Connected Chemistry
Acids & Bases Unit
Lesson 8: Buffers and Conjugate Acid-Base Pairs

Student's Lesson at a Glance

Lesson Summary

This lesson contains four activities that introduce students to the concept of conjugate acid base pairs and buffers. The Connecting Activity generates real-world connections to the concepts of buffers and conjugate acids and bases. In the Teacher Facilitated Discussion, students practice identifying conjugate acids and bases in various chemical equations. Following a teacher demonstration on using the buffer simulation, students generate self-selected trials in which they record data and describe changes from a submicroscopic perspective.

SWBAT (Students Will Be Able To)

- Know that buffers are solutions that contain conjugate pairs of a weak acid or base and resist changes in pH
- Buffers have a buffering capacity, which is defined as the amount of acid or base that can be added to the buffer without changing the pH
- Know that deprotonated acids are conjugate bases
- Know that protonated bases are conjugate acids

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in **bold**. Additional words that will expand your scientific vocabulary are in *italics*.

CCC Reminder

- Make sure to always include phases when writing out chemical reactions.
- Remember that the arrows in a reaction indicate if a reaction is reversible or irreversible.
- Familiarize yourself with common acids and bases and whether they can be classified as strong or weak. This will help you interpret what is happening in the CCC simulations.

Notes

Homework

Upcoming Quizzes/Tests

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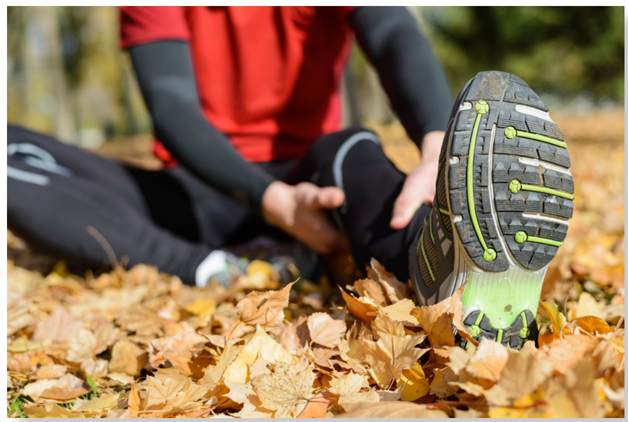
Activity 1: Connecting

1. In your own words, what does the word buffer mean?

If an acid or base is added to water, the pH of the resultant solution will drastically change. Pure water has no ability to resist the change in pH. However, there are some real-life scenarios in which systems need to resist changes in pH if an acid or base is added. To prevent changes in pH in solution from the addition of acid or base, chemists add a buffer to the solution in the lab. **Buffers** are solutions that resist changes in pH. Buffers are regularly added to substances in the lab that need to be placed into acidic or basic conditions to regulate pH.



Buffers are composed of a combination of a weak acid and the salt of its conjugate base or a combination of a weak base and the salt of its conjugate acid. For example, a mixture of the weak acid HF and its conjugate base (F^-) is a buffer. Similarly, a mixture of the weak base NH_3 and its conjugate acid (NH_4^+) is also a buffer. The buffer is made of two components because one part **neutralizes** any acid added to the solution, while the other part neutralizes any base added to the solution.

Your body has natural buffers to maintain a condition called *homeostasis*. Homeostasis plays an important role in the body. For example, muscle cramps can occur after long periods of exercise. When a person exercises, the body produces waste products that must be removed. One of these waste products is lactic acid, which builds up in muscles and reduces the body's pH. The result is that a person feels sore after long periods of exercise. It takes a while to feel sore, however, because muscles contain several natural buffers that can resist the change in pH. The body's pH remains relatively stable until the lactic acid completely neutralizes the buffer. At this point, the **buffering capacity** of the muscles is exceeded, and the local pH begins to decrease. Once this happens, muscle cramps and soreness are felt.

Recall that the Brønsted-Lowry theory states that an acid is a proton (H^+) donor and the base is a proton (H^+) acceptor. We can also consider Brønsted-Lowry theory using a general equation for the reaction between an acid and a base. The equation looks like this:

Acid + Base ⇄ Conjugate Acid + Conjugate Base

accepts H^+ to form

donates H^+ to form

- The products of the acid and base reaction are a **conjugate acid** and a **conjugate base**.
- The conjugate acid is the ion that forms after a base has accepted a H^+.
- The conjugate base is the ion that forms after an acid has donated a H^+.

2. What do the arrows in the middle suggest about the reaction?

3. What does the word neutralize mean?

4. What would the pH of a neutralized acid and base solution be? *Support your claim with evidence.*

5. Write an equation to show how an acid added to a base becomes a neutral solution. B*e sure to describe your answer in words.*

Activity 2: Teacher Facilitated Discussion

Consider the following reaction:

$$H_2O\ (l) + NH_3\ (l) \leftrightarrows OH^-\ (aq) + NH_4^+\ (aq)$$

6. Which reactant is the acid? *Please explain.*

7. Which product is the conjugate base? *Please explain.*

8. Which reactant is the base?

9. Which product is the conjugate acid?

Note that in the reaction, the reactants are water and ammonia. Even though we consider water a neutral substance, it can act as either an acid or a base in any given reaction. Water's ability to be both an acid or a base makes it **amphoteric**. If water donates H^+, it is an acid. If water accepts H^+, it is a base.

Consider the reaction between the following:

$$CH_3CO_2H\ (aq) + H_2O\ (l) \leftrightarrows CH_3CO_2^-\ (aq) + H_3O^+\ (aq)$$

10. Is water behaving as an acid or a base in the reaction? Please explain.

11. What is the conjugate base in the reaction? Please explain.

12. Is CH_3CO_2H behaving as an acid or a base in the reaction? Please explain.

13. What is the conjugate acid in the reaction? Please explain.

Activity 3: Buffer Demonstration

Demonstration: *Use Simulation 5,* ***Set 1***

- *Your teacher will demonstrate how to use Simulation 5.*
- *In the simulation, there are two sliders to set up the buffer solution.*
- *Based on the simulation that your teacher demonstrates, record answers to the following questions.*
- *You can change which graph is displayed by clicking the button on the top right corner of the graph display.*

14. What is the pH of the solution in the simulation?

15. How many hydronium ions and hydroxide ions are present in the solution?

16. How are these numbers related to pH?

- *Your teacher will start the simulation.*
- *Observe that the molecules are moving randomly around and colliding with each other.*
- *Adding one drop of acid represents adding 5 molecules of acid to the system.*
- *Use the simulation to answer the following questions:*

17. Is the addition of 5 molecules of acid in the simulation the same thing as adding 5 mL of acid in the lab?

18. What happened to the pH when the 5 mL of acid was added? *Explain why you think this happened.*

19. How many hydroxide and hydronium ions are present after the addition?

20. Are the hydroxide and hydronium ions destroyed in the reaction?

- *Your teacher will add 1 drop of base, this represents adding 5 molecules of base to the system.*
- *Observe and answer questions below:*

21. What changes do you see happening at the submicroscopic level?

22. Why do these changes occur?

23. Did the buffer prevent a pH change in the solution? *Support your claim with evidence.*

Activity 4: Buffer Simulations

Simulation

Continue to use Simulation 5, ***Set 1***

- *Explore the simulation using settings you select in your small groups.*
- *Complete two simulations in the time allowed.*
- *For each simulation, record what you start with and what you add (how many molecules of acid or base). Once you start the simulations, record what happens to the system. This includes pH changes, concentration of hydroxide and hydronium ions, and the amount of water.*

	$[NH_4Cl]$	$[NH_3]$	$[OH^-]$	$[H_3O]$	Final pH
Initial State of Equilibrium					
Add 5 HCl at Equilibrium					
Add 10 HCl at Equilibrium					

24. When you ran the simulation, what changes did you see over time?

Trial 1

Trial 2

25. In the simulation, there is the possibility of adding a large amount of acid or base into the buffer. How does the addition of large amounts of acid or base affect the buffer?

Activity 5: Teacher Facilitated Discussion

Working in your small groups, you will:

Pretend that you are in a company that sells buffers. In the time given by the teacher, your group needs to create a short ad that highlights the benefits of using buffers, how buffers work, and state a disclaimer about the limitations the capability of buffers. Once your ad is ready, have your salesperson present the advertisement to the class. During this time, evaluate each group's presentations for accuracy, how easy it was to understand, and how convincing they are. Your teacher may also ask clarifying questions if something is hard to understand.

Lesson Reflection Question

26. In your own words, define a buffer and describe how your definition has changed from the beginning of this lesson.