

## What are chemical and physical properties?

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**Objective** – teach the students what chemical and physical properties are through inquiry based learning. Students will understand that to observe a physical property, you do not need to change a substance into a new substance. To observe a chemical property, however, you need to change the substances via a reaction.

### Procedure overview

Set up 6 lab stations with the elements and compounds listed below. Divide the students into groups and have each group cycle through all of the stations. They will only be able to spend about 5 minutes at each station. At each station, a guide (see student pages) will instruct them on what to do and ask them questions including whether they are observing physical or chemical properties. Near the end of the period, the students will be asked which examples they saw in the lab demonstrated physical properties and which demonstrated chemical properties. In other words, the goal is to make the students draw their own conclusion about what a chemical property and a physical properties are based upon the examples they see during this lesson and then lead them in the right direction with discussion at the end.

### Lab stations

1. Liquid nitrogen – an instructor must be present here.

First ask the students what the states of matter are – solid, liquid, and gas. Next, ask what freezing points and boiling points are? Draw a simple phase diagram for water followed by one for nitrogen. Ask them which state nitrogen generally exists in at the Earth's surface. Lead them to the answer and show them a table of atmospheric gas abundances. Now pour out some liquid nitrogen and let them make some observations. They should note that it is boiling and cold. Ask them how cold? In other words, what is the warmest temperature it could be? Freeze a rubber band and let them break it. Ask them how they could make liquid nitrogen from the nitrogen in the air. Lastly, ask them whether freezing points and boiling points are chemical or physical properties of substances.

Element	Melting point		Boiling point	
	°C	°F	°C	°F
N <sub>2</sub>	-210	-346	-195	-320.42
O <sub>2</sub>	-218.8	-361.8	-183	-297.3

Composition of the Atmosphere	
78%	nitrogen
21%	oxygen
1%	other gases such as carbon dioxide and water

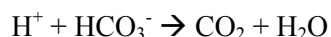
## 2. Metals

Supply the students with some Cu, Fe, Al, and Zn. Are these solids, liquids, or gases. Provide the melting temperatures. Tell them melting point and boiling point are physical properties. Provide them with a magnet and let them test the metals to see if they are magnetic. The magnetic character of these metals is also a physical property. Lastly, give them a piece of the mineral magnetite and let them test it with the magnet. Ask them if the magnetic property of magnetite gives them any clues as to its composition. Make the point that we can use physical and chemical properties to analyze materials.

Element	Melting point		Boiling point	
	°C	°F	°C	°F
Al	660.32	1220.58	2519	4566
Cu	1084.6	1984.3	2562	4643
Fe	1538	2800	2861	5182
Zn	419.53	787.15	907	1665

## 3. Vinegar and baking soda

Provide the students with vinegar (acetic acid  $\text{CH}_3\text{COOH}$ ) and baking soda (sodium bicarbonate  $\text{NaHCO}_3$ ). Have them first smell the vinegar (remember to whiff). Tell them smell is a physical property. Next, have them put about 20 mL of vinegar in a small beaker followed by a teaspoon of baking soda. The following reaction will take place:

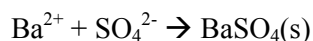


The students will be able to see the  $\text{CO}_2$  bubbles emanating from the beaker. This reaction represents a chemical property of baking soda and vinegar.

## 4. $\text{BaSO}_4$ precipitation

Provide the students with barium chloride ( $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ ) and copper sulfate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ). Have them add a small amount of copper sulfate to a beaker with 100 mL of DI  $\text{H}_2\text{O}$ . Remind them not to breathe the copper sulfate dust. Have them add a small amount of barium chloride to a beaker with 50 mL of DI  $\text{H}_2\text{O}$ . The solubility of these salts in water – the degree to which they dissolve – is one of their physical properties. Next, have the students add the two solutions together. The

mixed solution will be cloudy because a white precipitate has formed, BaSO<sub>4</sub>, according to the following equation.



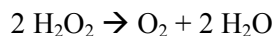
This represents a chemical property of barium and sulfate.

5. Immiscible liquids

Provide the students with some oil and some water. Have them put 30 mL of water in a graduated cylinder. Next, have them add 30 mL of oil. Do the liquids mix? Is one on top of the other?

6. Potato and hydrogen peroxide

Give the students a piece of potato and some H<sub>2</sub>O<sub>2</sub>. Have them put about 25 mL of H<sub>2</sub>O<sub>2</sub> into a small petri plate and then add a potato. An enzyme present in the potato, catalase (technical name: hydrogen peroxide oxidoreductase), catalyzes the splitting of two molecules of H<sub>2</sub>O<sub>2</sub> into oxygen and water as follows:



Production of oxygen and water from hydrogen peroxide represents a chemical property of hydrogen peroxide and the enzyme in the potato.

### **So what is a chemical property?**

A chemical property of matter is its potential to undergo a change or reaction by virtue of its composition to become a different compound. Iron, for example, reacts with oxygen in the air to form iron oxide (rust). The ability of iron, therefore, to react with molecular oxygen represents one of iron's chemical properties.

### **A physical property?**

A physical property of matter is a characteristic that can be observed using one of the 5 human senses and does not require creating a new compound. Examples include color, density, smell, malleability, solubility...

### **Notes**

- This lab as written requires more than 50 minutes for each student to make it through every station. The students generally got through enough, however, that they were able to see some examples of each type of property.

- Use 3 stacked styrofoam cups to hold the liquid nitrogen you are using.
- The copper remaining in solution after barium sulfate precipitation needs to be disposed of properly. Most universities provide that service. If this is inconvenient, consider using sodium sulfate instead of copper sulfate in that reaction. We chose to use copper sulfate because it makes a blue solution that provides a nice contrast to the white barium sulfate precipitate.