise 3.2 (b)

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**3.2** A buffer uses an acid with  $\text{p}K_a = 4.74$ , with  $[\text{HA}] = 0.30 \text{ M}$  and  $[\text{A}^-] = 0.15 \text{ M}$ .

(b) Find the pH.

[3]

## Exercise 3.2 (b)

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**3.2** A buffer uses an acid with  $\text{p}K_a = 4.74$ , with  $[\text{HA}] = 0.30 \text{ M}$  and  $[\text{A}^-] = 0.15 \text{ M}$ .

(b) Find the pH.

[3]

(b)

- $\text{pH} = 4.74 + \log(0.5) = 4.74 - 0.30 = 4.44$

## Exercise 3.3

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**3.3** You want a buffer at pH 5.0 using an acid with  $pK_a = 4.7$ . Find the required ratio  $\frac{[A^-]}{[HA]}$ . [3]

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**3.3**

- $\log \frac{[A^-]}{[HA]} = 5.0 - 4.7 = 0.3; \text{ ratio} = 10^{0.3} = 2.0$