The pH scale and the chemistry of ocean acidification

Education in Chemistry
Sustainability in chemistry 2021
Goal 14: conserve and sustainably use the oceans, seas and marine resources
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Check your understanding of the pH scale then apply it to explain why ocean acidification is an urgent issue to address for a sustainable future.

1. We talk about 'ocean acidification' because the pH of the oceans is decreasing, but seawater is actually an alkaline solution.

Match each pH change of a solution with the correct description of the change.

pH change	Description of change
1) Solution with a pH changing from 6 to 8	a) Alkaline solution, becoming more acidic
2) Solution with a pH changing from 8 to 9	b) Alkaline solution, becoming less acidic
3) Solution with a pH changing from 8 to 5	c) Acidic solution, becoming more acidic
4) Solution with a pH changing from 5 to 4	d) Acidic solution, becoming more alkaline

2. The pH of a solution is measured on a logarithmic scale, so each change in a unit of pH means the acidity or alkalinity has changed by a magnitude of 10.

For example, a solution with a *pH of 1* is 10 times as acidic as a solution with a *pH of 2*. A solution with a *pH of 8* is 10 times less alkaline that a solution with a *pH of 9*.

Match the sentence stems and endings to create a correct description of the relationship between pH values.

Sentence stems	Sentence endings
1) A solution with a pH of 8…	a) …is 10 times less acidic than a solution with a pH of 4
2) A solution with a pH of 3…	b) …is 10 times more alkaline than a solution with a pH of 7.
3) A solution with a pH of 5…	c) …is 10 times more acidic than a solution with a pH of 4
4) A solution with a pH of 6…	d) …is 10 times more acidic than a solution with a pH of 7.

3. A solution with a pH of 9 is 100 times more alkaline than a solution with a pH of 7. A solution with a pH of 2 will be 100 times more acidic than a solution with a pH of 4.

a. How much more acidic would a solution with a pH of 3 be than a solution with a pH of 5?

b. How much more acidic would a solution with a pH of 2 be than a solution with a pH of 5?

4. Ocean pH has dropped from 8.2 to 8.1 since the industrial revolution. If we continue to add carbon dioxide at current rates, seawater pH may drop to 7.8 or 7.7 by the end of this century, creating an ocean more acidic than any seen for the past 20 million years or more.

Many people think the oceans are acidic, because we talk about 'ocean acidification', and they may also believe that a change from pH 8.2 to pH 7.7 is only a small change.

Help them to understand more about the oceans, and correct some of their incorrect ideas, using ideas about acidity and pH.

Green chemistry extension questions

5. Carbonic acid is a weak acid. It dissociates into a hydrocarbonate ion and a hydrogen ion. Use your knowledge of acids and the equation shown below, to explain why carbonic acid is weak.

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$

6. a. Carbon dioxide reacts with seawater to form carbonic acid. Write a word and symbol equation to show this.

b. Shells of sea creatures, including corals, are often made from calcium carbonate ($CaCO_3$), which contains carbonate ions The hydrogen ions (H^+) released in the reaction in question 5 will react with carbonate ions (CO_3^{2-}) dissolving the shells of these organisms releasing more carbon dioxide.

Complete the equation below to show how shells could dissolve as the ocean becomes more acidic. Indicate which ion represents the shells.

$$2H^+ + \_\_\_\_\_ \rightarrow \_\_\_\_\_ + H_2O$$

c. Using the equation from question 5 ($H_2CO_3 \rightleftharpoons HCO_3^- + H^+$), state and explain what happens to the equilibrium position when the H^+ ions react with shells and are 'removed' from the equilibrium system.

7. Fish without shells are also affected by carbonic acid in seawater. It changes the pH of their blood, and they use energy to excrete the excess acid. This makes it more difficult to do other things, such as escaping predators, catching food or reproducing. You have already learnt about the effect on organisms that use calcium carbonate.

Produce an infographic or poster explaining some of the consequences of ocean acidification on marine organisms. Make your poster concise, focussing on the key points and the chemistry behind each point.

When finding information for your poster, think carefully about the source. Try to use reputable research institutions or universities.