

# Properties of Matter

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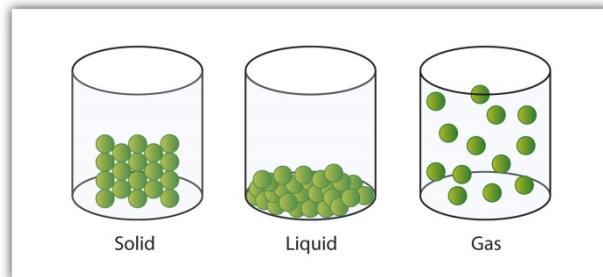
## Properties of Matter

## Matter on the Move

**Passport Question:** What are the three states of matter?

**Passport Answer:** Solid, Liquid, Gas

**Learning Target:** Students will be able to identify what the three phases of matter look like based on how close the molecules are to one another and how much they are able to move.



### **Materials:**

- 3 plastic plates
- Approximately 100 marbles (depending on the size of the plates)
- 3 baskets
- 2 pieces cut to the same size as baskets
- 270 Ping pong balls
- Blow dryer
- Marker (color one ball in each basket)
- Laminated solid, liquid, gas labels and pictures

### **Background:**

It is hard to imagine that matter is made of molecules since it is impossible to see the individual molecules. In this activity, we will show how molecules behave when they are in solid, liquid, and gaseous states.

### **Procedure:**

1. Ask students what the three states of matter are. If they do not know use water as an example (when it freezes it turns into ice, the solid state, and when it gets really hot it evaporates into steam, the gas state).
2. After tell them how in science we use models by taking something really big or small and make it a size we can relate to. The marbles represent molecules or atoms, things that you can only see under a microscope. Based on this information, have the students examine the relative space between the marbles on the three plates and determine which state of matter each plate is.
3. Next, place the blow dryer underneath the ping pong balls so they shift around in the available space. Have the students follow the colored ball, so they can follow the motion of a single "molecule"
4. Have the students match the model to each correct state of matter.
5. A blow dryer provides the heat to simulate the heating and cooling of gas, liquid and solid: the faster the balls move, the hotter the substance. Learners observe how the balls move at a slower rate a lower "temperatures"
6. How do the ping pong balls move differently? Explain that this represents how atoms move in matter when it is in each of the three phases. Have the students match the pictures of solid,

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liquid and gas to the corresponding pictures.

**Discussion:** How do the marbles move differently? How do the ping pong balls move differently?  
Also have them identify each phase by using the models.

Explain that this represents how molecules move in matter when it is in each of the three states.

What about molecules and this model are different than in real life?

A model is a representation, generally miniature, to show the construction or appearance of something. Models are used to explain and predict the behavior of real objects or systems. Molecules are tiny, so you can't actually see them moving with the naked eye, this is just a representation, not the real thing.

What did you notice about the movement of the different phases, did one move more or faster than the other states?

Gas takes up the whole space and moves around freely, liquid moves around a little but still maintains the shape of its container and solid holds its shape and does not move at all.

If you have more time: Adding heat to a gas increases the internal energy. The molecules of the gas move faster and strike the walls of their container more often, yielding an increase in pressure (force per area). This increased pressure simulated by the faster motion of the balls, which strike the sides of the basket harder and more often. Cooling the gas (lowering the speed or moving the blower farther away from the basket) lowers the internal energy, slowing the motion of the molecules and thus lowering the pressure. If you blow air on one side of the bottom of the basket and not the other, the balls will eventually "condense out." That is, they will form a pile on the side away from the blower, where it is "cooler."

## Phase Change Poppers

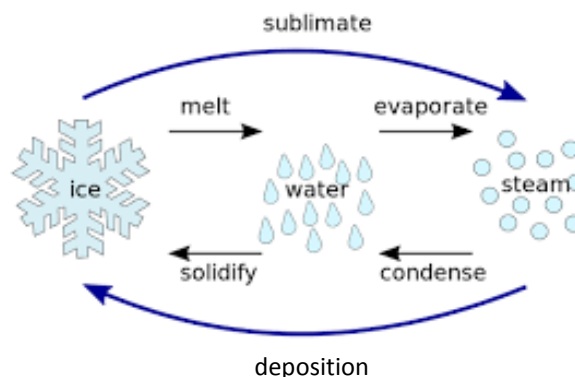
**Passport Question:** What is the phase change when a solid changes directly into a gas?

**Passport Answer:** Sublimation

**Learning Target:** Students will understand the phase changes that occur between solids, liquids, and gases, special emphasis on sublimation. They also learn that air compressed in the tube expands during this process.

### Materials:

- Safety Goggles
- Tall "Airborne" container
- Dry Ice
- Mortar and Pestle
- Screwdriver
- Cooler
- Plastic Spoon
- Two plastic bags
- Ice
- Laminated word "sublimation"



### Background:

Dry Ice is the solid form of carbon dioxide, a normal part of our earth's atmosphere. Carbon dioxide is the gas that we exhale during breathing and the gas that plants use in photosynthesis. It is also the same gas commonly added to water to make soda water. Dry Ice is particularly useful for freezing, and keeping things frozen because of its very cold temperature:  $-109.3^{\circ}\text{F}$  or  $-78.5^{\circ}\text{C}$ . Dry Ice is widely used because it is simple to freeze and easy to handle using insulated gloves. Handling it without insulated gloves can cause frostbite. Dry Ice changes directly from a solid to a gas in normal atmospheric conditions through a process called sublimation. This is why it gets the name "dry ice." The opposite process, which changes carbon dioxide from a gas to a solid, is called deposition.

### Procedure:

1. Put a small amount of crushed dry ice in one plastic baggy. Place water ice in a second plastic baggy. Have students observe both bags and discuss observations.
2. Have everyone wear safety goggles.
3. Crush a small amount of dry ice with the mortar and pestle.
4. Using a spoon take a small amount of dry ice from the mortar and pestle and put it in the "Airborne" container.
5. Making sure that the top of the container is pointed directly at the ceiling, place the lid on the container. Hold the container with one hand. "Fire in the hole..." **Make sure it is not pointed at anyone!**



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### **Discussion:** What happened?

When the solid CO<sub>2</sub> sublimates and turned into gas the molecules moved further away from each other, took up more space, and this expansion caused the lid to pop off the container.

### What are the three states of matter?

SOLID—LIQUID—GAS

### How does matter achieve various states and how does this relate to the process of phase changes?

Matter changes as a result of heating and cooling. This vocabulary explains the various phase changes.

Freezing: Liquid to Solid (Cooling)

Melting: Solid to Liquid (Heating)

Evaporation: Liquid to Gas (Heating)

Condensation: Gas to Liquid (Cooling)

Sublimation: Solid to Gas (Heating)

Deposition: Gas to Solid (Cooling)

### Can you explain why the lid launched off of the container?

When dry ice sublimates, it expands. The mass stays the same, but the volume increases.

## **Invisible Mass**

**Passport Question:** Air has mass.

**Passport Answer:** True or False (Circle one)

**Learning Target:** Students will comprehend that all matter has mass, even gases, just because you cannot see it does not mean that it is not there.

### **Materials:**

- One empty 2-liter bottle
- One Fizzkeeper pump cap
- One digital scale

### **Background:**

Air is usually invisible, so most of us don't give it much thought at all. In fact, when students are asked about the mass or weight of air, many are perplexed. Air seems like it doesn't have mass, but it does. Ask students, "Can you feel the air around you? Do you think it weighs anything?" We can measure the mass of air by weighing it before and after pumping air molecules into a bottle.

### **Procedure:**

1. Attach a Fizzkeeper cap to a 2-liter bottle. Don't pump any extra air into the bottle. Have students feel the bottle, checking for weight and pressure.
2. Weigh the bottle on a triple beam balance and record your findings.
3. Ask students to predict what will change if you pump extra air molecules into the bottle and then measure its mass.
4. Have students use the Fizzkeeper to pump more air molecules into the bottle. They can keep a count of the number of pumps if they like. If you have an accurate balance, students can measure the mass of the bottle as a function of the number of pumps. There is a clear trend, but at some point, the mass will stop increasing as the pump caps can't pump any more air into the bottle. It can take between 45 to 60 pumps to see a change in mass.
5. When the bottle is pumped as full as it can be, have the students pass the bottle around checking again for weight and pressure. What do they notice?
6. Weigh the bottle on the digital scale and compare and discuss your two findings. If there are more molecules in the bottle, there's more pressure and more mass!

**Discussion:** Why did the mass increase when we pumped air into the bottle?

Air has mass, because of this air is exerting pressure on our bodies all the time. In this experiment students pumped more air into the bottle creating more mass and pressure. Notice that the bottle is much more firm now. Due to the increased mass, the bottle now resists the pressure from students squeezing it.

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## It's a Gas

**Passport Question:** When citric acid and baking soda react, what bubbles out of the solution?

**Passport Answer:** Carbon Dioxide

**Learning Target:** Students will understand that chemicals can break down and form new chemicals when a chemical reaction takes place. This new chemical may end up in a different state of matter during the process.

### **Materials:**

- Three beakers
- One small Erlenmeyer flask
- One large Erlenmeyer flask
- 250 mL of water
- Blue Food coloring
- Teaspoon of baking soda
- Teaspoon of citric acid
- Tube/stopper setup
- Safety goggles
- Water pitcher
- Dump bucket
- Laminated word "Carbon dioxide"

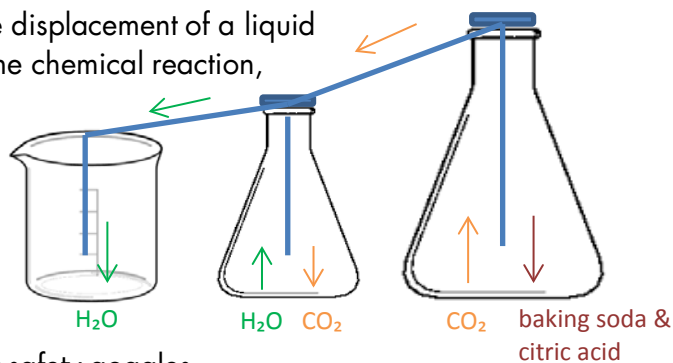


### **Background:**

This activity demonstrates a chemical reaction. Reactants (the original substances that react to each other) are changed during the process, so the end result (the product) is a substance that is chemically different from the two reactants. This differs from a physical change because the products of a chemical reaction cannot be easily converted back to the two reactants.

In this reaction, citric acid, baking soda (sodium bicarbonate) and water react to form carbon dioxide. Because the citric acid is unstable, it immediately breaks down into carbon dioxide and water. The fizzing that you see is the carbon dioxide gas bubbling out of the solution.

The second aspect of this experiment is the displacement of a liquid by a gas. When carbon dioxide is produced in the chemical reaction, it exerts pressure on the large flask. Some of that gas flows through the tube into the small flask, which displaces the water. As a result, some water moves through the second tube into the beaker.



### **Procedure:**

1. Put on a pair and have students also wear safety goggles.

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2. Add 200 ml blue water to the small flask.
3. Assemble the flasks, beaker, and tubing. Put the end of the loose tube in the beaker.
4. Add one teaspoon baking soda to the large flask. Add 50 ml of water. Swirl to mix the contents.
5. Add one teaspoon citric acid to the large flask and quickly replace the stopper. Hold the stoppers on both flasks. Be sure to hold tube that flows into the empty beaker as it can move around due to the pressure of the water.
6. Notice the bubbling gas produced in the large flask. Where is the gas going?
7. Try adding more citric acid. Does the reaction continue?
8. Rinse large flask.

**Discussion:** Why did the water moved from the flask to the beaker?

The chemical reaction of baking soda ( $C_6H_8O_7$ ) and citric acid ( $C_6H_8O_7$ ) and water ( $H_2O$ ) produces the gas carbon dioxide ( $CO_2$ ). The gas moves through the tubing into the flask with the water and displaces the water. Explain that gas takes up space and can exert pressure, even if it is not visible. For example, gas pressure inflates a balloon or escapes as fizz when you open a soda. Explain that what they saw was a chemical reaction and a phase change from liquid to gas.

## Slime Time

**Passport Question:** What type of fluid acts like both a liquid and a solid?

**Passport Answer:** A non-Newtonian fluid/Oobleck

**Learning Targets:** Students will learn that a non-Newtonian fluid has physical properties that act like a solid sometimes and a liquid at others.

### **Materials:**

- Sheet
- Measuring cups
- 1 cup cornstarch
- Large bowl or pan
- Green Food coloring
- ½ cup water



### **Background:**

Oobleck slime is a suspension (a liquid containing small solid particles that easily separate out of the mixture) of cornstarch and water. Under certain conditions, this substance has the properties of both a liquid and a solid. It is called a non-Newtonian liquid because sometimes it doesn't behave like a liquid should, according to Isaac Newton's laws. When struck, most liquids splatter and splash. However, when a non-Newtonian liquid is struck by a force, the physical structure of the material changes, increasing the thickness of the solution, making it behave more like a solid.

**Procedure/Discussion:** Try different experiments with the oobleck in the pan.

Put a small plastic toy on the surface. Does it sink? Yes.

How does the substance react when you press on it quickly? It sinks slowly and acts like a solid by resisting the student's hand. Slowly? It sinks faster, it acts like a liquid and there is no resistance on the student's hand.

What happens when you slap your hand or punch your fist into the substance? It acts more like a solid, it resists the student's hand.

When does it act like a solid or a liquid? It acts more like a liquid when there is no pressure and more like a solid when pressure is added.

Can you roll a small amount of it into a ball? Yes. What happens if you set the ball in your hand? It loses its shape and drips like a liquid.

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What happens if you put just a tiny amount between your fingers and then rub your fingers together? It holds its shape and can be moved around like a solid.

## Density:

**Passport Question:** What is the definition of density?

**Passport Answer:** How tightly packed a material is and how much space it takes up or Mass/Volume.

**Background:** The density of a material is its mass per unit volume. Mathematically, density ( $\rho$ ) is defined as mass ( $m$ ) divided by volume ( $V$ ):  $\rho=m/V$ . Another way to conceptualize this is by thinking of how packed together the molecules of a material are.

In general, density can be increased or decreased by changing either the pressure or the temperature. Increasing the pressure always increases the density of a material. Increasing the temperature generally decreases the density, but there are notable exceptions to this generalization. For example, the density of water increases between its melting point at 0 °C and 4 °C; similar behavior is observed in silicon at low temperatures. Pressure has a much stronger effect on the density of gasses than on the density of solids or liquids.

## Mystery Box

**Learning Target:** Students will learn that objects with the lowest densities will rise to the top of a mixture while objects with greater densities will sink to the bottom.

### Materials:

- Two ping-pong balls
- Two metal balls (same size as ping-pong balls)
- Bag of pinto beans
- Large mixing bowl

### Procedure:

1. Pour the beans into the bowl.
2. Bury the ping-pong balls under the beans and lay the metal balls on top. Make sure students don't see this for more of a wow factor!
3. Ask students, "What do you think will happen if we shake the bowl?"
4. Gently shake the bowl. The metal balls will sink to the bottom and the ping-pong balls will rise to the top.

**Discussion:** Have students make observations and try to explain what happened.

Then take out one of each item and pass around to the students.

What do you notice about these three items?

Introduce the concept of density. An object's density is its mass divided by its volume. Another way to think of this is how packed together the molecules in an object are. Of the three objects we experimented with, the metal ball has the highest density, the ping-pong ball has the lowest density,

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and the pinto bean is somewhere in between. As a result, the metal balls sank to the bottom of the bowl and the ping-pong balls "floated up" or "rose up to the top".

Can the students think of three other objects that we could do the same experiment with?

Students could use rice, golf balls, and styrofoam balls. Answers will vary.

## Floating Golf Ball

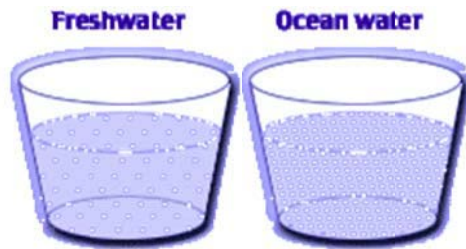
**Passport Question:** Which is more dense, freshwater or saltwater?

**Passport Answer:** Freshwater or Saltwater (Circle one)

**Learning Target:** Students will learn that even water can have different densities. Saltwater is more dense because it has more molecules in it taking up space.

### Materials:

- 16 oz plastic cups (5)
- Salt (5 lbs)
- Plastic spoons (2)
- Water
- Water pitcher
- Golf balls (10)
- Dump bucket
- Beaker (3)



Freshwater is made up of water molecules with a little bit of salt in it. Ocean water is made up of water molecules with a lot of salt. When put in the same container, denser materials fall to the bottom and less dense materials sit on top.

### Procedure:

1. Pass out one plastic cup and one spoon to each student.
2. Fill the cups 2/3 full with water
3. Have the students make a hypothesis: Will the ball sink or float when it is placed in the water?
4. Test the hypothesis by placing the golf ball in the water. It will sink to the bottom of the cup.
5. Talk to the students about changing the density of water using salt. By adding salt, we will increase the density of the solution. Will this make a difference?
6. Have students experiment to see how much salt is needed to make the ball float. **Make sure to mix the solution so that the salt can dissolve in the water! It takes about four spoonfuls of salt to make the ball float in half a cup of water.**
7. You may have to occasionally stir saltwater demonstration beakers to keep the salt in suspension.

**Discussion:** Why doesn't the ball float in fresh water?

Initially, the golf ball is denser than the water, so it sinks to the bottom.

Why the ball floats in the salt water?

On a molecular level, the salt is filling the microscopic spaces that exist between water molecules; this process packs the atoms that make up the solution together, which increases the density of the solution to the point that it is greater than the density of the golf ball. This is similar to what you experience when swimming in salt water. Ask the students if they've ever tried swimming in the ocean. Unlike when swimming in a pool, they can float almost effortlessly due to the density of the water.

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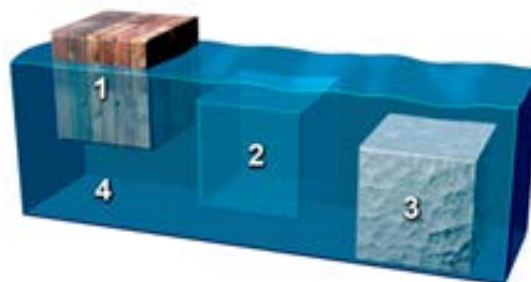


## Density Blocks

**Learning Target:** Students will learn how to calculate the density of a solid object.

**Materials:**

- Set of 12 density blocks
- Clear bowl filled with water
- Scales
- Handheld calculators
- Towels



**Background:**

Now that we've looked the density of several liquids, we're going to observe and measure the density of solid objects. During this activity, students will put different blocks in water to see which float and calculate the density of the blocks using a scale and a calculator. Objects that float in water will have a density less than  $1 \text{ g/cm}^3$  (density of water) and objects that sink will have a density greater than  $1 \text{ g/cm}^3$ .

**Procedure:**

1. Give students a couple minutes to experiment with the objects, test which ones float in the bowl of water, compare the weight of two blocks by holding one in each hand, etc.
2. Measure the density of a few of the blocks. Put a block on the scale, record the mass.
3. Divide mass by the volume of the cube ( $1 \text{ in}^3 = 16.387 \text{ cm}^3$ ). The result is the density. Record this on the laminated density sheet.

**Discussion:** Do the students understand how to measure density of a solid?

Answers will vary.

Were the students surprised by any of the results?

Answers will vary.

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## Stacking Colors

**Passport Question:** Which is less dense?

**Passport Answer:** Oil or Water (Circle one)

**Learning Target:** Student will learn that fluids that are more dense sink while fluids that are less dense rise.

### **Materials:**

- Small test tubes and test tube rack
- Five pipettes
- Colored dish soap
- Water
- Corn oil
- Rubbing alcohol
- Lamp oil
- 5 beakers/ small jars
- Rags
- Large graduated cylinder
- Ping pong ball, cork, grape, bead, bolt
- Dump bucket



### **Procedure:**

1. Tell the students that they'll be trying to stack the liquids on top of each other in their test tubes (having learned what density is in the previous demo.)
2. Ask them, "how should we arrange the liquids in the tube so that they stack on top of each other?" They should be stacked from highest density on the bottom to the lowest density on the top. Explain that liquids of different densities won't mix as long as the liquid with the lower density is sitting on top of the liquid with the higher density. Show them how liquids with higher densities (soap) are more viscous (move more slowly) compared to lower density liquids..
3. Give each student a pipette and a test tube. They will try to stack the liquids in order from highest density to lowest density by guessing the correct order. Try not to let the liquids drip on the table! They can get messy and sticky.
4. After they have put all five liquids in their tube, observe the results. Did any students guess them all in the correct order? What happened to the liquids if they guessed in the wrong order?
5. If none of the students put all five liquids in the correct order, demonstrate for them.

**Discussion:** How did students determine which liquids were most dense? Did they pick up the beakers to test the weight of each liquid? Did they tilt the beakers to test viscosity?

Liquids that are more dense will have a higher viscosity or "thickness" than liquids that are less dense.

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The same volume of two different liquids will have different weights because they have different masses. Put each beaker of liquid on the scale to show this.

Can the students think of other liquids that are very dense? (honey, molasses) Can they think of some liquids that are less dense? (propane, methane)

Bring out the graduated cylinder with the liquids stacked and the objects floating within the layers. Why did the cork, bead, etc. fall to different levels?

They have different densities so they fall to the level with similar densities.

Extra credit if time and interest allows: Add solid objects into the density column and observe where they end up. Why did they end up there?

## Gassy Lava Lamp

**Passport Question:** What is a chemical reaction?

**Passport Answer:** A process that rearranges molecular structure of a substance.

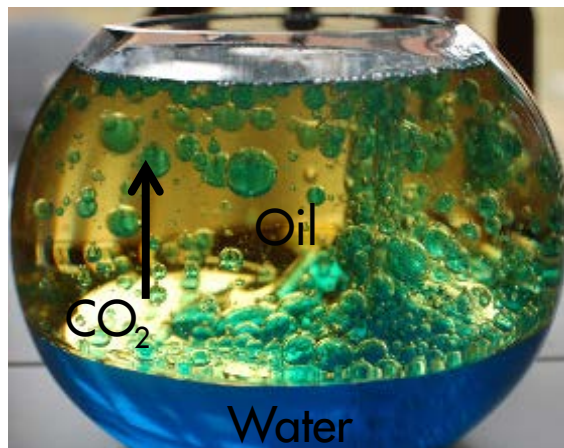
**Learning Target:** Students will learn that liquids have different densities. They will learn that oil is less dense so it sits on top of water. They will also learn that a gas is even less dense so it will bubble out of the mixture.

### **Materials:**

- 4 clear plastic bottles
- 4 bottles of dark food coloring
- 2 bottles of vegetable oil
- ½ tablet of Alka-Seltzer per bottle per experiment
- Room temperature water
- Flashlight

### **Procedure:**

1. Bottles prepped beforehand filled with ½ colored water and ½ oil
2. Have the students shake a bottle as hard as they can and ask if they think it will settle back to oil on top and water on the bottom (It takes around 30 seconds to settle)
3. Then break an antacid table in half and drop it in and watch what happens, ask the kids if they can tell which are gas droplets and which are water droplets?
4. Put the flight light underneath or behind it for greater affect



**Discussion:** Do oil and water have different densities? How can you tell?

The density of a liquid determines whether it will float above or sink below another liquid. A less dense liquid will float on top of a more dense liquid. Some liquids will mix together easily, and others will stay separated. Oil is less dense than water so it floats on top of the other liquid. Even if you shake it thoroughly it will settle back out to their different layers of density.

What happens when you add the antacid to the bottle? Why do you think this happens?

A chemical reaction is taking place.  $\text{CO}_2$  is formed, rises and releases out of the mixture because it is a gas and is the least dense substance in the mixture.

Would the same thing occur if the antacid was put into only oil?

No, the chemical composition of oil is different so  $\text{CO}_2$  would not be formed.

What happens if the lid is screwed on after the tablet has been added?

The  $\text{CO}_2$  remains trapped in the bottle creating more pressure. Once bottle is opened the pressure

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is released. The sound is the same as when you open a new bottle of soda, in both cases carbon dioxide is being released into the air.

## **Hot and Cold Density**

**Passport Question:** How can you change the density of water?

**Passport Answer:** You can change the density of water by changing its temperature.

**Learning Target:** Students will comprehend that you can alter the density of water by changing its temperature. Cold water has a higher density so it sinks while warmer water is less dense so it floats above the colder, denser water.

### **Materials:**

- Hot water dyed yellow (jet boil or hot pump)
- Cold water dyed blue
- Ice
- Cooler
- Water pitcher
- Seiche Model (clear plastic model with divider)
- Light
- Pipette
- Dump bucket
- Rags



### **Procedure:**

1. Place the hot water on one side and the cold water on the other. **Try to keep the levels equal as you add the water.**
2. Remove the breaker from between the two liquids and allow them to flow together
3. Have to students go to eye level with the water so they can see the stratification.

\*\*Have the hot water be as hot as possible and keep adding ice to the cold water. The greater the difference in temperature the less the colors will blend.

**Discussion:** What they think would happen if you placed the cold blue water on top of the hot yellow water? Try adding a pipette of cold, blue water and observe what happens. The cold, blue water will sink to the bottom where the water is the same density.

What does your experiment show the students about the relative densities of hot and cold water? Based on your observations, would you expect equal volumes of hot and cold water to weigh the same? Which temperature of water would you expect to weigh the most?

Cold water has a higher density than warm water. The molecules of the cold water are more compact causing it to weigh more and sink below the warmer water. Water is most dense at 4°C or 39°F, therefore water that is warmer than this temperature will float on top.

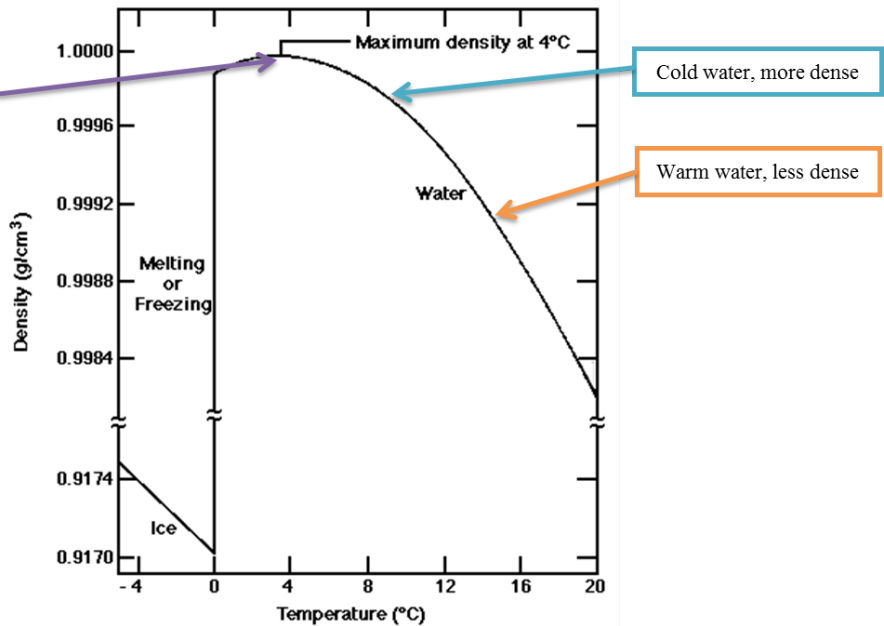
Relate hot water and cold water to lake mixing. Ask students about swimming in summer, do they

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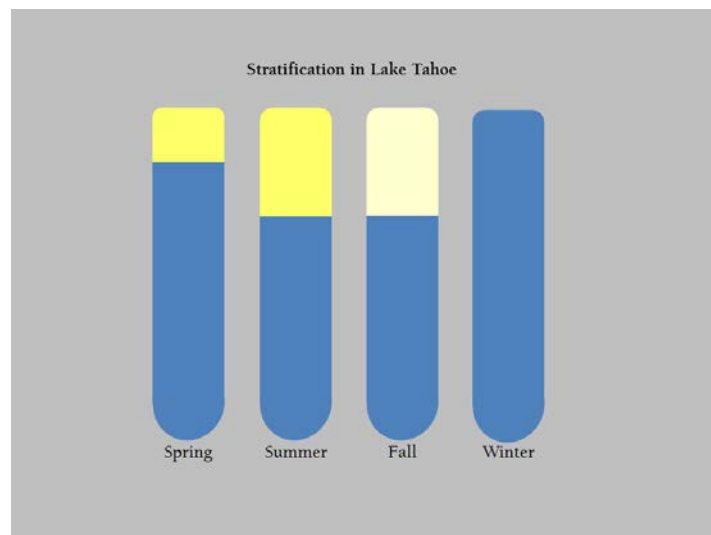
feel the warm layer on top and the cold on the bottom?

When the water on the top of the lake is warmer than the water at depth, the lake does not mix very much. This is often the case in warmer months because the sunlight warms the top layers of water, but does not reach the depths of the lake. When the air is very cold in winter and cools the surface of the lake, the cold water sinks to the depths and causes the lake to mix.

4°C water = most dense, sinks beneath all other water in large lakes to keep lake from freezing over. In the winter, water does not have a chance to drop below 4°C because once it gets that cold it sinks down and warmer, less dense water takes its place at the surface of the lake. As long as there is less dense, slightly warmer water available to take the place of the 4°C water as it sinks, this will prevent the water on the surface of the lake from ever reaching freezing temperatures



Density of water (and ice) as a function of temperature. Note maximum density of water at 4°C. (Data from Pauling 1953 and Hutchinson 1957: 204.)





## Changing the Density of an Object

**Passport Question:** Can two objects have the same volume but different densities? Why?

**Passport Answer:** Yes, because they have different mass

**Learning Target:** Students will understand that you can change the density of an object by increasing the mass a little and volume a lot.

### **Materials:**

- regular coke cans
- diet coke cans
- water
- small water-resistant item that sinks
- large plastic container
- bubble wrap
- tape
- cloth/ rag



### **Procedure:**

1. Holding the cans sideways, place a can of regular cola and a can of diet cola in the water. Observe. What do they notice? Why does one can sink and one can float?
2. Remove cans and use a paper towel to dry off the outside of the regular coke can
3. Cut a piece of bubble wrap so that it is as wide as the height of the can. The length of the bubble wrap should be just enough to go around the can once.
4. Wrap the can in bubble wrap and use tape to attach it securely.
5. Place the modified can in the water. Can you make the can float? Or what can you do to make the floating can sink?

**Discussion:** Tell students that the cans are made of the same material and have the same volume and are filled with the same amount of soda. Why do you think one can sinks and the other floats? Since the volumes are the same, what must be different about the sodas?

The mass of the regular soda is greater than the mass of the diet soda. The regular soda has 30-40 grams of sugar dissolved in it. The diet soda is sweetened with an artificial sweetener that takes many fewer grams to achieve a similar level of sweetness.

How can they make the can of regular coke float without opening the can?

Students may propose shaking the can, since this doesn't change the mass, they can try this. Students may suggest putting something on the can to increase its volume. Ask students if they can think of something that would add volume to the can but not add much weight. Students should realize that mass is increased slightly, while volume is increased much more. When the density of

## Properties of Matter

this larger combined object is less than the density of water, it floats.

Ask students to use the terms mass, volume and density to explain why adding the bubble wrap helped the can float. Be sure students understand that it is the combined mass and volume of the can and the bubble wrap that makes the can and bubble wrap object less dense than water so that it floats.

Tell students that life jackets work in a similar way. Ask students why a life jacket helps a person float. Explain that a person wearing a life jacket floats because of the combination of the body and the life jacket is less dense than water.

## Separation Anxiety

**Passport Question:** Are mixtures separated by chemical or by physical means?

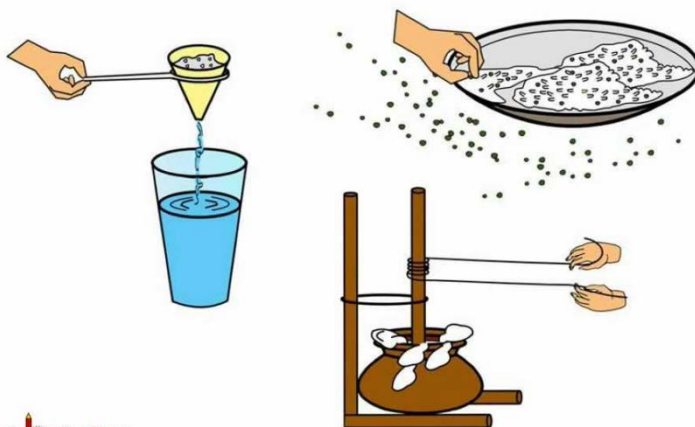
**Passport Answer:** Chemical or Physical (Circle one)

**Learning Target:** Students will understand that mixtures can be separated physically. The density or magnetic properties of an object can be used to help separate them from a mixture.

### Materials:

- Two cups sand
- One cup of small plastic beads
- One cup iron filings
- One cup poppy seeds
- Four magnets
- One plastic tablespoon
- One plastic cup
- Water and water pitcher
- One small strainer
- One stirring rod
- One small plastic bucket for waste
- Four petri dishes

### Different separation methods



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### Background:

Chemists often separate substances by their different properties or characteristics. Plastic beads, water, poppy seeds, iron filings and sand have different densities. Substances with a lower density than water, such as plastic beads will float on water. Objects, such as sand, with a greater density than water will sink. Many substances, like salt, dissolve in water, while others, like plastic beads, sand, and iron filings, do not. If you heat salt-water or leave it in the sun, the water evaporates, leaving solid salt behind. Some objects, like iron filings, can be pulled out of mixtures using their magnetic properties.

There are probably many ways to separate out the 4 components of the mixture in this activity. One straightforward way is to pick out the beads and use a magnet to pull out the iron filings. Then you can add water to the remaining mixture, which will dissolve the salt. Mix the solution and decant it through a filter. The poppy seeds are less dense than the sand and will tend to get caught in the filter rather than staying at the bottom with the sand. Both of these can now be collected and dried off. Evaporating the salt water by boiling or waiting a few days will recover the salt. The basic properties of size, magnetism, density, and solubility are common features used to recover pure substances from the mixtures that nature supplies.

A similar method to the one used in this experiment is used at many recycling facilities to separate materials. Previously it was necessary to separate all recycled materials at home before pickup, but now many can be mixed together and separated at the recycling center. Magnets can be used to separate many metals; water can separate materials with a higher density from those of a lower density.

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### Procedure:

1. Put a scoop of mixture in front of each student (into a petri dish)
2. Tell the students there are four components in the mixture and they need to separate them using the tools in front of them
3. First have them use the magnet to remove the iron fillings
4. Then place the mesh over the plastic cup and slowly pour the mixture over it. The beads will stay in the mesh.
5. Next pour a little water into the cup. The poppy seeds will float and the sand will sink. Explain how you can scoop the poppy seeds out with a spoon and boil the water off to get the sand. Dump the wet mixture into the waste container. Water can be boiled off it at the end to reuse it.

**Discussion:** What properties helped you separate sand, beads, poppy seeds, and iron fillings?

Explain that all of these objects are part of a mixture because they are not chemically joined together – they can be separated by physical means. The different materials density played a role in separating the objects. The poppy seeds are less dense so they float, while the sand sinks. Magnetism allowed them to remove the iron fillings using a magnet.

Chemists spend much of their time separating mixtures and solutions. Can the students think of real life examples?

Separating oil from water after an oil spill, removing environmental contaminants, etc.

## Shake It Up!

**Passport Question:** An indicator, like cabbage juice, is used to demonstrate that a chemical reaction has taken place.

**Passport Answer:** True or False

**Learning Target:** Students will learn that specific chemicals can be used to determine a chemical reaction has occurred by either turning a different color or some other physical change.

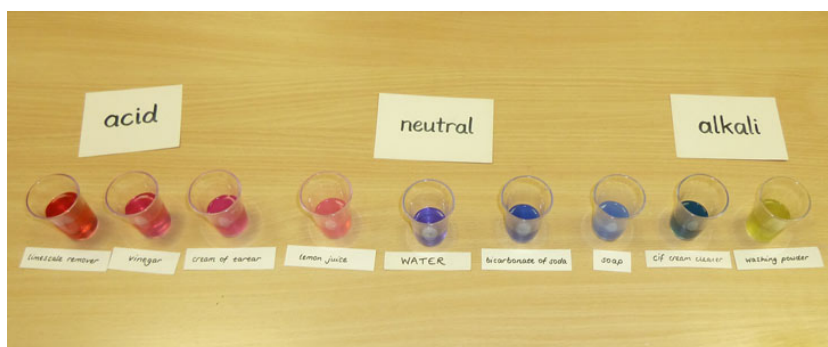
### **Materials:**

#### Procedure 1:

- One 500-ml plastic soft drink bottle with lid
- One 400-ml beaker
- 7.2 g KOH (potassium hydroxide) Warning! Items have been premixed. Do not have children open. It contains hazardous chemicals!
- 10 g C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> (dextrose (glucose))
- Pinhead of Methylene blue
- 300 ml dH<sub>2</sub>O (deionized water)
- Absorbent paper
- Hazardous waste container

#### Procedure 2:

- Cabbage liquid
- Citric acid
- Baking soda
- Three petri dishes
- One pipet
- Water and water pitcher to clean the petri dishes
- Dump bin



### **Background:**

#### Procedure 1

Indicators are chemicals that provide evidence of chemical reactions by changing color when certain ions or molecules are present. In the first activity, an indicator called methylene blue turns the solution blue or colorless, depending on which reaction is occurring. In the first chemical reaction, methylene blue combines with dissolved oxygen gas (O<sub>2</sub>) to turn the liquid blue. When you shake the bottle, oxygen dissolves in the solution. This reaction continues as long as oxygen gas (O<sub>2</sub>) is available. In the second chemical reaction, the solution becomes colorless when glucose (sugar) and other chemicals in the solution displace the oxygen and combine with the methylene blue.

#### Procedure 2

In the second activity red cabbage juice is used as a pH indicator solution. Red cabbage juice

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contains a natural pH indicator that changes color according to the acidity of the solution. It contains a pigment molecule called Flavin (an anthocyanin). This water-soluble pigment is also found in apple skins, plums, cornflowers, and grapes. Very acidic solutions will turn greenish-yellow. When indicator is added basic solutions will turn blue and acidic solutions will turn red. Therefore, it is possible to determine the pH of a solution based on the color it turns the anthocyanin pigments in purple cabbage juice.

### Procedure 1:

1. Have the students observe the clear colorless liquid.
2. Then have them to shake the container and the fluid turns blue
3. When allowed to sit for a few moments, the liquid turns colorless again.
4. Learners can repeat the cycle as many times as they wish.
5. After a half day the solution will turn yellow and won't change also periodically open the cap to let oxygen out and add more methylene blue\*\*

**Discussion 1:** Indicators, such as the blue dye, can be used to show that a chemical reaction has taken place. In this case oxygen dissolved in the shaken solution reacts with the indicator. Upon being shaken  $O_2$  is dissolved and combines with methylene blue, causing a change to blue. Then the glucose-hydroxide complex forms and reacts with methylene blue, changing the solution back to colorless. Agitation can dissolve a gas in a solution.

Where can you see this type of reaction in everyday life?

In streams when water flows over rocks, which creates white water rapids.

### Procedure 2:

1. Have the student pipette out a cabbage juice onto three different petri dishes.
2. Show them the pH scale, acidic solutions turn red and basic solutions turn blue.
3. Ask them what color the solution will turn when you add citric acid in one dish baking soda into separate petri dishes.
4. Next ask what color will the solution turn if you add both and what do you think will happen?

### Discussion 2:

Why did the cabbage juice change different colors when citric acid and baking soda were added?

The cabbage juice is used as an indicator because when the pH changes so does its color. Acidic solutions turn red and basic mixtures turn blue. When an acid and base are added together solution should stay a more neutral color and a chemical reaction also takes place forming  $CO_2$ .

What are indicators?

Indicators can be used to show that a chemical reaction has taken place by changing colors.

\*\* Wash hands and bottle thoroughly afterwards, the bottle contains substances that can cause skin irritations.

## **Exothermic vs. Endothermic**

**Passport Question:** \_\_\_\_\_ reactions release energy in the form of heat. (For example, Calcium chloride mixed with water feels warm and can be used to melt ice.)  
\_\_\_\_\_ reactions absorb energy in the form of heat. (For example, Urea mixed with water feels cold.)

**Passport Answer:** Exothermic, Endothermic

### **Materials:**

- Two 250-ml Erlenmeyer flasks
- Two 1-tsp measuring spoons
- Two small plastic funnels
- Two 250-ml beakers
- One 25-ml graduated cylinder
- Calcium chloride pellets
- Urea
- Two colors of masking tape. Instant heating packs, as an example
- Safety goggles
- Water and water pitcher

### **Background:**

In this activity, students will learn that some reactions release energy in the form of heat and others absorb energy, making their surroundings colder. There are practical uses for these kinds of chemical reactions. Calcium chloride, for instance, produces heat when it reacts with water. This is why it is used in deicers; it melts snow or ice.

Exothermic reactions produce heat because energy is produced when chemical bonds are broken and formed. Endothermic reactions absorb heat while breaking and forming new bonds, which is why they cause their surroundings to feel colder.

### **Setup:**

1. Label 250-ml squirt bottle "Water"
2. Using one color of tape, label a flask, a funnel, a teaspoon, and a beaker "Calcium Chloride."
3. Using the other color of tape, label a flask, a funnel, a teaspoon, and a beaker "Urea."

### **Procedure:**

1. Always wear safety goggles.
2. Use the graduated cylinder to pour 15 ml of H<sub>2</sub>O into each flask.
3. Use the funnel to add 1 teaspoon urea to the flask marked "urea", and 1 teaspoon calcium chloride to the flask marked "calcium chloride." (Be sure to keep measuring spoons and chemicals separate!)
4. Swirl both flasks 5-10 times.

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5. Touch the bottoms of the flasks to feel temperature changes.
  - a. Which reaction is warm, or exothermic? (Calcium chloride)
  - b. Which reaction is cold, or endothermic? (Urea)
6. When finished, empty both flasks and rinse with water.

### **Discussion:**

Which of these chemicals do you think is sprayed onto airplane wings to melt?

Calcium chloride.

Which of these chemicals works like the chemical used in first aid instant cold packs?

Urea.

Do the students understand the difference between exothermic and endothermic?

Answers will vary.

Use the instant hot pack to show how we can use exothermic reaction in real life.