SI Chemistry - Full Discipline Demo

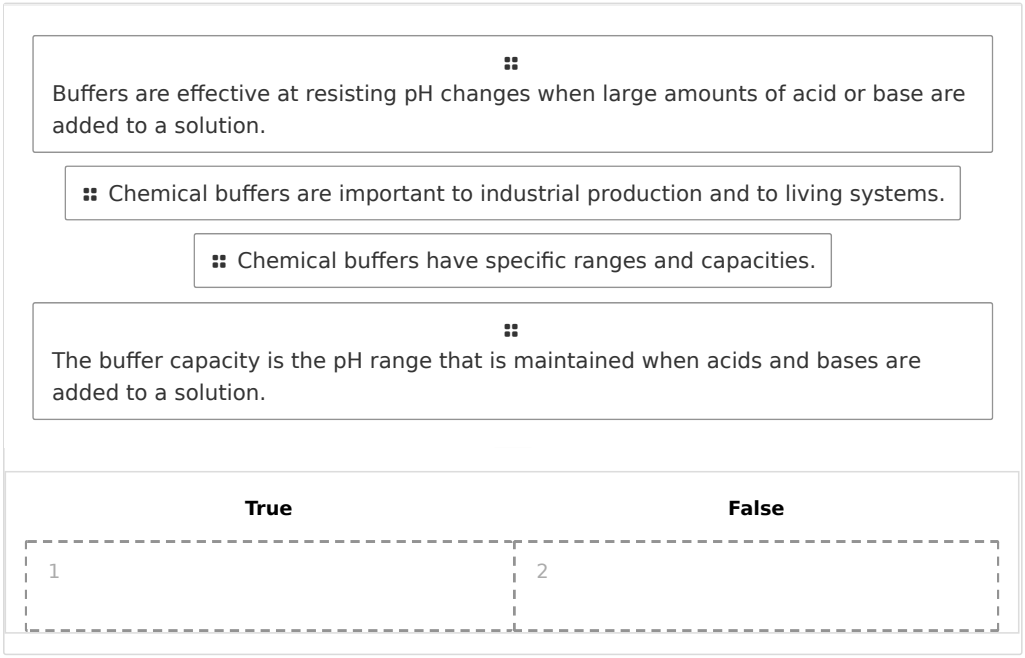
Using Buffers

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Categorize each statement as true or false.



Correct answers:

1

Chemical buffers are important to industrial production and to living systems.

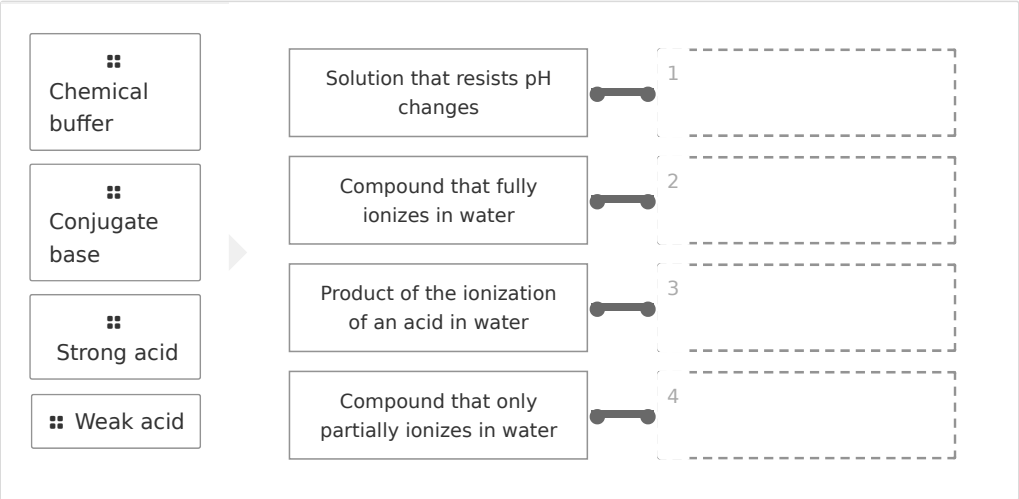
Chemical buffers have specific ranges and capacities.

2

Buffers are effective at resisting pH changes when large amounts of acid or base are added to a solution.

The buffer capacity is the pH range that is maintained when acids and bases are added to a solution.

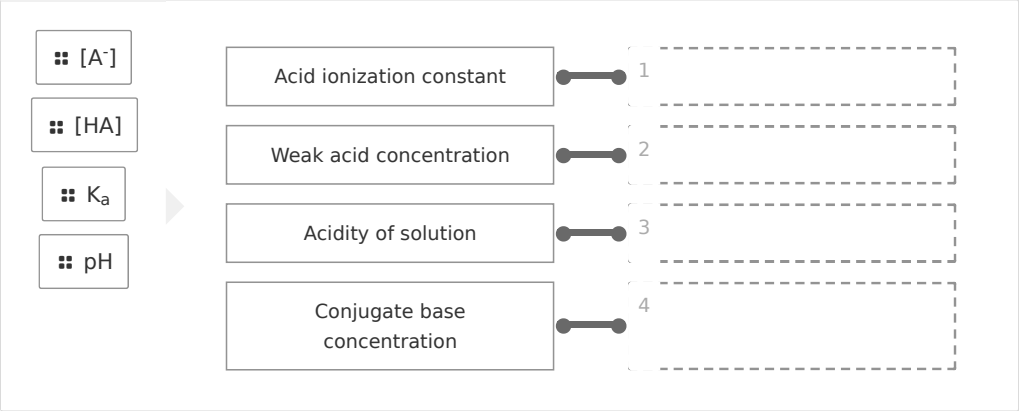
Match each term with the best description.



Correct answers:

1 Chemical buffer 2 Strong acid 3 Conjugate base 4 Weak acid

Identify the variables of the equation $\mathrm{pH} = \mathrm{pK_a} + \log\frac{[\mathrm{A^-}]}{[\mathrm{HA}]}$ **.**



Correct answers:

1 K_a 2 [HA] 3 pH 4 $[A^-]$

Exploration

A chemical buffer is a solution that resists _____ when small quantities of an acid or base are added to it.

- pH changes ✔
- pressure changes
- thermal changes

The function of a buffer is to keep a solution neutral when small amounts of acids or bases are added.

- True
- False ✔

The _____ is the amount of acid or base that can be added to a solution before the pH significantly changes.

- buffer capacity ✔
- buffer range
- buffer zone

Buffers typically consist of a _____ and _____.

- strong acid; its conjugate base
- weak acid; its conjugate base ✔
- strong acid; a strong base

The base component of the acetic acid buffer system is _____.

- acetate ✔
- ammonia
- sodium hydroxide

The concentration of an acid in the Henderson-Hasselbalch equation is represented by _____.

- pK_a
- $[A^-]$
- [HA] ✔

The Henderson-Hasselbalch equation is used to _____.

- calculate the pH of a buffered solution
- determine the acid and base concentrations required to prepare a buffer
- calculate the effect of adding additional acid or base to a buffer
- All of the above ✔

Exercise 1

Describe the purpose of a buffer.

The purpose of a buffer is to minimize the change in pH when an acid or base is added to the solution.

Write the chemical equations for the neutralization reactions that occurred when HCl and NaOH were added to the buffer solution.

CH_3COO^- (aq) + H_3O^+(aq) -> CH_3COOH(aq) + H_2O(l) CH_3COOH(aq) + OH^- (aq) -> CH_3COO^- (aq) + H_2O(l)

How do the results in Data Tables 1 and 2 support the role of a buffer?

Buffers are solutions that resist pH changes when small quantities of an acid or base are added to them. The fact that the pH of the solution did not change when either a dilute acid or dilute base were added support the idea that the acetic acid/acetate system behaves as a buffer.

Describe the buffer capacity of the acetic acid buffer solution in relation to the addition of both concentrated and dilute acids and bases. Reference the results in Data Tables 1,2,3, and 4 in your answer.

The buffer capacity of the solution was effective for large additions of dilute acids and bases, but was quickly exceeded upon the additions of concentrated acids and bases. The acetic acid buffer solution was able to maintain pH with the addition of 16 drops of dilute acid and base as recorded in Data Tables 1 and 2. However, the addition of concentrated acid and base exceeded the buffering capacity of the solution after only 2 drops as recorded in Data Tables 3 and 4.

Did distilled water act as a buffer in the experiment? Use the results in Data Tables 5 and 6 to support your answer.

The data in Tables 5 and 6 clearly show that water does not behave as buffer. Small additions of both dilute acids and bases resulted in a pH change in the solution

An acetic acid sodium acetate buffered solution needs to have a pH of 5.27. You have a solution that has an acetic acid concentration of 0.01 M. What molarity of sodium acetate will you need to add to the solution, given that the pK_a of acetic acid is 4.74? Show all calculations in your answer.

$pH = pK_a + \log [A^-]/[HA]$

5.27 = 4.74 + log (x/0.01 M)

log (x/0.01 M) = 0.53

x/0.01M = 3.39

x = 0.03 M sodium acetate

Data Table 1: Adding 0.1 M HCl from D1 to A1
(SAMPLE ANSWER BELOW)

Number of Drops	pH of Solution
0	5
2	5
4	5
6	5
8	5
10	5
12	5
14	5
16	5

Data Table 2: Adding 0.1 M NaOH from D6 to A6
(SAMPLE ANSWER BELOW)

Number of Drops	pH of Solution
0	5
2	5
4	5
6	5
8	5
10	5
12	5
14	5
16	5

Data Table 3: Adding 6 M HCl from Pipet into B1
(SAMPLE ANSWER BELOW)

Number of Drops	pH of Solution
0	5
2	5
4	4
6	1

8	1
10	1

Data Table 4: Adding 6 M NaOH from Pipet into B6
(SAMPLE ANSWER BELOW)

Number of Drops	pH of Solution
0	5
2	5
4	5
6	5
8	8
10	12

Data Table 5: Adding 0.1 M HCl from D1 into C1
(SAMPLE ANSWER BELOW)

Number of Drops	pH of Solution
0	7
2	5
4	4
6	3
8	3
10	2

Data Table 6: Adding 0.1 M NaOH from D6 into C6
(SAMPLE ANSWER BELOW)

Number of Drops	pH of Solution
0	7
2	8
4	10
6	12
8	12
10	12

Competency Review

A chemical buffer is a solution that increases pH changes when small quantities of an acid or base are added.

- ○ True
- ○ False ✔

Every buffer that is made has a certain _____ and _____.

- buffer temperature; buffer pressure
- buffer range; buffer capacity ✔
- buffer zone; buffer action

Weak acids make better buffers than strong acids because they have _____.

- conjugate bases of reasonable strength ✔
- weak conjugate bases
- low pH values

_____ is a weak acid present in commercial vinegar that can be used to create a buffer solution.

- Phosphoric acid
- Acetic acid ✔
- Hydrochloric acid
- Formic acid

The pH of a buffered solution is determined by _____.

- the concentration of the weak acid
- the concentration of the conjugate base
- the acid ionization constant
- All of the above ✔

pH = pK_a if acid concentration is _____.

- higher than conjugate base concentration
- lower than conjugate base concentration
- equal to conjugate base concentration ✔

_____ can be added to commercial vinegar to create an acetic acid buffer solution.

- Distilled water
- Hydrochloric acid
- Sodium hydroxide ✔

Large volumes of concentrated acids and bases should be added to buffered solutions when testing buffer ranges and capacities.

- True
- False ✔

Why would buffered solution tests be compared to distilled water?

- Distilled water is not a buffer and acts as a control. ✔
- Distilled water is an effective buffer against strong acids.
- Distilled water is an effective buffer against strong bases.

Acetic acid buffers are most effective in resisting pH changes to _____.

- concentrated acids and bases
- diluted acids and bases ✔

Extension Questions

John needs to create a buffered solution at a pH of 3.5 for his biomedical laboratory.

a. Using the chart below, determine the appropriate acid for this application.

Acid	pK_a
Phosphoric	2.12
Pyruvic	2.49
Lactic	3.86
Benzoic	4.19

b. Research and state the conjugate base of the the acid.
c. Describe how John would determine the amounts of acid and base needed to create the buffered solution.

(SAMPLE ANSWER BELOW)

a. John should select a buffer with a pK_a closest to the desired pH of his solution, 3.50. Lactic acid has the closest pK_a at 3.86.

b. The conjugate base of lactic acid is lactate: $C_3H_5O_3^-$.

c. John would use the Henderson-Hasselbalch equation: $pH = pK_a + \log [A^-]/[HA]$ where pH = 3.50 and pK_a = 3.86 to determine the molar ratio of lactate/lactic acid needed for the solution.