# Protect the Reef

## Overview
In this lesson, students will complete a POGIL (process oriented guided inquiry learning) about double replacement reactions that also serves as an introduction to solubility rules. Students will then relate the concept of precipitation reactions to the real world process of the formation of shells and protective coat of coral reefs.

## Key Search Words
Secondary; high school; chemistry; physical science; POGIL backwards design; double replacement reactions; crystal lattice; ionic bonds; law of conservation of mass; aqueous solutions; calcium carbonate

## Learning Objectives
SWBAT…
- verbally explain that in a double replacement, two reactants swap partners and form two distinctly different products
- predict how mass is added to a shell

## Curriculum Alignment
North Carolina Chemistry Standard: Chm.2.2 Analyze chemical reactions in terms of quantities, product formation, and energy.
- Chm.2.2.2 Analyze the evidence of chemical change.
- Chm.2.2.3 Analyze the law of conservation of matter and how it applies to various types of chemical equations (synthesis, decomposition, single replacement, double replacement, and combustion).

NGSS:
- 5-PS1-3. Make observations and measurements to identify materials based on their properties.
- 5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

## Classroom time required
45+ minutes

## Materials & Technology
- transparent BINGO tiles/rounds (suggested colors are red, blue, green, and yellow; don't have to be transparent if that is not readily available)
- colorful pencils/markers
- student computers

## Safety
Lab safety measures should be taken if doing the extension.

## Teacher Preparation for Activity
Gather materials.

## Student Preparation for Activity
To complete this activity, students should be familiar with and able to apply the law of conservation of mass. Familiarity with polyatomic ions and nomenclature is also recommended.

## Procedure

| Activity | Time Recommendation (min) |
|---|---|
| **Introduction/Engagement:** Backwards Design Worksheet<br>• This worksheet will guide students through guided | 45 |

| | |
|---|---|
| inquiry of double replacement reactions.<br>● Students start out with an abstract/more general introduction of the material. The abstract introduction is then connected to the scientific idea of double replacement reaction and the formation of distinct products.<br>● After completing the introduction, students will look into a real world application about the deposition of calcium carbonate in the formation of molluscs | |
| **Extension:** Adding Mass Challenge<br>● Materials: calcium chloride, sodium carbonate, potassium carbonate; distilled water; fabric<br>● Challenge: provide the materials to the students and see who can add the most mass to their fabric<br>● Safety: full laboratory safety measures should be taken | determined by teacher |

## Differentiation

- Color Blindness: Instead of having students focus on the mixing of colors, add numbers to the clear BINGO tiles. Assign the red tile the numerical value of 1, blue the value of 4, yellow the value of 5, green the value of 6.

## Assessment/Check for Understanding

- Check learning objectives

## Required resources

Ocean Acidification: A Risky Shell Game

- URL: https://www.whoi.edu/oceanus/feature/ocean-acidification-a-risky-shell-game/
- Explanation: students will read this article to learn about how calcium carbonate deposition adds mass to shells and a protective coat to coral reefs

## Sources

Madin, K. (2022, June 8). *Ocean acidification: A risky shell game: WHOI*. Woods Hole Oceanographic Institution.

Retrieved July 8, 2022, from https://www.whoi.edu/oceanus/feature/ocean-acidification-a-risky-shell-game/

## Appendices

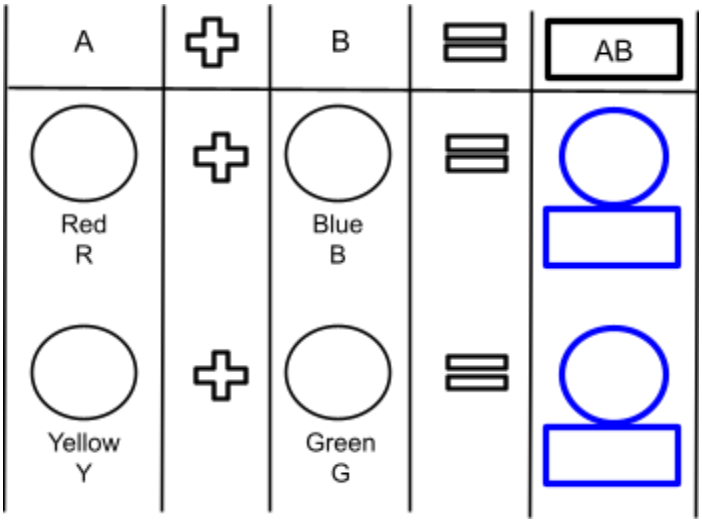
**Double Replacement Reactions POGIL**

**Instructions:** The parts where you have to **WRITE** something are **bolded and blue** in color. The parts where you have to **DO** something else are **bolded and orange** in color.

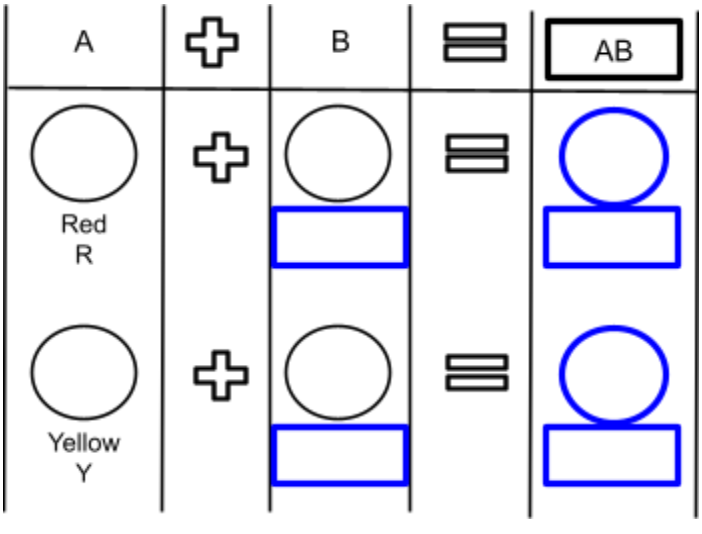
**Materials:**

- 1 red, green, blue, and yellow round
- Colorful pencils/markers

- Using your colorful rounds, **overlap the rounds** and **fill out the chart below:**




- Now, **swap the partners from the B column** and **fill out the chart below:**




- Write a **two sentence summary** of what happened from question #1 to question #2.

- The AB column from question #1 are the reactants and the AB column from question #2 are the products. **Write out a complete chemical equation that follows the law of conservation of mass.** After you are done, **color code your equation. Pair up with a partner and model with your rounds the equation you wrote out.**

**Double Replacement Reactions:** What we just did involved the mixing of 2 colors to produce a new and unique color. In question #2, the partner from column B was switched and we produced 2 totally different colors. This also happens at the atomic level between positive and negative ions that are floating/dissolved in solution. Depending on the atoms that meet, different products are formed. **This is known as a double replacement reaction as both partners switched places.** Scientists typically write the cation/atom with the positive charge first and the anion/atom with the negative charge second. This helps to make sure you always pair a positive and negative ion together to form a neutral product.

- **Fill out the AY + XB column below to form 2 NEUTRAL/UNCHARGED products:**

| AB (aq) | + | XY (aq) | = | Products: AY + XB | State symbols solid/insoluble (s) or aqueous/soluble (aq) | Explain how you decided between s/aq for each product. |
|---|---|---|---|---|---|---|
| NaCl Sodium chloride | | LiF | | | | |
| KI | | $Pb(NO_3)_2$ | | | | |
| $CaCl_2$ | | $Na_2CO_3$ | | | | |

**Predicting States pt 1:** When something is aqueous, it means it is dissolved into its ion parts and is floating around in the water. **Aqueous also means soluble.** If something forms a solid from two aqueous solutions, the **solid is called the precipitate** and is considered **insoluble**.

- **Define the following terms:**
  a. Aqueous:

  b. Precipitate:

**Predicting States pt 2:** After determining the products of a double replacement reaction, it is important to determine the states. The below system helps you determine whether something is aqueous or forms a solid. Look for the name of different ions from the reaction and **READ THE ENTIRE RULE** to determine the state of the product. If both products are aqueous, no reaction occurs.

**SOLUBILITY RULES**

**Soluble:**

- All Nitrates, Acetates, Ammonium, and Group 1 (IA) salts
- All Chlorides, Bromides, and Iodides, except Silver, Lead, and Mercury(I)
- All Fluorides except Group 2 (IIA), Lead(II), and Iron(III)
- All Sulfates except Calcium, Strontium, Barium, Mercury, Lead(II), and Silver

**Insoluble (0.10 *M* or greater):**

- All Carbonates and Phosphates except Group 1 (IA) and Ammonium
- All Hydroxides except Group 1 (IA), Strontium, Barium, and Ammonium
- All Sulfides except Group 1 (IA), 2 (IIA), and Ammonium
- All Oxides except Group 1 (IA)

*From the NC Chemistry reference table

- **Fill out the remaining two columns in the table on the previous page.**
- **Brainstorm** with your partner why no reaction occurs if both double replacement products are aqueous. **Outline your ideas below.**

- **Write out the complete chemical reaction between calcium chloride and sodium carbonate.** Include state symbols. **Write out the steps as you go to reference later.**

**Real world application:** Some research has shown that 95% of molluscan shells are made up of calcium carbonate. Coral reefs also have calcium carbonate on their outer layer.

- **Brainstorm** with your partner how sea shells add mass to their shells and form a protective layer in coral reefs. **Write your thoughts below.**

**Go to the following link:**
**https://www.whoi.edu/oceanus/feature/ocean-acidification-a-risky-shell-game/**

- Summarize the article in 5-7 sentences.

- Research actions you and/or your community could take to help protect the coral reefs.

**Double Replacement Reactions POGIL KEY**

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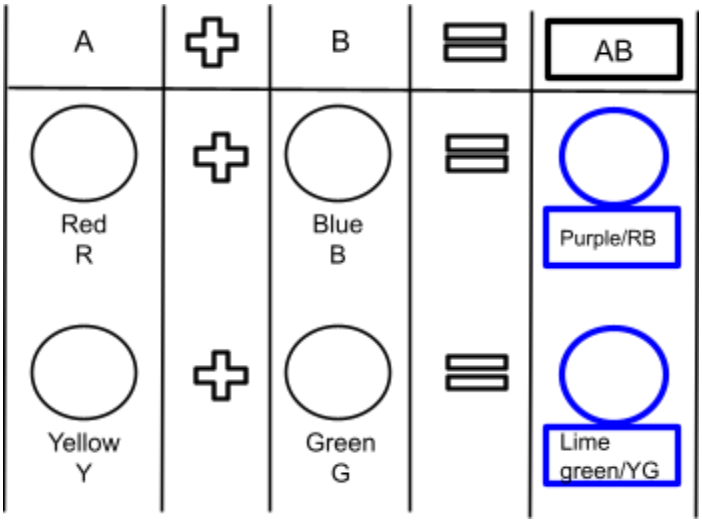


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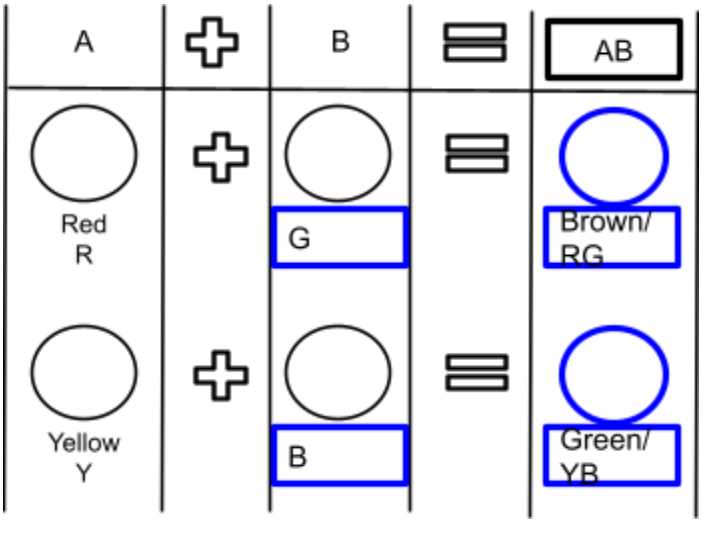


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**RB + YG → RG + YB (color code)**

**Double Replacement Reactions:** What we just did involved the mixing of 2 colors to produce a new and unique color. In question #2, the partner from column B was switched and we produced 2 totally different colors. This also happens at the atomic level between positive and negative ions that are floating/dissolved in solution. Depending on the atoms that meet, different products are formed. **This**

**is known as a double replacement reaction as both partners switched places.** Scientists typically write the cation/atom with the positive charge first and the anion/atom with the negative charge second. This helps to make sure you always pair a positive and negative ion together to form a neutral product.

- **Fill out the AY + XB column below to form 2 NEUTRAL/UNCHARGED products:**

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|---|---|---|---|---|
| NaCl Sodium chloride | LiF | NaF; LiCl | Aq → no reaction | |
| KI | $Pb(NO_3)_2$ | $KNO_3$ PbI | Aq S | |
| $CaCl_2$ | $Na_2CO_3$ | $CaCO_3$ NaCl | S Aq | |

**Predicting States pt 1:** When something is aqueous, it means it is dissolved into its ion parts and is floating around in the water. **Aqueous also means soluble.** If something forms a solid from two aqueous solutions, the **solid is called the precipitate** and is considered **insoluble**.

- **Define the following terms:**
  a. Aqueous: dissolve/floating in solution/soluble
  b. Precipitate: solid/insoluble

**Predicting States pt 2:** After determining the products of a double replacement reaction, it is important to determine the states. The below system helps you determine whether something is aqueous or forms a solid. Look for the name of different ions from the reaction and **READ THE ENTIRE RULE** to determine the state of the product. If both products are aqueous, no reaction occurs.

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**$CaCl_2$ (aq) + $Na_2CO_3$ (aq) → $CaCO_3$ (s) + NaCl (aq)**

**+ steps that make sense to student**

**Real world application:** Some research has shown that 95% of molluscan shells are made up of calcium carbonate. Coral reefs also have calcium carbonate on their outer layer.

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