Lesson Plan: Buffers, Buffer Action, and Ocean Acidification

Lesson plan based on an idea submitted by Dr. Pragya Gahlot, Sri Venkateswara College (University of Delhi), India.

As a **high school** or **undergraduate Chemistry, Environmental Sciences,** or **Earth Sciences** teacher, you can use this set of computer-based tools to teach about **buffers, how buffers work (buffer action)**, **ocean carbonate buffering**, and **ocean acidification** due to higher levels of atmospheric carbon dioxide (CO_2).

This lesson plan introduces the topic of buffers and describes carbonate buffering in the ocean when atmospheric CO_2 dissolves in seawater. The buffering capacity of the ocean is, however, limited, and therefore, higher concentrations of dissolved CO_2 can lead to ocean acidification. Students will use a computer-based activity/model to explore how higher atmospheric CO_2 levels (resulting in an increase in dissolved CO_2) can lead to ocean acidification. Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in Chemistry, Environmental Sciences, or Earth Sciences.

Use this lesson plan to help your students find answers to:

- What are buffers? Explain buffer action.
- Describe carbonate buffering in the ocean.
- What is ocean acidification?
- Discuss the possible global impact of higher levels of atmospheric CO_2 on the pH of oceans.

About the Lesson Plan

Grade Level: High School, Undergraduate

Discipline: Chemistry, Environmental Sciences

Topic(s) in Discipline: Buffers, Buffer Action, pH Level, Buffer Capacity, Buffer Range, Acidification, Le Chatelier's Principle

Climate Topic: Climate and the Hydrosphere, Climate and the Atmosphere, Climate and the Biosphere

Location: Global

Access: Online

Language(s): English

Approximate Time Required: 30-40 min

1 Contents

- Describe carbonate buffering in the ocean.
- What is ocean acidification?
- Discuss the possible global impact of higher levels of atmospheric CO_2 on the pH of oceans.

2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Introduce the topic with the help of a reading

Introduce the topic of buffers. Use the reading "How Does A Buffer Maintain pH?" by LibreTexts™ to explain buffer action and the maintenance of pH in a buffer solution. Explain the term buffer capacity, buffer range, and the pH equation of a given buffer. Use examples (1 and 2) given in the text to calculate changes in the pH values when a weak acid or base is added to a buffer solution. Discuss other examples of buffers in daily life, e.g., the buffering action of blood.

The reading is available at:

https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Acids_and_Bases/Buffers/How_Does_A_Buffer_Maintain_Ph%3F

2. Play a video micro-lecture to explain the buffer chemistry of oceans

Use the video micro-lecture "Ocean Buffer Chemistry" by Prof. David Archer, University of Chicago, to describe carbonate buffering in the ocean. Discuss how oceans behave as carbon sinks by absorbing atmospheric CO_2, and the maintenance of ocean pH levels owing to the buffering capacity of seawater. Further, use the video to explain the buffering range of oceans and the chemical implications of a higher concentration of dissolved CO_2 (due to increased levels of atmospheric CO_2). Explain how high levels of atmospheric CO_2 could result in an excess of free hydrogen (H^+) ions, thus potentially changing the pH values of seawater (acidification). Further, use the video micro-lecture to illustrate Le Chatelier's Principle—explain how increased CO_2 concentration in seawater sequesters more carbonate (CO_3^{2-}) ions to keep the system in equilibrium. In conclusion, explain how ocean biota may be affected in the absence of freely available carbonate (CO_3^{2-}) ions.

The video micro-lecture can be accessed at

http://www.kaltura.com/index.php/extwidget/preview/partner_id/1090132/uiconf_id/20652192/entry_id/1_16ghjcjg/embed/auto

3. Explore the topic further by using a visualization

Open the applet "Surface Ocean pH Levels" from The King's Centre for Visualization in Science (KCVS) available at https://applets.kcvs.ca/OceanAcidification/oceanAcid.html.

Select the "Resources" tab to read the background that provides a detailed explanation of the relationship between atmospheric CO_2 and ocean pH values.

Click on "Help" to read the instructions to run the applet.

- Run the simulation to enable students to visualize the global pH value (as indicated on the pH indicator strip) of oceans for a given concentration of atmospheric CO_2. Students can vary the atmospheric CO_2 levels by using the slider at the bottom left hand side to observe the corresponding changes in the pH value of the oceans.
- Click the tab "Show Graph" to observe the graphs for concentrations of various species of carbonate ions in (i) a closed system and (ii) an open ocean; and the graph depicting the pH value of oceans for various atmospheric CO2 concentrations.
- Go to the tab "Options" to view the different emission scenarios (Special Report on Emission Scenarios (SRES) projections) that can be selected. Select different SRES projection options and visualize the corresponding predicted ocean pH value on the pH indicator strip or on the aforementioned graphs.

Note: Detailed information about SRES projections can be obtained at http://ipcc-data.org/sim/gcm_clim/SRES_TAR/ddc_sres_emissions.html#a1b.

Finally, discuss the implications of the predicted pH value of oceans for different emission scenarios and the possible impacts on the Earth's biosphere.

4. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

- What are buffers? Explain buffer action.
- Describe carbonate buffering in the ocean.
- What is ocean acidification?
- Discuss the possible global impact of higher levels of atmospheric CO_2 on the pH of oceans.

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- define buffers and describe buffer action
- describe the terms buffer capacity and buffer range
- explain the buffering action of seawater
- explain ocean acidification and discuss its possible impact on the biosphere

4 Additional Resources

If you or your students would like to explore the topic further, these additional resources will be useful.

1. **Laboratory Activity** (High School)

A laboratory activity— "The Buffer Zone" by Stefani Hines, University of New Mexico, published in the Environmental Health Perspectives (EHP) Science Education Program—that allows students to explore the buffering ability of seawater and discuss how this buffer action is affected by increasing levels of atmospheric CO_2 and increasing global temperatures.

https://aamboceanservice.blob.core.windows.net/oceanservice-prod/education/pd/climate/teachingclimate/acid_base_chemistry_teacher.pdf

2. **Video**

An animated video, "Demystifying ocean acidification and biodiversity impacts" from the California Academy of Sciences, to learn about ocean acidification and its impacts on the biodiversity of the planet.

https://www.youtube.com/watch?v=GL7qJYKzcsk

5 Credits/Copyrights

1. Reading, "How Does A Buffer Maintain pH?"

Chapter provided by LibreTexts™

2. Video micro-lecture, "Ocean Buffer Chemistry"

Prof. David Archer, University of Chicago

3. Simulation, "Surface Ocean pH Levels"

Developed by The King's Centre for Visualization in Science (KCVS)

4. Additional Resources

"The Buffer Zone" by Stefani Hines, University of New Mexico in the Environmental Health Perspectives (EHP) Science Education Program

"Demystifying ocean acidification and biodiversity impacts" by the California Academy of Sciences