This activity helps students explore how nature creates calcium carbonate, a compound needed to manufacture cement, at ambient temperatures and using abundant, readily available raw materials. It has been modified from “Concrete without Quarries” and is used with permission from the Biomimicry Institute, https://biomimicry.org

**Balanced Chemical Equations**
The following series of 4 balanced chemical equations describe the reactions required to produce calcium carbonate from carbon dioxide:

1) Bubbling carbon dioxide through water causes the formation of carbonic acid:  
\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \]

2) The addition of the base causes the formation of sodium hydrogen carbonate and water:  
\[ \text{H}_2\text{CO}_3 + \text{NaOH} \rightarrow \text{NaHCO}_3 + \text{H}_2\text{O} \]

3) The addition of even more base results in the formation of sodium carbonate and water:  
\[ \text{NaHCO}_3 + \text{NaOH} \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \]

4) Finally the sodium carbonate reacts with the aqueous calcium chloride (seawater) to form the calcium carbonate that will be used in the production of cement for concrete (plus sodium chloride, or salt):  
\[ \text{Na}_2\text{CO}_3 + \text{CaCl}_2 \rightarrow \text{CaCO}_3 + 2\text{NaCl} \]

**Questions**
Use the reaction series above to answer the following questions:

1) Classify each of the above reactions either as a synthesis, decomposition, single replacement, or double replacement reaction. Explain your reasoning.

2) Assuming all the carbon dioxide reacts in the first step, if one mole of carbon dioxide is bubbled through excess water, how many moles of calcium carbonate could be produced?

3) If you started with one metric ton (1000 kg) carbon dioxide, how many kilograms of calcium carbonate could be produced assuming all the carbon dioxide reacts?

4) If 1138 kg of calcium carbonate are produced when one metric ton of carbon dioxide is reacted, what percent yield does this represent?

5) How many kilograms of calcium chloride would be required if one metric ton of carbon dioxide were reacted?
This activity helps students explore how nature creates calcium carbonate, a compound needed to manufacture cement, at ambient temperatures and using abundant, readily available raw materials. It has been modified from: “Concrete without Quarries” and is used with permission from the Biomimicry Institute, https://biomimicry.org

**Balanced Chemical Equations** The following series of 4 balanced chemical equations describe the reactions required to produce calcium carbonate from carbon dioxide:

1) Bubbling carbon dioxide through water causes the formation of carbonic acid: $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$
2) The addition of the base causes the formation of sodium hydrogen carbonate and water: $\text{H}_2\text{CO}_3 + \text{NaOH} \rightarrow \text{NaHCO}_3 + \text{H}_2\text{O}$
3) The addition of even more base results in the formation of sodium carbonate and water: $\text{NaHCO}_3 + \text{NaOH} \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$
4) Finally the sodium carbonate reacts with the aqueous calcium chloride (seawater) to form the calcium carbonate that will be used in the production of cement for concrete (plus sodium chloride, or salt): $\text{Na}_2\text{CO}_3 + \text{CaCl}_2 \rightarrow \text{CaCO}_3 + 2\text{NaCl}$

**Questions** Use the reaction series above to answer the following questions:

1) Classify each of the above reactions either as a synthesis, decomposition, single replacement, or double replacement reaction. Explain your reasoning. **Reaction 1 is a synthesis reaction because two materials are combining to form a new material. Reactions 2, 3, and 4 are all double replacement reactions because in all three there are two exchanges of positive ions and negative ions.**

2) Assuming all the carbon dioxide reacts in the first step, if one mole of carbon dioxide is bubbled through excess water, how many moles of calcium carbonate could be produced? **One mole of CO2 produces one mole of H2CO3 and / One mole of H2CO3 produces one mole of NaHCO3 and / One mole of NaHCO3 produces one mole of Na2CO3 and finally / One mole of Na2CO3 produces one mole of CaCO3. So overall one mole of CO2 produces one mole of CaCO3.**

3) If you started with one metric ton (1000 kg) carbon dioxide, how many kilograms of calcium carbonate could be produced assuming all the carbon dioxide reacts? **So about 2.25 metric tons of calcium carbonate can be produced from 1 metric ton of carbon dioxide!**

4) If 1138 kg of calcium carbonate are produced when one metric ton of carbon dioxide is reacted, what percent yield does this represent? **% yield = 1138 kg / 2275 kg = .5002 = 50.02 %**

5) How many kilograms of calcium chloride would be required if one metric ton of carbon dioxide were reacted? **So about 2.5 metric tons of calcium chloride are required to react completely with 1 metric ton of carbon dioxide.**

**ACS Program-in-a-Box** is an exclusive benefit for ACS Local Sections, Technical Divisions, and Student Chapters. Hosting an event is easy because it’s all in the box!