procedure

How does the ocean buffer?

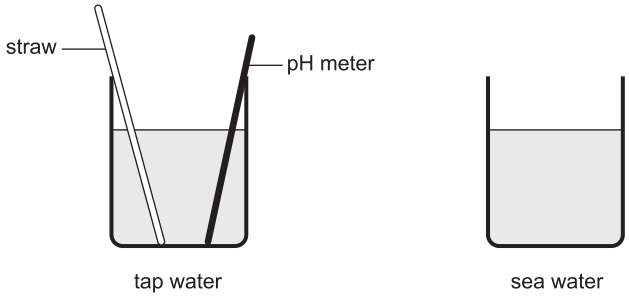
The ocean plays an important role in maintaining life on Earth. It is a habitat for many living things and needs to be able to maintain stable conditions. It is also a sink for about a quarter of the carbon dioxide released into the atmosphere by human activities. In order for marine life to survive, the ocean must continue to buffer an increasing amount of carbon dioxide.

In this experiment you will compare the way seawater and fresh water buffer carbon dioxide gas. Then you will look at the role carbonate and hydrogencarbonate ions play in this buffering process.

Part 1: Buffering atmospheric carbon dioxide

Equipment

150 mL seawater
150 mL tap water
pH meter
drinking straw
stopwatch
2 x 250 mL beakers
250 mL measuring cylinder



Method

1. Place 150 mL of tap water in one beaker and 150 mL of seawater into the other.
2. Measure the pH of the tap water using the pH meter and record your reading in the table below.
3. Use the straw to blow continuously into the water for five seconds. It is important to blow at a constant rate.
4. Measure the pH again and record.
5. Blow for another five seconds and record the pH again. The same person should blow each time. Repeat this procedure until you reach a total of 100 seconds of blowing.
6. Now repeat steps 2 to 5 for the seawater, using the same person as you used in the original trial.

Results

Complete the following table.

TOTAL TIME BLOWING (s)	pH OF TAP WATER	pH OF SEAWATER	TOTAL TIME BLOWING (s)	pH OF TAP WATER	pH OF SEAWATER
0			55		
5			60		
10			65		
15			70		
20			75		
25			80		
30			85		
35			90		
40			95		
45			100		
50					

Questions

1. Which of the solutions that you tested was the most effective buffer? Explain your answer.

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2. One variable difficult to control in this experiment is blowing the carbon dioxide into the water at a constant rate. It is also not a life-like way of exposing the seawater to atmospheric carbon dioxide. Suggest a better method.

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Part 2: The role of carbonate and hydrogencarbonate in buffering seawater

Equipment

450 mL seawater
pH meter
drinking straw
stopwatch
250 mL measuring cylinder
glass stirring rod
3 x 250 mL beakers
$CaCO_3$ (lumps)
0.5 g Na_2CO_3
0.5 g $NaHCO_3$

Method

1. Place 150 mL of seawater into each of the three beakers.
2. Add a small lump of $CaCO_3$ (approximately 0.5 g) to the first beaker, 0.5g Na_2CO_3 to the second beaker and 0.5 g $NaHCO_3$ to the third beaker. Stir each beaker.
3. Measure the pH of the first beaker using the pH meter and record the measurement in the following table.
4. Blow through a straw into the seawater in the first beaker for 5 seconds. (Once again it is better to use the same person for blowing through the straw in all the trials.) Measure the pH and record the result.
5. Repeat step 4 until you have been blowing for a total of 100 seconds.
6. Repeat step 3 to 5 for each of the other beakers.

Results

TOTAL TIME BLOWING (s)	pH OF SEAWATER CONTAINING $CaCO_3$	pH OF SEAWATER CONTAINING Na_2CO_3	pH OF SEAWATER CONTAINING $NaHCO_3$
0			
5			
10			
15			
20			
25			
30			
35			
40			
45			
50			
55			
60			
65			
70			
75			
80			
85			
90			
95			
100			

Questions

3. How did the addition of $CaCO_3$, Na_2CO_3 and $NaHCO_3$ affect the pH of the seawater before carbon dioxide was bubbled through? Why is this?

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4. How did Na_2CO_3 and $NaHCO_3$ affect buffering capacity? Compare your results with the seawater from part one.

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5. Why does solid calcium carbonate not have much effect on buffering capacity compared with Na_2CO_3?

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Discussion questions

6. If scientists added calcium carbonate to the ocean, do you think it would help improve its buffering capacity? Would it be a practical solution? Explain why or why not.

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7. Sea water is buffered according to the equilibrium reactions below:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons 2H^+ + CO_3^{2-}$$

Use this equation and Le Chatelier's principle to explain the following:

a. Why does bubbling CO_2 through seawater decrease its pH?

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b. Why does adding Na_2CO_3 to seawater increase its pH?

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c. Why does adding $NaHCO_3$ to seawater increase its pH?

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8. Identify the conjugate acid base pairs in the equation above.

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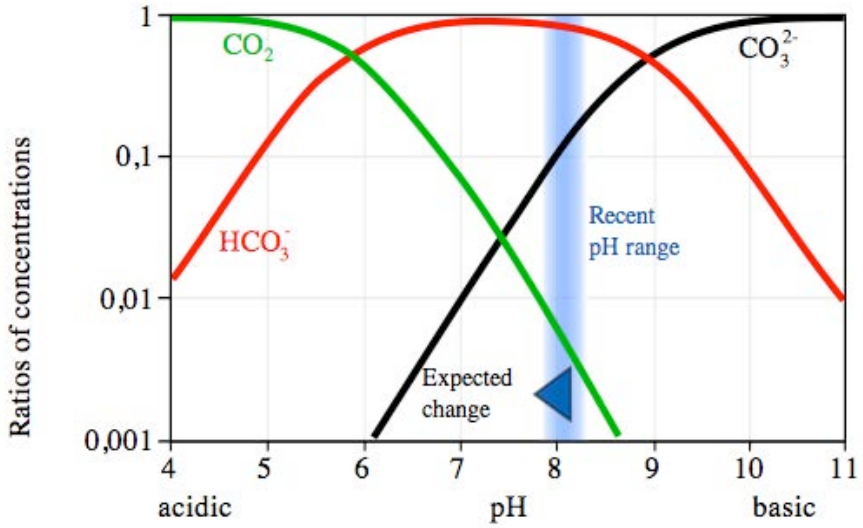
- The diagram below shows the distribution of carbon dioxide, hydrogencarbonate ions and carbonate ions in seawater.



9. Why isn't the proportion of carbonic acid shown on this graph?

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10. Organisms with calcium carbonate shells produce their shells according to the equation:

$$Ca^{2+}_{(aq)} + CO^{2-}_{3(aq)} \rightarrow CaCO_{3(s)} \text{ and } HCO^{-}_{3(aq)} \rightleftarrows H^{+}_{(aq)} + CO^{2-}_{3(aq)}$$

Use the graph to explain why these marine organisms won't be able to build shells if pH decreases.

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