Investigating Ocean Acidification: Structured Student Investigations

YEAR 9 AND 10
BIOLOGICAL SCIENCES
CHEMICAL SCIENCES
EARTH AND SPACE SCIENCES

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM NETWORK | Queensland Government

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Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers — creating a highly capable workforce for the future.

Cover Image: Giant Triton, Charonia tritonis*. Juvenile to adult. QM, Gary Cranitch*

QUEENSLAND MUSEUM NETWORK

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Investigating Ocean Acidification: Structure Student Investigations

Teacher Resource

In these activities, students investigate the impacts of carbon dioxide on the marine environment. For any experiment, it is important to complete a thorough risk assessment and wear appropriate protective equipment.

How does CO_2 affect water?

The air we exhale is 4-5% carbon dioxide. In this experiment, students use universal indicator, water, a straw and their breath to investigate the effect of carbon dioxide on water.

Part 2 of this investigation is a teacher demonstration. During the demonstration, a piece of dry ice is dropped into water with universal indicator and everyone watches what happens! Throughout this experiment, students should make predictions and observations. The similarities and differences between this experiment and the acidification of our oceans can also be discussed.

Remember to follow your school policy on the use of dry ice and complete a risk assessment. Safety glasses and gloves should be worn at all times during the demonstration.

How does acid affect organisms with calcium carbonate shells?

Students compare the effect of water and acid on calcium carbonate. Marine molluscs such as bivalves and gastropods have shells made of calcium carbonate and coral has a calcium carbonate skeleton. How might ocean acidification affect these organisms?

Which shelled organisms will be most affected by a change in pH?

Marine molluscs range from tiny pteropods only a few millimetres in length, to giant clams which can weight hundreds of kilograms. Will ocean acidification have the same impact on molluscs of different sizes? Students discuss what the results of this experiment could mean for marine ecosystems.

Student investigation: Effect of ocean acidification on calcium carbonate

Many marine organisms have shells or exoskeletons made of calcium carbonate ($CaCO_3$), including oysters, clams, sea snails and coral. In this activity, students investigate how ocean acidification may affect these organisms. Students develop and conduct an experiment to test the effect of acid on calcium carbonate and then analyse the results in a scientific report. To increase similarities between the model and the real world, carbonic acid/carbonated water could be used for this investigation.

Curriculum Links

Science

YEAR 9

Science Understanding

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

Chemical reactions involve rearranging atoms to form new substances; during a chemical reaction mass is not created or destroyed (ACSSU178)

Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer (ACSSU179)

Science Inquiry Skills

Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)

Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS166)

Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS169)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)

Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problems (ACSIS172)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

YEAR 10

Science Understanding

Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189)

Different types of chemical reactions are used to produce a range of products and can occur at different rates (ACSSU187)

Science Inquiry Skills

Formulate questions or hypotheses that can be investigated scientifically (ACSIS198)

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS199)

Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS200)

Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS203)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS205)

Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problems (ACSIS206)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208)

Investigating Ocean Acidification: We Are Scientists

Student Activity

Have you ever encountered a problem you had to investigate or research to solve? Then you are a scientist! Scientists investigate the world around us to learn more. In these activities you are scientists investigating the impacts of carbon dioxide on the marine environment.

How does CO_2 affect water?

Aim

To investigate how carbon dioxide affects the pH of water.

PART 1: Student Investigation

Materials

Universal indicator

Water

500 mL conical flask

One-way straw

Method

1. Make a prediction: What will happen when you blow carbon dioxide into water?
2. Add 2 mL of indicator and 250 mL of water to the beaker.
3. Submerge the straw in the solution and blow air through the straw for 2 minutes. (When you need to take a breath, remove your mouth from the straw and breathe normally, do not inhale through the straw).
4. Describe your observations. Did anything change? Why?

Results

How did the pH of your solution change?

Approximately how many times more acidic did your solution become? Explain the results (remember pH is a logarithmic scale - see pH scale diagram).

PART 2: Teacher Demonstration (optional)

Materials

Universal indicator

Water

1 L measuring cylinder

Dry ice

Gloves

Method

1. Make a prediction: What will happen when dry ice is added to water?
2. Add 9 mL of universal indicator to the measuring cylinder and pour in 600 mL of warm water.
3. Using gloves, drop a small handful of dry ice into the measuring cylinder.
4. Describe your observations. Did anything change? Why?

Results

Explain the results and describe the change in pH of your solution.

Approximately how many times more acidic did your solution become?

Questions

1. How does CO_2 affect water?

2. Why are our oceans becoming more acidic?

3. Explain the similarities and differences between this experiment and the real world.

4. How could this model be improved to better represent the ocean acidification in the natural environment?

Further Investigations

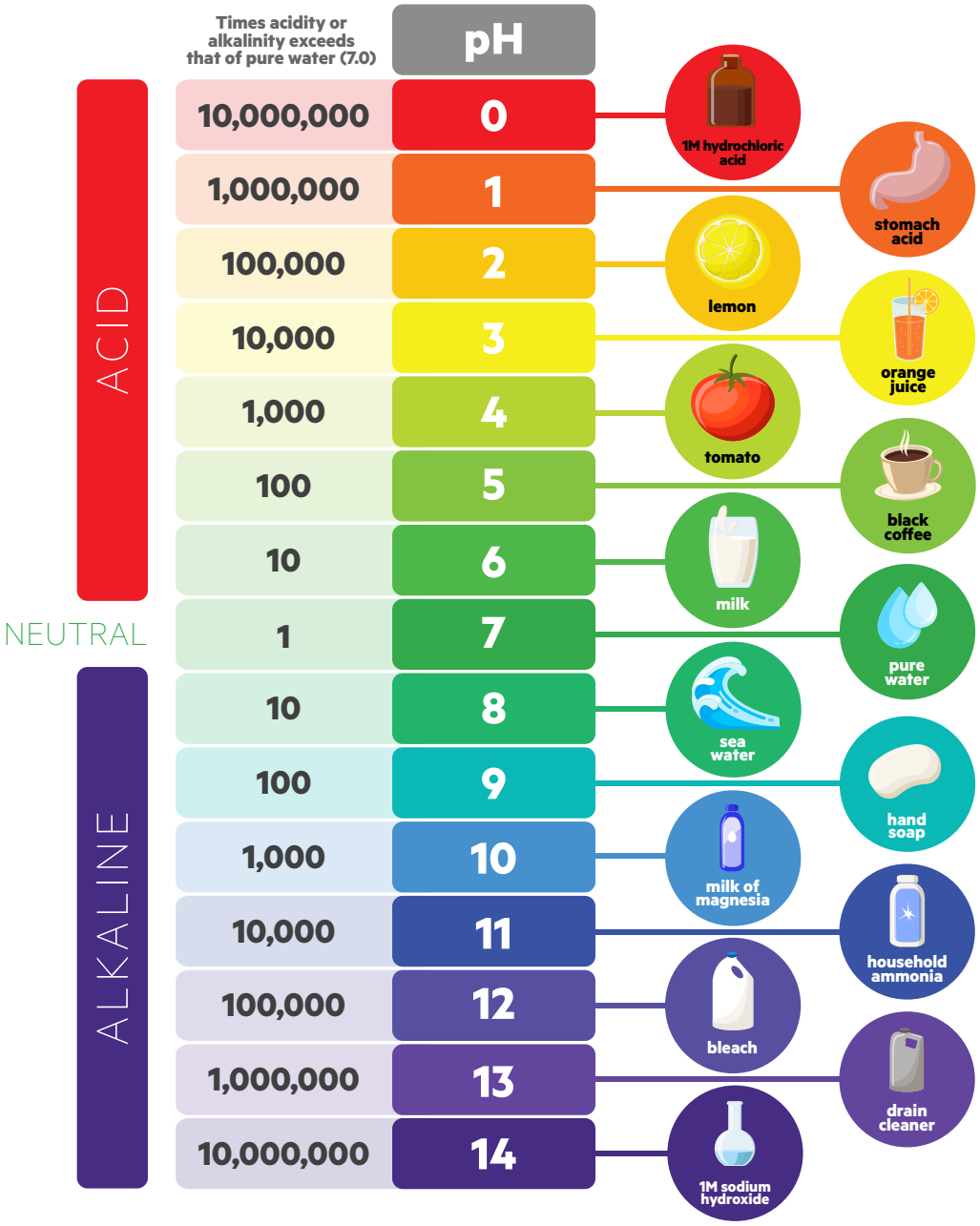
- Try comparing fresh water with sea water. Fill one beaker with 100 mL of fresh water and one with 100 mL of sea water. Add 5 drops of universal indicator and gently blow bubbles into each beaker for 2 minutes. Observe differences in pH and explain your results. (If sea water is not available, a substitute can be made by dissolving 30 g of common salt (sodium chloride) in 1 L of water.)
- Design an experiment to investigate the pH change in exhaled breath before and after exercise. Remember to keep your experiment fair by controlling the variables. You should write a justified hypothesis before you conduct the experiment. This activity links to the human body and homeostasis.

Identifying the pH of a solution

The pH of a solution tells us how acidic or alkaline (basic) a substance is. The acidity depends on the concentration of hydrogen ions, written as [H+]. The greater the hydrogen ion concentration, the more acidic the solution (and the lower the pH).

The pH scale is a 'logarithmic' scale (similar to the Richter scale for earthquakes). This means that every drop in pH value is 10 times more acidic than the value above: a pH of 6 is TEN TIMES more acidic than a pH of 7 (if this is converted to a percentage it would be 1000% more acidic)!

Since the industrial revolution, the pH of the oceans is estimated to have decreased from 8.2 to 8.11. This may not seem like much, but because pH is logarithmic this accounts for a 25 to 30% increase in acidity!



How does acid affect organisms with calcium carbonate shells?

Aim

To investigate the effect of acid concentration on calcium carbonate.

Materials

3 x 50 mL beakers

Calcium carbonate chips

Water

0.1 M hydrochloric acid

0.5 M hydrochloric acid

Method

1. Make a prediction: How will different strength acids affect the calcium carbonate?
2. Pour 40 mL of water into beaker A, 40 mL of 0.1 M hydrochloric acid into beaker B, and 40 mL of 0.5 M of hydrochloric acid into beaker C.
3. Pour approximately ¼ tsp of calcium carbonate chips to each beaker at the same time.
4. Describe your observations.

Results

Describe and explain the results.

When an acid and carbonate are combined they react to form a salt, carbon dioxide and water. This can be written as: **acid + carbonate → salt + carbon dioxide + water**

More specifically, hydrochloric acid and calcium carbonate form calcium chloride, carbon dioxide and water: **hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water**

Questions

1. Complete the balanced chemical equation for this reaction.

$2HCl + CaCO_3 \rightarrow$ [ ] + [ ] + [ ]

2. What could this mean for marine organisms with calcium carbonate shells and corals with calcium carbonate skeletons?

3. How might this affect the marine ecosystem?

4. How could this experiment be modified to collect quantitative data? Write a method for this experiment.

5. How could this experiment be improved to better model the real world?

Which shelled organisms will be most affected by a change in pH?

Aim

To investigate how surface area of calcium carbonate affects the rate of reaction with hydrochloric acid.

Materials

0.1 M hydrochloric acid

Calcium carbonate powder

Calcium carbonate chips

4 x 50 mL beakers

Electronic scale

Method

1. Make a prediction: How will surface area affect rate reaction?
2. Pour 40 mL of hydrochloric acid into a small beaker and place on a scale.
3. Place another empty, dry beaker on the same scale with the hydrochloric acid beaker and tare the scale.
4. Add 0.75 g of calcium carbonate power to the dry beaker.
5. Record the starting mass of the scale (this should be 0.75 g).
6. Pour calcium carbonate into the hydrochloric acid and place the empty beaker back on the scale.
7. Measure the mass every 30 seconds for 2 minutes and record in a table.
8. Repeat the experiment with calcium carbonate chips.
9. Graph the results (remember the dependent variable – mass – should be on the y-axis).

Results

Explain the results.

Questions

1. Based on these results, are smaller shelled organisms or larger shelled organisms likely to be more affected by ocean acidification?

2. What could this mean for the marine ecosystem?

3. How could changes in the pH of the ocean affect people?