



# Reaction: Yes or No?

**Learning Objectives:** Students will list and identify three characteristics of chemical reactions.

## GRADE LEVEL

3–8

## SCIENCE TOPICS

Solutions and Mixtures  
Chemical Reactions

## PROCESS SKILLS

Describing and Defining  
Measuring  
Explaining

## GROUP SIZE

1–3

If available, goggles are recommended for this activity.



## SNEAK PEAK inside ...

### ACTIVITY

Students mix household materials and observe color changes, fizzing, and heat.

### STUDENT SUPPLIES

see next page for more supplies

turmeric powder,  
rubbing alcohol  
calcium chloride (from hardware stores)  
baking soda  
sealing plastic bags, etc....

### ADVANCE PREPARATION

see next page for more details

Dilute alcohol with water  
Set out plastic cups, etc....

### OPTIONAL EXTRAS

### DEMONSTRATION

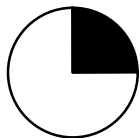
Acid Base Indicators (p. B - 40)  
Gas Production (p. B - 41)

### EXTENSIONS

Test Turmeric Indicator (p. B - 46)  
De-Icer Product Investigation (p. B - 47)

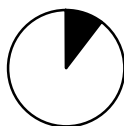
## TIME REQUIRED

### Advance Preparation



15 minutes

### Set Up



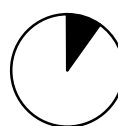
5 minutes

### Activity



20 minutes

### Clean Up



5 minutes

## SUPPLIES

Item	Amount Needed
sealing plastic bag, (e.g., Ziploc™) pint or sandwich size *see Notes and Hints in Advanced Preparation	1 per group
plastic spoons	3 per group
turmeric	1 teaspoon per group
baking soda	¼ cup per group
calcium chloride (available in hardware stores)	¼ cup per group
isopropyl alcohol, 70% (rubbing alcohol) or 90%	< ¼ cup per group
plastic cups, 8 oz.	3 per group

For Extension or Demonstration supplies, see the corresponding section.

## ADVANCE PREPARATION

### Supplies Preparation

#### Dilute isopropyl alcohol solution:

- Dilute 70% or 90% rubbing alcohol to make a 30–35% solution:
  - For 70% isopropyl alcohol (rubbing alcohol), mix 1 part rubbing alcohol to 1 part water (this makes a 35% solution).
  - For 90% isopropyl alcohol, mix 1 part isopropyl alcohol to 2 parts water (this makes a 30% solution).
- Fill pop-top squeeze bottles with about ¼ cup of alcohol.
- Label the bottles “alcohol solution” and write the concentration (30% or 35%).
- Make certain the pop-top is closed on all bottles so the alcohol does not evaporate.

**CAUTION: Isopropyl alcohol is flammable at 90% and 70% concentrations. At a concentration of 30%–35%, its flammability is greatly reduced. Nevertheless, all open flames and sparks should always be kept away from these solutions.**

#### Baking Soda:

Fill plastic cups with ¼ cup of baking soda.  
Label the cups “baking soda.”

#### Turmeric

- Fill plastic cups with about 1 teaspoon of turmeric powder.
- Label the cups “turmeric.”

### Calcium Chloride:

- ❑ Calcium chloride ( $\text{CaCl}_2$ ) is available as a deicer or as a dehumidifier.
  - ❑ deicer brands: ComboTherm and Road Runner.
  - ❑ dehumidifier brands: Dry Z Air.
  - ❑ other brands may work also—look on the side panel and test other brands before using in class.
- ❑ Fill plastic cups with  $\frac{1}{4}$  cup of calcium chloride.
- ❑ Label the cups “calcium chloride.”

**CAUTION:** Since calcium chloride absorbs moisture from the air, always store calcium chloride in an air-tight container.

### Notes and Hints

- ❑ Choose higher quality sealing plastic bags with slightly thicker plastic, because upon excessive handling some of the turmeric might diffuse through the plastic onto students' fingers.

## SETUP



#### For each group

- ❑ 1 sealing plastic bag, pint or sandwich size
- ❑ 3 plastic spoons
- ❑ about 1 teaspoon turmeric in a plastic cup
- ❑  $\frac{1}{4}$  cup baking soda in a plastic cup
- ❑  $\frac{1}{4}$  cup calcium chloride in a plastic cup
- ❑  $\frac{1}{4}$  cup diluted alcohol solution in a pop-top squeeze bottle (keep top closed until ready to use)

#### At a central location (or with the teacher)

- ❑ sponges and towels for clean up

## INTRODUCING THE ACTIVITY

*Let the students speculate before offering answers to any questions. The answers at right are provided for the teacher.*

In this activity, students will investigate a simple chemical reaction with easily observable changes.

The most common signs of chemical reactions include the following:

- ❑ appearance of a new gas, solid, or liquid
- ❑ change in temperature
- ❑ appearance of light
- ❑ change in color
- ❑ change in pH
- ❑ production of electricity

Choose questions that are appropriate for your classroom.

**What do you think of when you hear the word “chemistry”?**

*Explosions, foaming and bubbling potions, messy science, mixing things together, etc.*

**Yes, chemistry is the study of matter (stuff) and how it reacts with other matter (stuff). When two things react together in a chemical way, they change each other, and the results can be quite dramatic (e.g., explosions, color changes, etc.).**

**Can anyone list some specific examples of chemical reactions?**

*Student answers will vary depending on exposure to chemistry. Students might suggest fires, batteries, baking soda and vinegar, pH test kits for pools or hot tubs, bleaching hair, cooking food, rusting, gasoline in car engines, medical test strips used by family members (e.g., for diabetes), etc. It's not critical that students correctly identify reactions at this point, but rather that they use what they know to make a list.*

**Those all sound like chemical reactions, but how can we be sure? Let's just guess and make a list of what we think are signs of a chemical reaction using these examples.**

*Some will say things explode or change color. Others might point out that heat is involved. You might ask students to list some real life examples of chemical reactions. Students can come up with their own list of signs of a chemical reaction and test it against the reaction in this experiment.*

In this experiment, students will perform and analyze a real chemical reaction.

## TEACHER DEMONSTRATION

### Acid Base Indicators

This demonstration shows how the turmeric changes color in acids and bases. Because it changes color in different solutions, turmeric is an **indicator** for acids and bases.

#### Supplies

- ❑ 2 clear plastic cups, 8 oz. or larger
- ❑ 30% or 35% alcohol solution from the activity
- ❑ turmeric powder
- ❑ 1 tablespoon vinegar
- ❑ 1 teaspoon baking soda

#### Demonstration

- ❑ Add about  $\frac{1}{4}$  cup alcohol solution to each cup. Add a pinch of turmeric powder to each cup and stir until it dissolves.
- ❑ Add 1 tbsp. vinegar to one cup of indicator, and then add 1 tsp. baking soda to the other. The turmeric turns red with baking soda but stays yellow with vinegar.

Students will no doubt ask that you pour them together. You can safely mix these together and demonstrate the reaction of baking soda and vinegar by performing the "Gas Production" demonstration below.

#### Explanation

Turmeric (and curry powder, which contains turmeric) is an acid base indicator. When it reacts with bases (like baking soda), it changes color to deep red. This red form of the indicator can change back to yellow when acids are added. Thus the color of the chemical "indicates" the presence of an acid or base.

Alternatively, use the cabbage juice indicator from **Of Cabbages and Kings** with vinegar and baking soda; it will change to two different colors.

#### Gas Production

This demonstration shows the fizzing reaction (i.e., the production of gas) that occurs when baking soda is added to vinegar.

#### Supplies

- ❑ 1 tsp. baking soda
- ❑ ¼ cup vinegar
- ❑ 12 oz. plastic cup

#### Demonstration

Add the teaspoon of baking soda to the vinegar in the cup. The solution fizzes and pops as the chemicals react and produce carbon dioxide gas.

#### Explanation

When vinegar and baking soda combine, they form carbon dioxide gas as a product. This gas escapes the mixture causing the fizzing, bubbling reaction.

## CLASSROOM ACTIVITY

Have students follow the Scientific Procedure on page B - 49, working in groups of 1–3. Below are suggestions to help the teacher facilitate the activity.

### NOTES

If available, goggles are recommended for this activity.



## Reaction: Yes or No?

### SCIENTIFIC PROCEDURE

1. Add 5 spoonfuls of alcohol into the plastic bag.
2. Add 1 spoonful of baking soda into the same plastic bag.
3. Close the bag tightly and mix the baking soda and alcohol until the baking soda dissolves.
4. Dry the spoon with paper towel.
5. Add a pea-sized amount of turmeric powder. Close the bag and mix the bag contents for 30–60 seconds.
  - What do the contents of the bag look like?



This handout  
is on p. B - 49.

### Running Suggestions

- ❑ Remind students to completely seal their bags after adding the ingredients.

Choose higher quality resealable plastic bags with slightly thicker plastic, because upon excessive handling some of the turmeric might diffuse through the plastic onto students' fingers.

- ❑ If students double the ingredients, the bags may burst. Caution students against this (perhaps by emphasizing how the turmeric could stain their clothes).
- ❑ Watch students to see that they are careful when measuring the alcohol solution. One person should hold the spoon over the bag while the other person CAREFULLY squeezes alcohol onto the spoon.
- ❑ Discourage students from opening their bags after the reaction happens. The pressure of the gas can force the liquids out.

## Ongoing Assessment

- ❑ Which chemical inside is changing color (baking soda, alcohol, turmeric, etc.)? Why do you think so? How could you find out?  
*Students can add any two of the ingredients to see which is responsible for the color change.*
- ❑ How can you tell there is a gas (or air) inside the bag? Can you see it?
- ❑ What new chemical or chemicals are being produced? How can you tell?
- ❑ Where do you think the heat is coming from?

## Safety and Disposal Information

- ❑ If available, goggles are recommended for this activity.
- ❑ Caution students to be careful with the turmeric indicator since it can stain their fingers and clothes.
- ❑ Students can throw their bags away at the end of the experiment.

**CAUTION: Isopropyl alcohol is flammable at 90% and 70% concentrations. At a concentration of 30–35%, its flammability is greatly reduced. Nevertheless, all open flames and sparks should ALWAYS be kept away from these solutions.**

## CLASSROOM DISCUSSION

*Ask for student observations and explanations. Let the students guide the discussion and present their hypotheses before discussing explanations.*

*Choose questions that are appropriate for your classroom.*

### **What did the chemicals look like before you mixed them in the bag?**

*The baking soda was a white powder. The turmeric was yellow and the alcohol solution was clear. The mixture of baking soda with turmeric is red.*

### **How was the mixture different after you added the calcium chloride? What did you see, hear, and feel?**

*It turned yellow; it got hot/warm; the bag filled up with air; bubbles appeared; it got foamy, etc. Yellow color change, slight bubbling sound, heat in the baggie, etc.*

### **What evidence of a chemical reaction do you notice?**

*The color changed. A new substance (a gas) was produced. The temperature changed.*

### **How do you know that you have produced a gas? Can you see it?**

*Although the gas is invisible, students can infer its presence by observing the bubbles and the increase in volume of the bag.*

### **How many color changes did you observe? What happened in each one?**

*There are two color changes—one when the yellow turmeric powder was added to the baking soda and turned red, and again when the calcium chloride was added and the solution turned yellow. In each case, the turmeric detected a base (baking soda) or an acid (carbon dioxide gas).*

### Where did the gas come from?

*The baking soda produces the carbon dioxide gas in this experiment, although this is not necessarily obvious.*

Caution students to not rush to this conclusion, however. There are many ingredients in the bag, and each of them could have produced the gas, in principle. Ask students how they could figure out where the gas came from—e.g., by eliminating ingredients to see if the reaction still occurs. (The mixture still bubbles without the turmeric, for instance.)

## EXPLANATION

*This background information is for teachers. Modify and communicate to students as necessary.*

When atoms and molecules rearrange, they turn into new substances with different properties and different appearances. Students investigate and explore these changes in this activity.

### BACKGROUND FOR ALL GRADES

In chemical reactions, substances interact and transform each other. When students combine all the chemicals in the bag, the bag warms up, the mixture changes color, and a new gas forms that inflates the bag. These changes show that a **chemical reaction** has occurred.

#### Signs of a Chemical Reaction

The following changes usually indicate a new substance has been formed:

- ❑ Appearance of a new gas, solid, or liquid
- ❑ Change in temperature
- ❑ Appearance of light
- ❑ Change in color
- ❑ Change in pH

#### What Happened in the Bag

The main reaction in the bag is between calcium chloride and baking soda. The calcium chloride causes the baking soda to break apart and produce carbon dioxide gas (CO<sub>2</sub>). The other chemicals are incidental to this primary reaction.

In this reaction, students can identify the following signs of a chemical reaction:

- ❑ New gas: Since the CO<sub>2</sub> produced by baking soda and calcium chloride is a **gas**, it bubbles out of the liquid into the bag. As the many invisible gas molecules build up in the bag, they continuously bounce off the walls and therefore exert **pressure** that pushes out on the plastic, increasing the volume of the bag.
- ❑ Color change: The turmeric acts as a chemical **indicator** to the reaction of calcium chloride and baking soda. It starts red to indicate that baking soda is a **base**. As the reaction continues, it turns yellow to show an **acid** is being produced. For more on how turmeric works, see “The Role of Turmeric” below.



- ❑ Change in temperature: It takes energy to connect atoms together into molecules, and when those atoms are rearranged, as they are in chemical reactions, the energy changes. The difference in energy can be positive or negative. In this reaction, rearranging the atoms releases energy, which the students feel as heat.

**Misconception Alert:** Students may incorrectly infer or claim that any temperature change shows a chemical reaction. This isn't true: some processes give off heat or light but don't make a new substance. For example, the glowing electric coil on a stove gives off both heat and light, as does the glowing wire in a light bulb. In both cases electricity is just heating metal hot enough to make it glow. The metal changes the electric energy into heat energy. Since no new substance is being created, there is no chemical reaction.

## EXTRA BACKGROUND FOR GRADES 5–8

### New Substances in the Bag

Although students are likely to notice only the carbon dioxide formed in this experiment, several new substances are actually created:



The table salt, limestone, and water formed in the reaction are very difficult to detect without more advanced chemical methods. Students might nevertheless improvise ways to detect these other chemicals. For instance, some students may notice the limestone as a white, chalky residue forming on the sides of the bag. Others might suggest letting the alcohol and water evaporate a bit to see if the limestone will **precipitate** or come out of solution (limestone is much less soluble in water than table salt).

Observant students may notice that not all of the baking soda or the calcium chloride has reacted. These two ingredients react in definite proportions to each other (as shown in the equation above, it takes twice as much baking soda as calcium chloride). Therefore it is likely that one will run out before the other.

### Chemical Bonds and Energy

The substances in the bag are all made of **molecules**, i.e., collections of two or more **atoms** arranged in a certain way. For instance, baking soda molecules are each made of a sodium atom, a hydrogen atom, a carbon atom, and three oxygen atoms ( $\text{NaHCO}_3$ ). When the atoms in these molecules interact chemically, they trade places and rearrange, producing new molecules (substances) with new characteristics. The baking soda, for instance, rearranges to produce  $\text{CO}_2$  (a gas) and Na and OH.

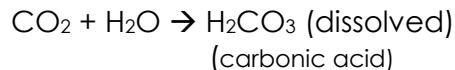
When atoms and molecules react, they have to break the **chemical bonds** that hold them together and then form new bonds to make new substances. In this case, the formation of new bonds releases energy that the students feel as heat. In other cases,

the formation of new bonds requires energy and the reaction will feel cold as heat is taken from students' hands.

### The Role of Turmeric

Turmeric contains **curcumin**, a chemical that turns red with bases and yellow with acids in water. Baking soda is a base, so when students add turmeric, the curcumin in it turns red. The carbon dioxide produced in the reaction mixes with water to make an acid. So in the course of the reaction, the solution turns yellow.

Carbon dioxide produces acid (carbonic acid) in water through the following reaction:



Carbonic acid itself ( $\text{H}_2\text{CO}_3$ ) is invisible in water, but when it reacts with the curcumin, it changes the shape of the curcumin molecule, causing that molecule to reflect light differently. This turns the curcumin yellow.

For information on pH and what it means with regard to acids and bases, see the activity *Of Cabbages and Kings*.

## EXTENSIONS

### Extension A: Turmeric Indicator

Students add turmeric indicator to various household items to determine if they are acids or bases.

#### Extra Supplies

- ❑ two extra cups with  $\frac{1}{4}$  cup each baking soda and calcium chloride
- ❑ extra  $\frac{1}{4}$  to  $\frac{1}{2}$  cup turmeric indicator (dissolve  $\frac{1}{2}$  teaspoon turmeric per cup of 30% isopropyl alcohol to make an acid base indicator)

Choose one or all of the following:

- ❑ vinegar in a plastic cup ( $\frac{1}{4}$  cup per group)
- ❑ lemon or lime juice in a plastic cup ( $\frac{1}{4}$  cup per group)
- ❑ ammonia in a plastic cup ( $\frac{1}{4}$  cup per group)
- ❑ 7UP, Sprite, or another clear soda in a plastic cup ( $\frac{1}{4}$  cup per group)
- ❑ saltwater in a plastic cup ( $\frac{1}{4}$  cup per group)

#### Extra Instructions

Add turmeric indicator to each of the items. If the turmeric turns red, the item is a base. If the turmeric stays yellow, the item is an acid.

### Extension B: Deicer Product Testing

Students test the effectiveness of different products to melt ice. (Many such products use calcium chloride, which heats up on contact with water.)

#### Extra Instructions

- ❑ Follow the link in the Resources section of this activity to the Journal of Chemical Education's Web site to the Lesson "Meltdown Showdown! Which Deicer Works Best?"
- ❑ There is some advanced preparation required (making ice blocks ahead of time). Alternatively, if you live somewhere where ice is common in the winter, do the same activity outside.

## CROSS-CURRICULAR CONNECTIONS

### SOCIAL STUDIES

#### Research the History of Chemical Reactions

Have students research and report on early, famous chemical reactions or chemical concoctions, such as Greek fire (used by Greek sailors to burn enemy ships) or fireworks (developed by the Chinese). Students should identify why each instance is a chemical reaction.

### MATHEMATICS

#### Graph Temperature Changes

Have students measure the temperature change of the reaction with small steel thermometers (they can be placed directly in the resealable bags and read through the clear plastic). If students would like to vary the amounts of baking soda and calcium chloride, they can produce and compare different temperature graphs.

## RESOURCES

#### Web – <http://jchemed.chem.wisc.edu/HS/classAct/ClassActsList.html>

The Journal of Chemical Education publishes online lesson plans for high school students on multiple topics. Under the topic, Consumer Chemistry, the lesson "Meltdown Showdown! Which Deicer Works Best?" investigates the effectiveness of different brands of deicers.

#### Web – [http://www.chem4kids.com/files/react\\_intro.html](http://www.chem4kids.com/files/react_intro.html)

A brief overview of chemical reactions with colorful pictures that show atoms from different molecules combining and rearranging to form new substances.

#### Color Changing Paper

Available at most Kinko's stores, this goldenrod paper is bright gold but will change to bright red when exposed to base. It contains the same dye, curcumin, that makes the turmeric change color in this experiment. The brand is Wausau Papers, Astrobrights, Galaxy Gold.

## VOCABULARY

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<b>acid:</b>	a substance with an excess of available hydrogen ions; often sour in taste
<b>atom:</b>	a very, very small particle that makes up all matter
<b>base:</b>	a substance that takes up hydrogen ions; often bitter in taste
<b>chemical bond:</b>	a connection that holds two atoms together
<b>chemical reaction:</b>	when two substances are mixed together to create a new substance; often characterized by fizzing, color change, change in temperature, or creation of light
<b>curcumin:</b>	the active ingredient in turmeric that changes color in acids and bases
<b>gas:</b>	state of matter where molecules are spread far apart and interact only by random collisions; this state will expand to fill a container of any size
<b>indicator:</b>	A chemical that changes color to show the presence or amount of a certain chemical
<b>molecule:</b>	a group of at least two atoms held together in a definite arrangement
<b>pressure:</b>	continuous force applied by touching; force on a surface created by collisions of gas molecules
<b>precipitate</b>	to come out of a liquid solution as a solid

# Reaction: Yes or No?

## SCIENTIFIC PROCEDURE

1. Add 5 spoonfuls of alcohol into the plastic bag.
2. Add 1 spoonful of baking soda into the same plastic bag.
3. Close the bag tightly and mix the baking soda and alcohol until the baking soda dissolves.
4. Dry the spoon with paper towel.



5. Add a pea-sized amount of turmeric powder. Close the bag and mix the bag contents for 30–60 seconds.
  - What do the contents of the bag look like?

6. Put 1 heaping spoonful of calcium chloride into the same plastic bag. Close the bag and mix the bag contents for 30–60 seconds.



- Do you notice any changes occurring?
  - What do you feel, hear, and see?
  - What evidence is there of a chemical reaction?
7. Clean up your area.
    - Follow your teacher's directions

This worksheet is available online at [www.oms.edu/k8chemistry](http://www.oms.edu/k8chemistry).

# Reaction: Yes or No?

Recommended group size: 1–3

Number of Students:  Number of Groups:

Supplies	Amount Needed	Supplies on Hand	Supplies Needed
sealing plastic bag, (e.g., Ziploc™) pint or sandwich size	1 per group		
plastic spoons	3 per group		
turmeric	1 teaspoon per group		
baking soda	¼ cup per group		
calcium chloride	¼ cup per group		
isopropyl alcohol, 70% (rubbing alcohol) or 90%	< ¼ cup per group		
plastic cups, 8 oz.	3 per group		
<b>Extension A</b>			
extra plastic cups	1 per extra ingredient per group		
vinegar	¼ cup per group		
lemon or lime juice	¼ cup per group		
ammonia	¼ cup per group		
clear soda (7UP, Sprite)	¼ cup per group		
salt water	¼ cup per group		
<b>Extension B</b>			
Follow the link in the Resources section to the Journal of Chemical Education's Web site to the Lesson "Meltdown Showdown! Which Deicer Works Best?"			
<b>Teacher Demonstration</b>			
<b>Acid Base Indicators</b>			
clear plastic cups, 8 oz. or larger	2 for demonstration		
30% or 35% alcohol solution from the activity	½ cup in each plastic cup		
turmeric indicator			
vinegar	1 tablespoon		
baking soda	1 teaspoon		
<b>Gas Production</b>			
baking soda	1 teaspoon		
vinegar	¼ cup		
plastic cup, 12 oz.			