

ENGINEERING DESIGN CHALLENGE

Design a Model of Ocean Acidification

Your school science club has been tasked with making topics in the news more relatable to the general public. One of these topics is climate change. In particular, your science club has to come up with a straightforward way to demonstrate two ideas related to ocean acidification: the cycling of carbon between Earth's ocean and the atmosphere, as well as the effects of ocean acidification on coral reef formation.

Focus on Engineering Practices

SEP 1 Defining the Problem

SEP 3 Planning and Carrying Out Investigations

SEP 6 Designing Solutions

Materials Per Group

- Bromocresol green indicator solution, 0.04% aqueous
- Calcium hydroxide solution, saturated $\text{Ca}(\text{OH})_2$, 400 mL
- Drinking straws
- Hot plate
- Ice bath
- Seltzer water

Safety

Calcium hydroxide is a skin irritant. Avoid dust inhalation. The solution is a weak base. Avoid ingestion of the limewater solution. Wear safety goggles and gloves while carrying out your investigation. Alert your teacher if you break a glass object. At the end of the lab, wash your hands thoroughly with soap and warm water.

Develop a Solution

1. **SEP Define the Problem** In your own words, briefly define the problem.

2. **SEP Identify Criteria and Constraints** List criteria and constraints you have identified or that your teacher has provided.

Criteria	Constraints

3. **Conduct Research** Go online and research the equilibrium equations that exist in ocean water and relate to its acidification. Record these equations in the space that follows and discuss the relationship between the amount of dissolved CO_2 in the oceans and pH. Also, discuss the relationship between the amount of dissolved CO_2 in the oceans and coral reef persistence, or the solubility of CaCO_3 . Are the relationships direct or indirect? Explain in terms of LeChatelier's principle.

- 4. SEP Design a Solution** Using only the materials listed in the constraints section, design models of chemical systems that demonstrate the indirect relationship between dissolved CO_2 and pH, and the direct relationship between dissolved CO_2 and CaCO_3 solubility. In the space, describe the two chemical systems you will use to demonstrate these relationships and thereby model the effects of increased global CO_2 production.

5. SEP Test Your Solution Describe how your group will evaluate the efficacy of your models.

6. SEP Evaluate Your Solution Review your group's criteria and constraints. Based on your observations, do you consider your models suitable for communicating the effects of CO₂ production on Earth's oceans to the public? Why or why not?

7. **SEP Refine Your Solution** How might you improve your models to better demonstrate the relationships between CO₂ absorption and pH, and CaCO₃ solubility?