Beginning Chemistry and the Scientific Method

Units Study for Grades 5-7

The Good and the Beautiful
# Table of Contents

Unit Information........................................................................................................ii
Supplies Needed..........................................................................................................iii
Optional Read-Alouds ...............................................................................................v
Vocabulary ..................................................................................................................vi
Lesson 1: Introduction to Chemistry........................................................................1
Lesson 2: The Scientific Method...............................................................................10
Lesson 3: Scientific Measurement ..........................................................................21
Lesson 4: States of Matter......................................................................................33
Lesson 5: Phase Transitions...................................................................................38
Lesson 6: Atoms, Elements, and Molecules.........................................................53
Lesson 7: Chemical and Physical Properties.......................................................58
Lesson 8: Identifying Chemical Changes..............................................................69
Lesson 9: Elements and the Periodic Table..........................................................78
Lesson 10: The Atom .............................................................................................85
Lesson 11: Molecules, Compounds, and Chemical Bonding..............................97
Lesson 12: Conservation of Mass..........................................................................110
Lesson 13: Mixtures and Pure Substances............................................................115
Lesson 14: Properties of Water ............................................................................123
Featured Elements...................................................................................................131
Unit Information

**Journal**
All of The Good and the Beautiful science units include activities for a science journal. For each child, prepare a 1” to 2” 3-ring binder to function as his or her science journal. Tabbed divider pages may be used to separate the different units. Have wide-ruled paper and blank white paper on hand for journal activities. All completed journal activities are to be kept in the science journal. You may also consider having children create a cover for their journals, which they insert under the clear cover of the binder.

**Science Wall**
All of The Good and the Beautiful science units include vocabulary words to be placed on your science wall, which is a wall (or a 3-fold presentation board) in your learning area on which you attach the vocabulary words and other images. *Cut out the vocabulary word cards at the beginning of the unit.* The course will indicate when to place them on the wall.

**Lesson Mini Books**
Some lessons in this unit incorporate science mini books. To make your mini books, simply print the pages single-sided, cut them in half along the dotted lines, stack the pages together, and staple twice along the left side.

**Lesson Preparation**
All of The Good and the Beautiful science units include easy-to-follow lesson preparation directions at the beginning of each lesson.

**Teaching Older Children?**
This unit study is designed for Grades 5–6. If you are teaching older children (Grades 7–8), look for the “older children” symbol (a magnifying glass) at the end of most lessons. There you will find ideas for guiding older children through more in-depth research and study. This course, even with the extensions, is not considered sufficient for high school level coursework.
Supplies Needed

Lesson 1
- A bowl or basket
- White coffee filters, 3–6 per student
- A ball-point pen
- 3–6 cups per student, any kind
- Water
- A permanent black marker
- Five colors of washable markers, including black and brown

Lesson 2
- 3–4 items worn for protection (such as gloves, a helmet, swimming goggles, etc.)

Lesson 3
- A ruler that shows both inches and centimeters
- A clear measuring cup for liquids (with measurements printed on the outside, indicating both cups, pints, or quarts and milliliters or liters)
- A packaged drink bottle (or any packaged container that has the volume printed on the label in fluid ounces and milliliters)
- A kitchen scale that can display both grams and either ounces or pounds
- An object that can be weighed on the scale
- (Optional) graduated cylinders and beakers (a recommended set is available on Amazon.com, item #B01MR0OVIH)

Lesson 4
- A rock
- A drink in a cup with a straw for each child
- Empty cups of various sizes, one for each child
- A balloon

Lesson 5
- Four paper cups
- A permanent marker
- Salt
- Water
- 1 tsp measuring spoon
- 1 cup liquid measuring cup or a 250 mL graduated cylinder
- A candy thermometer
- Playdough
- A straw
- A cup of water
- A short glass cup or jar
- (Optional) food coloring

Lesson 6
- Three colors of playdough (at least 5 oz. of each color for each child)
- Toothpicks
Lesson 7
- Three objects (your choosing)
- 1 Tbsp vegetable oil
- Two glasses filled with water
- 1 Tbsp sugar
- A graduated cylinder or measuring cup filled halfway with water
- A marble (or other small, sinkable object)
- A kitchen scale
- A calculator
- (Optional) ¼ cup each of honey, corn syrup, dish soap, water, vegetable oil, and rubbing alcohol
- (Optional) food coloring
- (Optional) a few small objects like a raisin, a safety pin, a screw, etc.

Lesson 8
- A 250 mL graduated cylinder (or an empty disposable water bottle)
- A funnel (if using a water bottle)
- A 50 mL beaker (or a ¼ cup measuring cup)
- A 300 mL beaker (or a drinking cup)
- A tray lined with foil
- Warm water
- A kitchen scale
- Food coloring
- Hydrogen peroxide (at least 3% strength)—see note at the end of Lesson 8
- Dish soap
- Yeast
- A spoon

Lesson 9
None

Lesson 10
- Three different colors of playdough
- Craft wire

Lesson 11
- Two magnets (bar magnets, if possible—recommended magnets can be found on Amazon.com, item #B001DRORA8)
- Tape

Lesson 12
- Vinegar
- Baking soda
- A balloon
- A measuring spoon
- A 100 mL graduated cylinder (or an empty disposable water bottle with a narrow neck)
- A mini measuring cup (similar to a plastic cup that comes with children’s cough syrup)
- A kitchen scale

Lesson 13
- A variety of beads or buttons (a handful for each child)
- School glue
- A kitchen scale
- A 50 mL beaker (or a ¼ cup measuring cup)
- A small bowl
- A small baking dish (about 8” x 8”)
- A spoon
- Salt
- Water

Lesson 14
- A calculator
- Tape
- A pitcher of water
- A glass
- A cookie tray
- Crayons or colored pencils
Lesson 5 - Phase Transitions

Objectives
Help the children understand that matter can change states. The children should become familiar with the transitional names and points in changing states of matter.

Preparation
- Cut and assemble the mini book *Phase Changes of Matter*.
- Print one copy of the sheet titled “Types of Phase Transitions” for each child.
- Print a copy of the lab notebook pages titled "Lesson 5 - Expanding Water Experiment" (three pages) for each child.
- Print a copy of the lab notebook pages titled "Lesson 5 - The Freezing Point of Water Experiment" (two pages) for each child.

Supplies needed
- Four paper cups
- A permanent marker
- Salt
- Water
- 1 tsp measuring spoon
- 1 cup liquid measuring cup or a 250 mL graduated cylinder
- A candy thermometer
- A straw
- A cup of water
- Playdough
- A short glass cup or jar
- Food coloring (optional)

Read to the children:
As we learned in the previous lesson, the three classic states of matter are solids, liquids, and gases. Solids, liquids, and gases are comprised of matter, and the tiny particles that make up these three states of matter are called molecules. These molecules are in constant motion, but they will move faster in a gas state than in a liquid state and faster in a liquid state than in a solid state. In this lesson we are going to learn how matter can change phases. When matter changes from one state to another, we call this transition a phase (or state) change of matter.

Mini Book
Read the mini book *Phase Changes of Matter* included in this lesson.

Activity: Types of Phase Transitions
Give each child a copy of the last page of this lesson titled “Types of Phase Transitions.” When finished with the activity below, place the "Types of Phase Transitions" page on the science wall.

Read to the children: I will read to you a few scenarios involving the phase changes of matter. When you hear me say the words SOLID, LIQUID, or GAS, slide a finger along the correct arrow to the correct picture, saying aloud the name of the phase transition your finger slid across. You will also be wiggling the tip of your finger at a speed you feel best matches the movement of the molecules at that state. For example, if your finger is on LIQUID and you hear me say GAS, you will move your finger from LIQUID to GAS, and you will say VAPORIZATION out loud. When you land on GAS, your fingertip should be wiggling more rapidly.

Have the students start with their fingers on SOLID. Instruct the children to not remove their fingers between scenarios. Read to the children:

1. It is a hot summer day, and you accidentally left a chocolate candy bar in the car. You come back to the car and notice your once SOLID chocolate bar is now a runny LIQUID. The children should have slid their fingers along the MELTING arrow (while saying, “melting” out loud) and stopped on LIQUID. Their fingers should have wiggled at a
slow speed at first and ended wiggling at a faster, but moderate speed.

2. You hear your mom blow drying her hair. The heat from the blow dryer causes the molecules in the LIQUID water on her hair to gain kinetic energy, allowing them to phase change into a GAS. The children should have slid their fingers along the VAPORIZATION arrow (while saying, “vaporization” out loud) and stopped on GAS. Their fingers should have wiggled at a moderate speed at first and ended wiggling at a rapid speed.

3. It is a cold, frosty morning. You step outside and see ice crystals on the leaves of your tree. It is below freezing, so you know this frost formation is a result of water vapor, which is a GAS, changing into a SOLID. The children should have slid their fingers along the DEPOSITION arrow (while saying, “deposition” out loud) and stopped on SOLID. Their fingers should have wiggled at a rapid speed at first and ended wiggling at a slow speed with minimal movement.

4. Your family is going camping and they purchase dry ice to keep in one of the coolers. You notice what looks like smoke rising from the dry ice. This is SOLID carbon dioxide changing into GAS carbon dioxide. The children should have slid their fingers along the SUBLIMATION arrow (while saying, “sublimation” out loud) and stopped on Gas. Their fingers should have wiggled at a slow speed at first and ended wiggling at a rapid speed.

5. Your parent is cooking dinner and boils a pot of water. You notice steam rising above the pot, and water starts to collect above the stove. The GAS water molecules are changing into LIQUID water. The children should have slid their fingers along the CONDENSATION arrow (while saying “condensation” out loud) and stopped on LIQUID. Their fingers should have wiggled at a rapid speed at first and ended wiggling at a slower, but moderate speed.

6. You blow out a lit candle and notice the LIQUID wax changing into SOLID wax. The children should have slid their fingers along the FREEZING arrow (while saying “freezing” out loud) and stopped on SOLID. Their fingers should have wiggled at a moderate speed at first and ended wiggling at a slow speed with minimal movement.

☐ Read to the children:

Another factor that can affect phase changes is pressure. Have the children take their hand and gently squeeze their arm. You are using the energy in your hand to apply pressure to your arm. Pressure is the measure of force per unit area, or how spread out a force is. Have the children push on the table with the palm of one of their hands. Then have the children use that same force and press their palm against their fingertip on the other hand. Did the table and your fingertip feel different against your palm? Pause for answers. You applied the same force, but it felt different because the force was applied over different surface areas. When pressure is applied, the molecules of a solid, liquid, or gas may squeeze closer together. A substance whose molecules can squeeze together under pressure is compressible. Gases are very compressible since they have more free space between molecules. However, liquids and solids have less free space between molecules and are not easily compressed. Changing the amount of pressure applied to a substance affects its ability to phase change. For example, if more pressure is applied to water vapor, water molecules will be forced closer together causing a liquid to form. Also, in environments of lower pressure, like in high altitudes where the air is thinner, water can boil before it reaches 100°C! Therefore, a substance’s boiling, melting, and freezing points depend on its surrounding pressure, which affects when phase changes occur. Interestingly, carbon dioxide naturally sublimates from a solid (dry ice) to a gas, and it requires about five times the normal amount of pressure for carbon dioxide to transition to a liquid state.
Experiment: The Freezing Point of Water

This experiment will require room in your freezer to hold four cups of water. During this time, the children will need to check the status of their experiment every thirty minutes for two hours.

Give each child a copy of the Lab Notebook journal pages titled “Lesson 5 - The Freezing Point of Water Experiment” and have them read the instructions and fill out the HYPOTHESIS section. When they have completed their hypothesis, provide the children with the "Freezing Point of Water Experiment Instructions" and have the children complete the experiment and finish filling out their Lab Notebooks up to the RESULTS section. The RESULTS section will be completed at the beginning of the next lesson.

Experiment: Expanding Water

This experiment will require room in your freezer to hold one jar of water with a straw. The children will need to observe the jar 1 ½ hours after it is placed in the freezer.

Give each child a copy of the Lab Notebook journal pages titled “Lesson 5 - Expanding Water Experiment” and have them read the instructions and fill out the HYPOTHESIS section. When they have completed their hypotheses, provide the children with the "Expanding Water Experiment Instructions" and have them complete the experiment and finish filling out their Lab Notebooks.

Video Activity (Optional):

Search Online for time lapse videos showing melting, freezing, condensation, vaporization, deposition, sublimation, and supercooling of water. Here are some suggested videos (if still available):

2. Deposition & Sublimation —Search on YouTube: "Example of Sublimation: Iodine" by Wayne Breslyn at https://youtu.be/FtZkItP8Lk

Older Children - Lesson Extension

Have older children (Grades 7–8) read and complete the following activity:

Matter usually follows the steps of phase transitions that we learned today, but there are some exceptions. This is what makes science and chemistry so fascinating.

Research the following examples below. Include a definition and example of each exception. If desired, find and research more examples of instances where matter does not follow the common phase change transitions.

- no melting point
- super cooling (Optional recommendation: search Online for videos demonstrating supercooling with water. You may choose to attempt these experiments as well.)
Matter can undergo a phase (or state) change when it receives or releases energy, most commonly in the form of heat. When the right amount of heat is absorbed (heating), a substance can transition from a solid to a liquid or from a liquid to a gas. Likewise, if the right amount of heat is released (cooling), a substance can transition from a gas to a liquid or from a liquid to a solid. Thus we see that temperature plays an important role because temperature change can cause a phase change.

Remember, molecules are constantly moving. Temperature is the measurement of the amount of moving energy (kinetic energy) in a substance. If a substance’s temperature increases, the kinetic energy of its molecules increases and can change to one of the higher energy phases (solid to liquid or liquid to gas).
Melting: Solid to Liquid

If you leave an ice cube out of the freezer, it will eventually turn into liquid water. Because it is warmer outside of a freezer, the solid ice will absorb the surrounding heat, supplying more kinetic energy to the molecules, and eventually change phases to a liquid. This process is called **melting**, and the temperature at which this change occurs is called the **melting point**.

As temperatures rise, frozen water begins to melt to liquid water as observed in this photo of a mountain stream.

Melting: A Molecular View

Molecules are so small that it is difficult to see their structure, even with high-powered microscopes. Scientists are developing technology that allows us to get a better view of molecules, but most of our understanding about how molecules work is based on tests that prove their existence rather than actually seeing them.

Scientists have found that as temperatures increase, molecules gain enough kinetic energy to break the bonds holding them in their rigid, solid state, resulting in a liquid. In liquid form, these attraction forces between molecules will form and break as the molecules move, allowing them to flow freely.
Imagine a hot summer’s day at a swimming pool. Have you noticed that the water which drips off swimmers or splashes outside of the pool onto the cement eventually disappears? This happens because of vaporization, the phase change of a liquid to a gas. Vaporization happens when small water molecules have enough energy to completely escape the forces holding them to each other, dispersing into their environment as a gas. Vaporization most easily happens at boiling point (100°C), when water is boiled and bubbles form. The water at the surface is able to overcome the forces holding it together, releasing water vapor (gas) into the air.

Condensation: Gas to Liquid

Have you ever taken a hot shower and noticed steam fog up the mirror? This is caused by water vapor (water in a gas state) that has cooled and gathered onto a surface. As it cools, it turns back into a liquid. The tiny droplets of water all over your mirror are a result of condensation, the phase change from a gas to a liquid. Condensation can also occur inside of a water bottle. As water evaporates and then comes in contact with the wall of its container, it condenses back into a liquid. This is often seen at warmer temperatures where there is more kinetic energy, allowing the molecules to phase change from liquid to gas, then condense back into a liquid when they hit the bottle.
Clouds result from water vapor molecules condensing onto tiny particles in the sky. The warmer the water vapor particles, the higher they rise. As they rise up into the sky, they cool and condense onto particles of dust or debris. So clouds are actually groupings of condensed water particles. Isn’t it amazing that God has created a way to recycle and move water throughout our planet through evaporation, condensation, and precipitation?

Freezing: Liquid to Solid

Liquids will turn to solids through the phase transition called **freezing**. When you lower the temperature of water by putting it in the freezer, the water will turn to a solid. The point at which a liquid freezes is called its freezing point. This freezing point may be the same as the melting point when transitioning from solid to liquid. For example, liquid water can begin to freeze at 0°C (32°F) to form solid ice. Likewise, ice will begin to melt at 0°C (32°F), resulting in liquid. But have you ever thought about the solids that you see all around you? Candle wax, plastic, and even metal are considered to be “frozen” at room temperature.
Freezing: A Molecular View
When freezing occurs, molecules become rigid and merely vibrate. Most things will shrink during freezing because the molecules contract closer together. Melted candle wax will contract when it freezes, and you may observe a dip in the center of the wax. The molecules of the wax squish together the same way packed Lego pieces "squish" together, taking up less space than if they are spread out.

However, water actually expands when it freezes! Have you ever put a water bottle in the freezer? The water expands and the bottle may bulge slightly. This is because of the characteristics of water molecules. Solids are arranged in a crystal lattice. In water's case, the ice crystalline lattice has a lot of empty space, as shown in the picture, which makes it less dense than the liquid state. The temperature at which water freezes depends on how pure the water is. If water has anything mixed in it, like salt, its freezing point will be affected.

![Water and Ice Molecules](image)

Deposition: Gas to a Solid
Some substances can actually “skip” a phase step. We generally think of things like water going from a solid to a liquid to a gas as they increase in kinetic energy, or going from a gas to a liquid to a solid as they lose kinetic energy. But, gas can “skip” the liquid phase and jump to its solid phase if it’s very cold. You can see this in the form of frost or hoarfrost. Hoarfrost forms when water vapor in the air solidifies on sub-freezing surfaces (like blades of grass), forming tiny ice crystals.
The opposite of deposition is **sublimation**, which happens when a solid releases gas molecules. This can happen with ice. If left out, some of the water molecules on the surface of the ice will sublimate even while some of the molecules are melting to liquid. A popular example of sublimation is with dry ice. Dry ice is frozen carbon dioxide, which occurs naturally as a gas. At really low temperatures, carbon dioxide can be stored as a solid. At room temperature, dry ice will sublimate and release carbon dioxide gas. The molecules below show an example of sublimation of frozen water (ice) to water vapor.

---

God has created our amazing world with laws that provide order and stability. Matter and phase changes follow laws. But not all matter is the same, and it’s important to keep in mind that not all substances naturally transition from solid to liquid to gas as easily as water does. For example, many metals require extremely high temperatures to melt. Other materials do not melt at all, like wood or paper. As you go about your day, pay attention to the different phases of matter around you, and ask yourself if these phases of matter can easily transition from one form to another. Healthy curiosity makes a good scientist!
Types of Phase Transitions

- Vaporization
- Condensation
- Deposition
- Sublimation
- Freezing
- Melting
- Solid
- Gas
- Liquid
The Freezing Point of Water Experiment Instructions

Gather the needed supplies: four paper cups, water, salt, a measuring spoon, and a 250 mL graduated cylinder (or a liquid measuring cup). Read through each step before starting.

Don’t forget! If you are measuring liquids, be sure to read the measurement at eye level at the bottom of a concave meniscus and at the top of a convex meniscus. (If the meniscus is flat, you will just read the measurement at the water line.)

1. Begin by properly labeling your cups. Label each cup with one of the following labels: Water, Water + 1 tsp Salt, Water + 2 tsp Salt, Water + 3 tsp Salt.

2. Measure 1 tsp of salt and place it in the corresponding cup. Do this with 2 tsp of salt and 3 tsp of salt, placing each measurement in their correct cups. Then measure out 1 cup or 250 mL warm water for each cup. Try your best to keep the temperature of the water consistent for each cup.

The cup with just water is the control of the experiment. Having a control group ensures there are no other factors, aside from salt, affecting the freezing process.

3. Stir each cup until the salt is dissolved, beginning with the least salty to the most salty. This is a good lab technique to ensure you are not introducing more salt into the cups with the lesser amounts of salt. To dissolve means to mix a solid into a liquid so that it becomes a part of that liquid. Note: Dissolving a solid into a liquid is NOT a phase change, and the concept of dissolving will be discussed in greater detail in a later lesson.

4. Measure and record: Once the salt has dissolved into the water, measure the temperature of the water in each cup. Remember to practice good lab techniques by rinsing the thermometer after each measurement, or go in order from no salt to the greater amount of salt. Record each measurement of temperature on the first row of the Data Recordings section on your Lesson 5 Lab Notebook page.

Tip: When observing and recording temperature, record the temperature when the red liquid inside a glass thermometer stops moving, or if you’re using a digital thermometer, when the numbers stop moving. Place the thermometer in the center of your liquid—not too close to the surface, the bottom, or the sides of the cup.

5. Carefully place all four cups into the freezer and set a timer for 30 minutes. Record the time at which you placed the cups into the freezer in the box labeled “Start Time” on the first row of the Data Recordings section. While you wait, set this experiment aside and proceed with the "Expanding Water" experiment.

6. Once 30 minutes has passed, open the freezer, gently stick the thermometer in each cup in order from no salt to the greater amount of salt, and record the temperature and the time at which you took the reading.

7. Set your timer for 30 minutes again. Repeat Step 6 three more times, every 30 minutes, so that you have a total of five readings. After the last reading, pull the cups out and observe the characteristics of the ice in each cup. Record your observations by either writing and/or drawing what you see.

8. Be sure to clean up. This is an important lab habit!

Optional: Go one step further. Try this same experiment but with sugar. Does sugar affect the freezing point of water the same way salt does? The way salt breaks down and the way sugar breaks down in water is different. This would explain any differences you observe.
Expanding Water Experiment Instructions

Gather all supplies needed: a cup filled halfway with water (you may choose to color the water with food coloring, if desired), a straw, playdough, a short glass cup or jar, and a permanent marker.

1. Roll up a small mound of playdough, about 1–2 inches in diameter, and place it in the bottom of your clear jar.

2. Draw up some water into your straw by placing your straw into the cup of water. Then, place your thumb over the top opening to create suction and pull out the straw with your thumb still covering the hole.

3. Carefully lodge the straw (water side down) into the center of the playdough. The playdough will hold the straw vertically in place.

4. With a permanent marker, carefully mark the top of the waterline on the straw. Your experiment should look similar to the second image below.

5. Gently place your jar with the straw into the freezer. Be sure the jar will be able to sit straight up and undisturbed during this time. Immediately set a timer for about 1 to 1½ hours.

6. After sufficient time has passed, pull out your jar. Observe the water level. Don’t forget to clean up when you are done.
Lesson 5 - The Freezing Point of Water Experiment

Information
In this experiment, we will discover the effect on the freezing point of water when salt is mixed into it. Pure water can freeze at 0°C (32°F). When salt is mixed into the water, this affects its freezing temperature because it is no longer just water.

Hypothesis
To hypothesize means to make an educated guess. Take a guess, based on information provided above.

How do you think salt will affect water when we freeze it? Which do you think will freeze faster, pure water or salt water? Which will require a lower temperature to freeze, pure water or salt water?

_______________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________

Notes during my experiment:
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________

Data Recordings
When recording data be sure to include units: a.m., p.m., °C, or °F.

<table>
<thead>
<tr>
<th></th>
<th>Temperature of cups at 30 minute intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
</tr>
<tr>
<td>Start time:</td>
<td></td>
</tr>
<tr>
<td>Time:</td>
<td></td>
</tr>
<tr>
<td>Time:</td>
<td></td>
</tr>
<tr>
<td>Time:</td>
<td></td>
</tr>
<tr>
<td>End time:</td>
<td></td>
</tr>
</tbody>
</table>
Observations:
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________________________________________

Results
What did you observe? Which cups of water froze faster? What were the differences in temperature of each cup? What do you think caused the outcome of this experiment?
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________________________________________
_______________________________________________________________________________________________________________________________________________________________________________________________________________________________
Lesson 5 - Expanding Water Experiment

Information
In this experiment, we will observe the rare property water has to expand when freezing. The molecules of liquid water are able to crowd together, but upon freezing, these molecules form a crystalline lattice structure in the shape of a hexagon. This takes up more space than when the molecules are in liquid form.

Hypothesis
To hypothesize means to make an educated guess. In this experiment we will be marking a level of water, then observing where the water level is after it is frozen. Based on what you’ve learned so far, form a hypothesis on what will happen to the water level after freezing.

Notes during my experiment:

Results
What did you observe? What did you notice about the water level after the water froze? What can you conclude about the freezing properties of water?

What happened?
Because water expands when going from a liquid state to a solid state, you should have noticed the frozen water level increase past the line you originally drew. The molecules of ice take up more room, causing the water to take up more space in the straw.
Lesson 7 - Chemical and Physical Properties

Objectives
Help the children identify chemical and physical properties and understand the difference between the two types of properties.

Preparation
- Cut along the dotted lines on the pages titled "Pictured Properties."
- Print a copy of the lab notebook page titled "Lesson 7 - Calculating Volume and Density" for each child.
- Print a copy of the sheets titled "Physical or Chemical Properties" (two pages) for each child.

Supplies needed
- Three objects (your choosing)
- Two glasses filled with water
- 1 Tbsp vegetable oil
- A calculator
- A graduated cylinder or measuring cup filled halfway with water
- (Optional) ¼ cup each of honey, corn syrup, dish soap, water, vegetable oil, and rubbing alcohol
- (Optional) food coloring
- (Optional) a few small objects like a raisin, a safety pin, a screw, etc.

Optional Read-Aloud
At any point in the lesson, you may read the book listed in the read-aloud section at the beginning of the unit.

Activity: Discovering Properties
Place three objects of your choosing on a table. Point to one of the objects and ask the children to describe some of the characteristics of that object. You may probe for ideas by asking them to identify these properties of the object: color, size, feel, smell, or weight. Repeat for the other two objects.

Picture Activity: Properties
Have the images from the pages titled “Pictured Properties” ready to show when prompted. Also be prepared with the needed supplies that are listed at the beginning of the lesson.

Read to the children: What we just identified about these objects are their physical properties. In your own words, how would you define a physical property? Pause for answers. Great! Physical properties are characteristics of an object that can be observed without changing its chemical identity. If we were to cut or break one of the objects we looked at, we would NOT be changing what it is. Its chemical identity would still be the same since the molecules that make up these objects are still the same.

Show image #1. For example, if we were to break a rock because we wanted to learn about its strength, we wouldn’t be changing its identity as a rock.

However, if we were to change something in such a way that changes its chemical makeup, we would be able to observe its chemical properties. Chemical properties are observations made about a substance during chemical changes. During chemical changes,
Corrosion

Corrosion happens frequently with certain types of metals. Corrosiveness is a chemical property because a metal, like iron, will react with oxygen in the presence of water to form rust (iron oxide). Iron oxide has completely different physical and chemical properties from iron and oxygen.

Show image #7. Another example is the green coating that forms when copper corrodes. Did you know the Statue of Liberty used to be brown like a copper penny? Over time the copper corroded, forming the green outer layer.

Volume

Show image #8. Volume, or how much space something takes up, is also a physical property. This example measures volume by showing how many cubes fit into the rectangular prism. We will use the measurement of centimeters. When we multiply the length, width, and height of the rectangular prism, we find its volume. What is the volume of the rectangular prism? [12 cm³ (centimeters cubed)]

“Centimeters cubed” or “cubic centimeters” means we can fit twelve 1-centimeter cubes into this box.

Give each child a copy of the sheet titled "Lesson 7 - Calculating Volume and Density." Have the children find, measure, and calculate the volume of a rectangular prism of their own choice and record their measurements and calculations on their Lab Notebook pages. Have them wait to fill out the rest of the page until prompted.

Another way to find volume is through displacement. Displacement means to move from one position to another. Show the children a graduated cylinder or measuring cup filled halfway with water. (It does not matter exactly how much as long as the water is level with a labeled marking.) Have the children note the volume of the water on their Lab Notebook page. Place a marble (or other small, sinkable object) in the cylinder and then have the children note the volume again. Have the children subtract the first measurement from the second to discover the volume of the object you placed in the water. Be sure they record the calculation in their Lab Notebooks. Because our object is a solid, we should write the volumetric units as centimeters cubed (or cubic centimeters) rather than milliliters. We use the units mL and cm³ interchangeably because 1 milliliter converts to 1 cubic centimeter.

Density

Density is how compact a solid, liquid, or gas is; it is dependent on the mass and volume of a substance. Imagine a rock the same size as a soccer ball. The two objects are the same size, but the rock is more dense than the ball because there is more mass contained in the same space. Take the marble out of the graduated cylinder, dry it thoroughly, and place it on a scale. Have the children note the weight of the item on their Lab Notebook pages. Density equals mass divided by volume. Have the children calculate the density and write it in their Lab Notebooks (a calculator may be used). The unit of measure for density is g/cm³, meaning grams per centimeters cubed. This is how dense the object is in grams for each cubic centimeter.

Activity: Vocabulary Words

Review the vocabulary words on your science wall. Then place the vocabulary words PHYSICAL PROPERTY, CHEMICAL PROPERTY, SOLUBILITY, and DENSITY on your science wall. Read and discuss each of the words and meanings.

Activity: Identifying Physical and Chemical Properties

Give each child a copy of the sheets titled "Physical or Chemical Properties." Have the children cut out each box and discuss whether the properties are chemical or physical. Have the children glue the boxes under the appropriate headings (an answer key with explanations is provided). Place the completed pages in their science journals.
☐ (Optional) Experiment: Observing Density

Carefully layer 50 mL (¼ cup) each of the following substances into a 250 mL graduated cylinder or a tall glass (a turkey baster may be helpful to layer the substances so that the substances don’t mix as you layer them): honey, corn syrup, dish soap, water, vegetable oil, rubbing alcohol (in that order). You may choose to add food coloring to the clear liquids to be able to see them better. Discuss your observations.

Read to the children: In this experiment we observed that the liquids that are less dense float above the liquids that are more dense. The substances that are more dense have more matter in them compared to liquids that are less dense. The amount of matter depends on the types of atoms that make up each of the substances and how these atoms are arranged.

Find small objects around your home, like a raisin, a safety pin, a screw, etc. Drop each object into the liquid layers and observe how far each item falls. You will be able to see how each solid item’s density compares to the various liquid densities.
Image #1

Image #2

Digestion

Image #3
Pictured Properties

Image #4

Hydrogen + Oxygen → Water

\[ 2H_2 + O_2 \rightarrow 2H_2O \]

Image #5

Image #6
<table>
<thead>
<tr>
<th>Physical or Chemical Properties (Cut-Outs)</th>
</tr>
</thead>
</table>

*Cut out the boxes below containing physical or chemical properties. Glue them under the correct category on your science journal page “Physical or Chemical Properties.”*

| **Appearance:** how something looks (e.g., white, dark, yellow, solid, liquid, gas, powdery, sticky, etc.) |
| **Odor:** how something smells (e.g., sour, sweet, burnt, etc.) |

| **Combustibility:** burning (e.g., wood burning) |
| **Corrosiveness:** objects can be "eaten away" by other substances (e.g., rust forms when iron corrodes) |

| **Flammability:** how easily something can catch fire (e.g., rubbing alcohol is flammable, meaning it will catch fire easily) |
| **Volume:** how much space an object takes up (e.g., 500 mL of water or the measurement of a cube) \( \text{length} \times \text{width} \times \text{height} \) |

| **Solubility:** how well a substance dissolves (e.g., salt is soluble in water) |
| **Mass or Weight:** relating to the heaviness of an object |

| **Texture:** how something feels (e.g., soft, coarse, bumpy, smooth, etc.) |
| **Viscosity:** how well a liquid pours; its thickness (e.g., syrup is more viscous than water because syrup does not pour as easily as water) |

| **Compressibility:** how well a material is able to compress (or squish down) under pressure (e.g., a helium tank used to fill up balloons contains compressed gas, so helium is compressible) |
| **Malleability:** how well a material dents or bends, or how well it can be shaped (e.g., a sheet of aluminum foil is more malleable than a steel knife) |

| **Reactivity:** how easily a substance will react with another substance; chemical bonds between atoms and molecules of these substances are broken and new ones are formed (e.g., fluorine is highly reactive and will even spontaneously ignite—reacting with the water in the surrounding air) |
| **Density:** the amount of mass in a specified volume; a way to measure how compact an object is (e.g., syrup is more dense than water; a brick is more dense than a piece of Styrofoam™ of equal size—objects with greater densities have molecules that are closer together) |
Physical or Chemical Properties

When identifying a characteristic as a physical or chemical property of a substance, ask yourself if these properties could be observed without changing its chemical identity. If so, it is a physical property. If not, it is a chemical property.

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Chemical Properties</th>
</tr>
</thead>
</table>
Physical or Chemical Properties - **KEY**

*Note: If the students struggle with this activity, for each property, ask them if they would need to change a substance in such a way that it would form a new substance in order to observe that property.*

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Chemical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Texture, Odor, Appearance</strong>—Each of these properties can be observed by touch, smell, or sight. Nothing has to change the substance. (While a change in odor, texture, or appearance can be a sign of a chemical reaction, we are specifically referring to a current substance’s texture, odor, and appearance.)</td>
<td><strong>Combustibility</strong>—We would need to burn what we are testing, causing a chemical reaction with oxygen and the production of light and heat.</td>
</tr>
<tr>
<td><strong>Viscosity</strong>—This can be tested by pouring syrup or water and seeing how well they run. The chemical identity of water and syrup doesn’t change.</td>
<td><strong>Flammability</strong>—To test this property, we would have to test our substance’s ability to catch fire, thereby causing a change that would be irreversible.</td>
</tr>
<tr>
<td><strong>Malleability</strong>—To bend or dent something does not change its chemical identity (i.e., an aluminum can or modeling clay is malleable because it bends and shapes easily—this property doesn’t change what it is chemically).</td>
<td><strong>Reactivity</strong>—To see if a substance will react means whether or not it will undergo a chemical reaction. To positively identify a substance as reactive, it goes through a chemical change. The ending materials are not the same as the starting materials.</td>
</tr>
<tr>
<td><strong>Solubility</strong>—When a substance dissolves, often you cannot see it, but that substance is still there. For example, by dissolving salt into water, you can still taste the salt in the water; salt and water have not changed into a different substance. They are both part of the mixture.</td>
<td><strong>Corrosiveness</strong>—Through corrosion a substance (like a metal) is being corroded while oxygen and water are doing the corroding. In both cases, testing corrosiveness results in the formation of a new substance (i.e., iron changing into rust). Oftentimes, the word corrosive is associated with strong acids that can be dangerous to the touch, as it damages (chemically changes) the skin.</td>
</tr>
<tr>
<td><strong>Mass or Weight, Volume, and Density</strong>—These properties are measurements that can be made without changing the chemical identity of the substance.</td>
<td><strong>Compressibility</strong>—Applying pressure to a substance (typically a gas) will not alter the way the atoms of the gas molecules are bonded to each other. They will simply move closer to each other.</td>
</tr>
</tbody>
</table>
Lesson 8 - Identifying Chemical Changes

Objectives
Help the children learn to identify a chemical change through observation and experimentation.

Preparation
- Cut and assemble the mini book Clues of Chemical Changes.
- Print a copy of the sheet titled "Clue Cards for Chemical Changes."
- Print a copy of the lab notebook page titled "Lesson 8 - Elephant Toothpaste Experiment" for each child.

Supplies needed
- A 250 mL graduated cylinder (or an empty disposable water bottle)
- A 50 mL beaker (or a ¼ cup measuring cup)
- A kitchen scale
- Warm water
- A 300 mL beaker (or a drinking cup)
- A funnel (if using a water bottle)
- Food coloring
- Dish soap
- Yeast
- A spoon
- Hydrogen peroxide (at least 3% — see note at end of lesson)

Activity: Vocabulary Words
Review the vocabulary words on your science wall.

Read to the children:
In the last lesson, we learned the difference between physical and chemical properties. When we can identify a chemical property, we know that a chemical change has taken place. A chemical change produces a new substance with different properties than it had before.

Mini Book
Read the mini book Clues of Chemical Changes included in this lesson.

Activity: Clue Cards
Give each child a copy of the sheet titled "Clue Cards for Chemical Changes." Have the children see if they can remember the clues of chemical changes from the mini book by having them write and draw each clue on a separate clue card. Reference the mini-book if needed. When completed, place the clue card pages in their science journals.

Experiment: Clue Cards
Give each child a copy of the lab notebook page titled "Lesson 8 - Elephant Toothpaste Experiment."
Have them read the information and fill out the Hypothesis section. Then give the children the page titled "Elephant Toothpaste Experiment Instructions" and have them complete the experiment together.

Read to the children: Elephant toothpaste got its name because it looks like giant toothpaste—big enough for an elephant. However, it is NOT toothpaste and should not be put into your mouth.

As you formed a mixture of liquids (dish soap, hydrogen peroxide, and food coloring), you may have noticed a color change. However, none of these substances interacted chemically to form new substances, so this observation would be a physical
A detective looks for clues to help him or her solve mysteries. In doing chemistry experiments, you can be a science detective and look for clues to help you figure out what is going on. Part of being a good science detective is knowing what clues to look for and what information you can gather from these clues. When doing experiments, you can look for signs to help you know if a chemical change is taking place.
Clue #1: Do you see bubbles?

Bubbles are a sign of a chemical change in which gas is produced. When vinegar and baking soda are mixed, bubbles are produced as carbon dioxide gas is released.

Bubbles do not always indicate a chemical change. We also see bubbles in boiling water, but this is just an indication of a phase change. Remember, a new substance will be formed if a chemical change has taken place.

In this photo, the solid medicine tablets contain sodium bicarbonate (baking soda) and citric acid. In water these two compounds react with each other, and carbon dioxide gas is released as a product. These tablets are used to treat certain types of pain, including stomachaches.

Clue #2: Do you smell a new odor?

A change in smell (odor) is an indication of a chemical change. Have you ever opened the fridge and smelled something foul, or have you noticed the stinky smell of rotting food in the garbage can? Smell is a sign of a chemical reaction where the food molecules are being broken down through a process called decomposition. Decomposition is a chemical reaction in which a compound breaks down into its individual parts, forming new substances. Even though food decomposition smells bad, it is a necessary part of nature as it recycles matter into usable nutrients and minerals. For instance, if your family plants a garden, you may have used compost or fertilizer, which is full of decomposed matter. This decomposed matter adds nutrients to the soil.
**Chemical changes may release or absorb heat.** If the reaction feels hot, it means heat is being released. This is called an exothermic reaction. If the reaction feels cold, it means heat is being absorbed. This is called an endothermic reaction. The prefix “en,” sounds a lot like “in.” Use this to remember that heat is taken “into” the reaction, leaving the surrounding area cold to the touch. The prefix “ex” means “out,” so if heat is going out, it will feel hot in the area surrounding the reaction. In exothermic reactions, we may also see light as well as feel heat. Physical changes can also be endothermic or exothermic, just as heat is a part of phase changes. The important thing to note is whether the heat is a result of the elements changing into something new. A burning match is an exothermic chemical reaction because the heat is a result of new substances being formed—ash and smoke.

**Clue #3: Do you sense a change in temperature or see a light?**

A change in color is another clue of a chemical change. You can see examples of this in your daily life. For example, when bananas ripen they go from green to yellow to black. This is because of the decomposition (breaking down) of starch molecules into sugar molecules. Another example of color change as a clue of a chemical change is the production of rust on metal. This is corrosion. Corrosion happens when metals deteriorate as they react with water vapor and oxygen in the air.
Clue #5: Do you see a solid form?

The scientific term for a chemical change in which a solid forms in a liquid is a precipitation reaction. The precipitate that forms in the liquid is insoluble. Remember, insoluble means it cannot dissolve. In this image, a yellow precipitate is formed above the green liquid.

Clue #6: Do you hear a sound?

Hearing a sound is a sign of a chemical change. Two examples are the sizzling sounds when food is being cooked or the popping sounds of a firecracker. When a firecracker is lit, the heat causes the solid compounds to react with each other. Gas is produced, and the firecracker explodes. Think about mixing baking soda and vinegar. Can you hear any sizzling sounds from that chemical reaction?
Do you recognize this molecule? It is a water molecule. When making molecular models, spheres are used to represent atoms and rods are used to represent bonds, but today we are going to zoom in a little closer to see how atoms actually look.

In this image each blue sphere with H represents hydrogen, which is an element on the periodic table. The red sphere with O represents oxygen, which is also an element. There is one oxygen atom and two hydrogen atoms in a single molecule of water. Notice how the oxygen atom is bigger than the hydrogen atoms.

Different elements combine together to make up all the materials and objects in this world, but keep in mind that atoms are extremely tiny. It is impossible to count the number of atoms that exist in the period at the end of this sentence.
John Dalton was an English chemist, physicist, and meteorologist born in the 1700's. He formed a theory of atoms that explains four key concepts.

**Dalton’s Atomic Theory:**
1. Atoms are tiny particles that make up matter.
2. The atoms of one type of element are all the same, but the atoms of one element type are different than the atoms of another element type.
3. Atoms do not change into other atoms during chemical reactions (e.g., oxygen will not turn into hydrogen).
4. In chemical reactions, atoms can form bonds to other atoms to form compounds.

Atoms bond together to form molecules, but when atoms of different element types bond, these specific types of molecules are also called compounds. For example, water (H₂O) can be called a compound as well as a molecule. But oxygen (O₂), being composed of only one element type, can only be called a molecule, not a compound.

Have you ever felt static electricity? It is the result of an electric charge. Electric charges are either positive or negative. Opposite charges attract each other, while similar charges repel. A similar force can be felt on a magnet.

In the 1800s experiments were done that led to the idea that atoms have electric charges, but scientists were still figuring out how these charges were arranged inside an atom. A scientist named J.J. Thomson thought the atom was made up of negatively charged particles that were scattered about in a sea of an equal number of positively charged particles. These negative charges could be visualized as seeds in a watermelon, where the red part of the watermelon is the sea of positive charges. However, there were some faults in this model, and Ernest Rutherford proved a more complete structure of the atom.
Rutherford shot a beam of positively charged (alpha) particles through a thin sheet of gold. He noticed that most of these particles passed straight through the sheet (think of a flashlight shining through a window). However, some of the positively charged particles “bounced” off the gold sheet at wide angles! Remember, similar charges repel, so Rutherford postulated that the positively charged particles must have struck something in the gold sheet that was also positive! Since most of the particles passed through the gold, Rutherford concluded that most of an atom was empty space, and the positive charges had to be very small and located in the center of the atom, which is now called the nucleus.

Rutherford’s experiments gave way to the idea that the atom must have a centralized nucleus with a positive charge and negative charges surrounding this nucleus. The word nucleus means "the central part of an object." The nucleus of an atom contains positively charged particles called protons and particles with no charge called neutrons. Surrounding the nucleus, in an area called the electron cloud, are negatively charged particles called electrons. See if you can identify the nucleus, protons, neutrons, electrons, and the electron cloud on the picture above.
Most of the particles in Rutherford's experiment went through the gold sheet. This tells us that most of the particles went though the electron clouds rather than deflecting off the nuclei. Therefore, most of the space of an atom is taken up by the electron cloud. The nucleus takes up a very small area of the atom, but it is much more dense.

Electrons are constantly moving in sections around the nucleus called orbitals. Orbitals are areas where electrons are most likely to be found. An “orbit” is a predictable path, whereas an “orbital” is an area where the electron could be found; since electrons are in constant random motion, their exact location is unpredictable.

An element's **atomic number** is unique to that element. Carbon has the atomic number of 6. No other element has the atomic number of 6. The atomic number defines the number of protons an element has. Because an atom has no overall charge, there must be an equal number of electrons. Therefore, carbon must have six electrons.
Electrons do not orbit the nucleus; instead they zip around the nucleus in areas called orbitals. Orbitals are grouped into sections in the electron cloud called electron shells. The first electron shell is closest to the nucleus, and each subsequent shell moves outward from the central nucleus. To visualize electron shells, think of a set of Russian stacking dolls. Electrons generally fill orbitals starting with the first shell, then filling outward to the second shell, then the third shell, and so on. Electron structure does have more than three shells and can become very complex, but we will just focus on the first three shells. As electrons fill additional electron shells, we say electrons are in higher energy levels. Try to memorize the information in the table below:

<table>
<thead>
<tr>
<th>Electron Shell</th>
<th>Electron Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Electron Shell</strong></td>
<td><strong>2 electrons total</strong></td>
</tr>
<tr>
<td><strong>Second Electron Shell</strong></td>
<td><strong>8 electrons total</strong></td>
</tr>
<tr>
<td><strong>Third Electron Shell</strong></td>
<td><strong>Up to 18 electrons</strong> (Note: We will focus on the first 8 electrons.)*</td>
</tr>
</tbody>
</table>

* Additional information regarding electron shell capacity and orbitals can be found at the end of the lesson, if children would like to learn more.

The atomic mass is the measure of how heavy an atom is. Because an atom is so tiny, a special unit of weight called the atomic mass unit (amu) is used to measure its mass. Carbon’s atomic mass is 12.01 amu. Only protons and neutrons contribute to atomic mass; electrons are too small and light to add any significant weight. While an atom has the same number of electrons and protons, the number of neutrons can be different. However, this difference in the number of neutrons does not change the identity of the atom, because it is defined by its number of protons. Individual forms of an element, having the same number of protons but a different number of neutrons, are called isotopes. Carbon is an element that can have a different number of neutrons. Carbon that has 6 protons and 6 neutrons is called carbon-12, while carbon that has 6 protons and 8 neutrons is called carbon-14. Because neutrons contribute to weight, isotopes with more neutrons are heavier. The atomic mass printed on an element symbol on the periodic table is a weighted average of the atomic mass of an element with all of its known isotopes.
As you study and learn more about atoms, you will find that science is full of patterns and many amazing, hidden discoveries are yet to be made. It is incredibly fascinating to ponder how studying science leads to the discovery of these “hidden secrets” God has used in creation. It is amazing to think that God created and arranged all the particles in such a way that we, and all the things around us, can exist. As you learn about atoms, you gain proof that God works in wisdom and order. Coming to understand the basics of chemistry lets you better understand and appreciate how He has masterfully created the beauty we enjoy. You are blessed as you acknowledge Him "in whom are hid all the treasures of wisdom and knowledge” (Colossians 2:2-3).
Element Structure Images

Neon

Oxygen

Sodium Ion

Helium

Sodium

- Neon: 10 Protons, 10 Neutrons, 10 Electrons
- Oxygen: Atomic mass: 15.999, Electron configuration: 2, 6
- Sodium Ion: Sodium atom Na 2, 8, 1
- Sodium: 11 Protons, 12 Neutrons, 11 Electrons
- Helium: 2 Protons, 2 Neutrons, 2 Electrons
## ATOMIC STRUCTURE

<table>
<thead>
<tr>
<th>Number</th>
<th>Atomic Mass</th>
<th>Element</th>
<th>Protons</th>
<th>Neutrons</th>
<th>Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>12.011</td>
<td>C (Carbon)</td>
<td>6</td>
<td>6</td>
<td>2, 4</td>
</tr>
<tr>
<td>15</td>
<td>30.974</td>
<td>P (Phosphorus)</td>
<td>15</td>
<td>16</td>
<td>2, 8</td>
</tr>
<tr>
<td>3</td>
<td>6.941</td>
<td>Li (Lithium)</td>
<td>3</td>
<td>4</td>
<td>2, 1</td>
</tr>
<tr>
<td>13</td>
<td>26.982</td>
<td>Al (Aluminium)</td>
<td>13</td>
<td>14</td>
<td>2, 8, 3</td>
</tr>
<tr>
<td>17</td>
<td>35.453</td>
<td>Cl (Chlorine)</td>
<td>17</td>
<td>18</td>
<td>2, 8, 7</td>
</tr>
<tr>
<td>11</td>
<td>22.99</td>
<td>Na (Sodium)</td>
<td>11</td>
<td>12</td>
<td>2, 8, 1</td>
</tr>
<tr>
<td>9</td>
<td>18.998</td>
<td>F (Fluorine)</td>
<td>9</td>
<td>10</td>
<td>2, 7</td>
</tr>
<tr>
<td>7</td>
<td>14.007</td>
<td>N (Nitrogen)</td>
<td>7</td>
<td>7</td>
<td>2, 5</td>
</tr>
<tr>
<td>10</td>
<td>20.18</td>
<td>Ne (Neon)</td>
<td>10</td>
<td>10</td>
<td>2, 8</td>
</tr>
</tbody>
</table>
Lesson 11 - Molecules, Compounds, and Chemical Bonding

Objectives
Help the children learn the basics of chemical bonding and understand that ionic and covalent bonds form new compounds and molecules.

Preparation
- Cut out the pages titled "Gaining Charges Activity."
- Obtain "The Periodic Table of the Elements" from Lesson 9.
- Cut along the black dotted lines on the pages titled "Ionic Bonding Roleplay–Props" (two pages).
- Print a copy of the sheets titled "Ionic vs. Covalent Bonding" for each child (two pages).

Supplies needed
- Two magnets (bar magnets, if possible—see note on page iv)
- Tape

- Read to the children:
So far in this chemistry unit, we have learned that atoms can form chemical bonds with other atoms to create molecules. We have also learned that molecules made up of different types of elements are often called compounds. How do these atoms bond together? Pause for answers. Bonding happens because of extremely strong forces of attraction.

Give the children two magnets and have them experiment with feeling the forces of attraction and repulsion between the magnets. As you can see, when opposite ends are placed together (north to south), you can feel a strong pull between the magnets. In contrast, when similar ends are placed together (north to north or south to south), you should feel a strong push of repulsion.

Similarly, forces of attraction and repulsion exist between positive and negative charges. These charges are found in atoms, molecules, and ions.

- Activity: Gaining Charges
Shuffle the eight cards labeled PROTON and ELECTRON and place them in a pile face down. Have a child grab two cards. Tell the children to bring them close together if the two particles attract and to move them away from each other if they repel. Repeat this activity until all the cards are used.

Why were neutrons not included in this activity? [Neutrons do not carry a charge.]

- Science Journal
Read to the children: As we learned in the previous lesson, ions are formed when atoms or molecules gain or lose electrons. Gaining or losing electrons helps atoms feel more stable because their electron shells become complete.

Find sodium on the periodic table. What is sodium’s atomic number? [11] As you continue to read, have the children draw and label a picture of a sodium
Activity: Covalent Bonding

When we think of bonding, we can imagine a tug of war. Elements are pulling with all their might to take electrons away from the other elements because they both want to have a full electron shell to feel stable. In the case of the ionic bond, which we just learned about, one element is stronger than the other and wins, taking the electrons. But when neither element is strong enough to take the electrons, they end up in an eternal tug of war that neither side can win; this is called a covalent [co–VAY–lent] bond.

Water is an example of a covalent bond. Do you remember which atoms make up water? [two hydrogen and one oxygen] Show the children the periodic table. Find hydrogen and oxygen. How many electrons does elemental hydrogen have? [1] How many electrons are needed in the first electron shell to make hydrogen stable? [2] This means hydrogen would like to gain an electron. Looking at oxygen, how many electrons does elemental oxygen have? [8] Remember, two electrons will be found in the first electron shell, so how many will be in the second electron shell? [6] Thinking of the octet rule, how many more electrons should be in the second electron shell to make oxygen stable? [2] From this we see that the two hydrogen atoms share their one electron with one oxygen atom, filling each atom’s electron shells.

Show the children the image “Covalent Bonding Water—(H₂O).” Point to the electrons that are being shared. (These are the four electrons located where the rings intersect.) Point to one of the hydrogen atoms (one of the blue atoms). One of the electrons being shared comes from the only electron that the hydrogen has, and the second electron being shared comes from one of the oxygen electrons. Point to the other hydrogen atom. Notice that the sharing happens here too. How many electrons are now surrounding oxygen’s outer shell? [8] How many are now surrounding each hydrogen atom? [2] All of these atoms are now stable because their electron shells are full.

Activity: Vocabulary Words

Place the vocabulary words OCTET RULE, IONIC BOND, and COVALENT BOND on your science wall. Read and discuss the words and definitions.

Octet Rule
Ionic Bond
Covalent Bond

Activity: Ionic vs. Covalent Bonding

Give each of the children the sheets titled “Ionic vs. Covalent Bonding” (two pages). Have them read and complete the instructions. When they have completed the pages, review the answers together using the answer sheet included at the end of this lesson. Have the children correct any incorrect answers. Place the completed page in their science journals. Periodically study the images on those pages that show the transferring and sharing of electrons.

Older Children - Lesson Extension

Choose one or more of the following activities to complete:

1. Research more information regarding ions. How does ion formation make an atom either stable or unstable? What are polyatomic ions? Research common ions and what types of compounds they form.

2. Research electronegativity.

3. Research 3D models of different types of compounds we have learned about (for example, acetic acid, sodium bicarbonate, carbon dioxide, and water).

4. Research dipole moments. Discover how the 3D shape and bond type influences them and learn how the dipole moment of a molecule affects the properties of the compound.
Ionic Bonding Roleplay—Props

Chlorine Atom

Sodium Atom

$^{17}\text{P}^+ \quad ^{18}\text{N}$

$^{11}\text{P}^+ \quad ^{12}\text{N}$
Ionic Bonding Roleplay—Props

+  

-  

NaCl
SODIUM CHLORIDE
Covalent Bonding—Water (H₂O)
Ionic vs. Covalent Bonding

Read: An ionic bond is formed when electrons are transferred. This results in the formation of ions because the number of positively charged protons and negatively charged electrons is unbalanced within that ion. For example, if an atom containing 10 protons and 10 electrons loses 2 electrons, the resulting ion would have an overall 2+ charge. This is because there would be two more positively charged protons (10) than electrons (10 - 2 = 8). Covalent bonds occur when atoms share their electrons with each other, creating stable electron shells.

Look at the interaction of each set of bonding atoms. Is an ionic or covalent bond being formed? Circle the correct answer.

**Magnesium oxide - MgO**

*Magnesium oxide is used as a supplement, or as a medicine to treat an upset stomach or heartburn. It is also used to make cement.*

Circle the correct bond: **covalent** ionic

**Sodium chloride - NaCl**

*Sodium chloride is an example we have seen before. This compound forms salt that is used to flavor foods and is vital for our body functions.*

Circle the correct bond: **covalent** ionic

**Carbon dioxide - CO₂**

*Carbon dioxide is a well-known gas. It is the gas we breathe out of our lungs and that plants use to make food. Carbon dioxide is the “fizz” that is dissolved in carbonated drinks, like sodas.*

Circle the correct bond: **covalent** ionic

**Calcium chloride - CaCl₂**

*Calcium chloride is a salt commonly used to melt snow and ice on roads.*

Circle the correct bond: **covalent** ionic
Lesson 12 - Conservation of Mass

Objectives
Help the children understand the law of conservation of mass.

Preparation

- Print a copy of the lab notebook pages titled "Lesson 12 - Growing Foam Experiment" (two pages) for each child.

Supplies needed

- Vinegar
- Baking soda
- A balloon
- A measuring spoon
- A 100 mL graduated cylinder (or an empty disposable water bottle with a narrow neck)
- A mini measuring cup (similar to a plastic cup that comes with children's cough syrup)
- A kitchen scale

Important People in Chemistry
Review the "Important People in Chemistry" cards.

Read to the children:
Chemical reactions produce chemical changes because atoms rearrange themselves to form new compounds. We can observe chemical reactions because we notice chemical properties. Recall from Lesson 7 that chemical properties include combustibility, flammability, reactivity, and corrosiveness. In a chemical reaction, you may notice things like gas being released, heat being absorbed or released, a spark, or solids forming in a solution (called a precipitate), among other occurrences.

Experiment: Growing Foam
Give each child a copy of the Lab Notebook journal pages titled “Lesson 12 - Growing Foam Experiment.” Have the children read the instructions and fill out the HYPOTHESIS section. When they have completed their hypotheses, provide the children with the "Growing Foam Experiment Instructions" and have them complete the experiment and fill out the rest of the first page of their Lesson 12 Lab Notebooks.

When the experiment is complete, read the following to the children:

During this experiment we witnessed a chemical reaction. You may have noticed that upon adding the baking soda to the vinegar, a gas was released. How do you know that a gas was released? Pause for answers. Remember, gas molecules fill the space they are in; so in the experiment, the gas molecules took the shape of the balloon. By collecting the gas molecules inside the balloon, we were able to capture all the products, rather than let the gas escape into the air around us. The observation of the release of a gas shows us that a chemical reaction took place. We can also conclude that this was a chemical reaction because the products we ended up with were not the same as the reactants with which we began. Have the children look at the chemical formula diagram on the second page of their Lesson 12 Lab Notebooks. The diagram is read: Acetic acid plus sodium bicarbonate yields sodium acetate and water and carbon dioxide.
On the left side, the reactants are shown. Do you remember what reactants are? [the substances used in an experiment; in this case, sodium bicarbonate (baking soda) and acetic acid mixed with water (vinegar)]

The arrow represents that a chemical reaction has occurred. During a chemical reaction, atoms and molecules are rearranged, chemical bonds are broken and reformed, and electrons are shared or transferred between different atoms.

To the right of the arrow, the products are shown. What are products? [the substances produced] The experiment produced sodium acetate, water, and carbon dioxide gas.

Look at the molecule sodium bicarbonate. Do you notice that there are atoms clumped closer together, and there is a gray atom to the left that is barely touching the clump? The gray atom represents a sodium ion. This sodium ion is spaced a little farther away to represent an ionic bond. The rest of the compound “bicarbonate,” which is represented by the atoms more clumped together, is held by covalent bonds. This whole structure is held together because the sodium ion has an overall positive charge and bicarbonate has an overall negative charge, and remember—opposites attract! You also see these characteristics with sodium acetate on the products' side.

Look at the chemical formula written under the image of each compound. The small number written after the element symbol is the number of atoms in that compound. For example, for water (H₂O) there are two hydrogen atoms and one oxygen atom. Have the children count the number of hydrogen (H), carbon (C), oxygen (O), and sodium (Na) atoms on the left side of the arrow and record their numbers in the tables titled "Exploring the Law of Conservation of Mass" under the REACTANTS headings. Have them do the same for the right side of the arrow, and record their numbers under the PRODUCTS headings.

What do you notice about the number of each element on the reactants' side and the number of each element on the products' side? Pause for answers. Why are they the same? The law of conservation of mass (also known as The law of conservation of matter) states that matter cannot be created nor destroyed. In an experiment, atoms and molecules may be rearranged, but the mass is “conserved” (or unchanged) from beginning to end. Therefore, the mass of the reactants must equal the mass of the products, and the number of atoms in the beginning equals the number of atoms at the end. Have a child read aloud the information below the table in the Lab Notebook.

During the experiment carbon dioxide gas was captured in the balloon. The law of conservation of mass was observed when the total weight of the reactants proved equal to the total weight of the products.

Activity: Vocabulary Words

Review the definitions that you have put on the science wall so far in this unit. Place the vocabulary phrase LAW OF CONSERVATION OF MASS on your science wall. Read and discuss the phrase and definition.

LAW OF CONSERVATION OF MASS
Lesson 12 - Growing Foam Experiment

Information

In this experiment, a chemical reaction will occur by mixing two common household substances—baking soda (sodium bicarbonate) and vinegar (acetic acid mixed with water). The two substances will be mixed inside a cylinder (or a bottle) covered with a balloon. The substances used in an experiment are called the reactants, and the substances produced are called the products. The reactants in this experiment are baking soda (sodium bicarbonate) and vinegar (acetic acid mixed with water).

Hypothesis

To hypothesize means to make an educated guess. Take a guess, based on information provided above or from doing additional research (if desired).

What do you think may result from mixing baking soda and vinegar?

_______________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

Data Recordings

<table>
<thead>
<tr>
<th>Total Weight of Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning of Experiment</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Record observations during the experiment. Make note of any changes you had to make to the experiment procedure. Raw recordings of observations can be quick notes or pictures. You will write more complete sentences in the Results section.

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

Results

Using complete sentences, write what you observed during the experiment. Use your “lab notes” in the Data Recordings section to help you recall what you observed.

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________

_______________________________________________________________________________________________________________________________________________________________________________________________
The formula below represents the reaction and is called a chemical equation.

\[ \text{HC}_2\text{H}_3\text{O}_2 + \text{NaHCO}_3 \rightarrow \text{NaC}_2\text{H}_3\text{O}_2 + \text{H}_2\text{O} + \text{CO}_2 \]

When the number of atoms of each element is the same on both the reactants' and products' side of the arrow, the chemical equation is balanced.
Objective
Help the children understand that water has special physical and chemical properties which help sustain life on earth.

Preparation
- Obtain the "Salt Water Solution Experiment Instructions" from Lesson 13.
- Obtain each child's lab notebook page titled "Lesson 13 - Salt Water Solution Experiment" from Lesson 13.
- Print a copy of the sheet titled "The Special Properties of Water" for each child.

Supplies needed
- A calculator
- Tape
- A pitcher of water
- A glass
- A cookie tray
- Crayons or colored pencils

Optional Read-Aloud
At any point in the lesson, you may read the book listed in the read-aloud section at the beginning of the unit.

Experiment: Salt Water Solution Part 2
Complete this part if the water has evaporated. Read to the children: In the last lesson, we did an experiment with a salt water solution. Today we are going to observe the results. Show the children the dish with the solution from the last lesson. Have the children complete Part 2 of the Salt Water Experiment Instructions from Lesson 13.

What happened in the experiment? Pause for answers. Even though it may seem like salt disappears in a solution, it does not! After the water evaporated over the course of a few days, the salt was left behind.

NOTE: If the end date and starting date measurements are off by a couple of grams, this may have been due to a variety of reasons. Some examples include inaccurate measuring due to equipment or human error, an ingredient may have spilled out, or something may have fallen into your experiment.

Read to the children:
Water is a fascinating compound! Even though water is tasteless, odorless, and colorless, it is essential for sustaining life on earth and is one of the most abundant natural resources we have. Water is all around us and is even inside of us. In fact, about 70% of the earth's surface is water, and about 65% of our bodies are made up of water! In our bodies water is needed to carry nutrients to our cells and waste out of our bodies. However, when compared to molecules of similar size, water tends to behave very differently. As we move forward with this lesson, we will learn more about the special properties of water. In addition, we will be able to see how God is truly the grand designer of His creations.
PROPERTY #1: WATER MOLECULES ARE POLAR

Show the children the page titled "Water Molecules are Polar — Images." Point to Image A. Read to the children: We have learned that positive and negative charges are parts of atoms and ions. When molecules are formed, they may also have slightly charged areas depending on how the electrons are distributed. In a water molecule, oxygen tends to hog the electrons, giving the oxygen part of the molecule a partial negative charge and leaving the hydrogen end of the molecule with a partial positive charge. This is because oxygen tends to have a greater attraction toward the electrons than hydrogen does. Have a child point to these areas of partial positive and partial negative charges on Image A.

The δ sign is the lowercase Greek symbol “delta,” which is used to represent this slight charge. Molecules that have a partial positive end and a partial negative end are called polar molecules, and these ends act like a magnet. Water molecules have polarity, a separation of charges in a molecule; we will learn that this property influences all the other properties of water.

Have you noticed that water has the tendency to bead together into droplets? Pause for response. This is one example of how polarity causes “sticking,” which is similar to how magnets pull together. The partial positive end of one water molecule “sticks” to the partial negative end of a neighboring water molecule, forming a hydrogen bond. Hydrogen bonds require at least one hydrogen atom and must be bonded to an atom that hogs electrons (like oxygen or nitrogen). Point to Image B. Have each child run a finger along the hydrogen bonds by starting on the partial negative end of an oxygen atom and running his or her finger along the dotted lines to the partial positive end of a hydrogen atom of a neighboring water molecule. Do this for all hydrogen bonds.

Hydrogen bonds are really not bonds at all; the term is misleading. Rather, a hydrogen bond is a strong dipole-dipole force, a force that acts between two molecules. Covalent and ionic bonds have a much stronger force that acts within a molecule, holding it together. Despite this, hydrogen bonds are strong enough to keep water molecules close together, and a lot of energy is needed to pull them apart. For example, a lot of energy (in the form of heat) is required for water to transition from a liquid phase into a gas phase.

Have the children complete the section titled "Property #1 – Water Molecules are Polar."

PROPERTY #2: WATER IS A UNIVERSAL SOLVENT

In the last lesson, when we began the "Salt Water Solution Experiment," what happened to the salt as we stirred it into the water? [it dissolved] Can you think of some other things besides salt that might dissolve in water? Pause for answers. Excellent! Water is a universal solvent. In chemistry, the term "aqueous solution" is used to describe a solution where water is the solvent because "aqua" means "water" in Latin.

This property of water being a universal solvent is very important to sustaining life. Water dissolves and carries many nutrients, compounds, and minerals to places where they are needed. Take, for instance, our bodies. If we do not drink enough water, we can get dehydrated. This can make us very sick, even to the point that we can die. We need water to carry nutrients around in our bodies and to hydrate our cells.

Water helps all of the other life forms on the earth, too. Water transports different sediments and minerals through rivers and underground water systems to ponds, lakes, and oceans where plants and animals take it in. Oxygen mixes with water to feed the fish and other underwater animals and plants. If water was not such a good solvent, every living thing on earth would be in trouble!

Show the children the page titled "Water is a Universal Solvent — Images." Point to Image C.

NOTE: (aq) stands for in an aqueous solution, or...
that the element is dissolved in water. Water’s polarity is what allows it to be a good solvent. What do you notice is happening in this image? Pause for responses. The partial negative part of water, the oxygen end, is what is attracted to the positively charged sodium ion. The partial positive part of water, the hydrogen end, is what is attracted to the negatively charged chloride ion. Water molecules begin to fully surround each sodium and chloride ion, breaking the bonds between the ions and pulling the ions away from each other, dissolving the salt crystal. This is what was happening when we made our salt water solution; the cloudy solution of salt water gradually became a clearer liquid. The salt was literally being “chipped away” by water molecules until the entire crystal had disappeared in the solution. Point to Image D. This is another representation of sodium chloride in an aqueous solution. Here we see the partial positive and partial negative signs written in. There are different ways artists represent these structures.

Water’s identity as a universal solvent is true for solutes that are polar or contain ionic compounds (like NaCl) because of their charges. Non-polar substances are insoluble in water because they do not carry charges. An example of a non-polar substance is oil. Recall from the lesson on solubility that oil did not dissolve in water. This is because non-polar substances do not have negative and positive ends. When oil is mixed with water, the water molecules are more attracted to each other than the oil because the oil lacks the partial charges.

Have the children complete the section titled "Property #2 – Water is a Universal Solvent."

PROPERTY #3: WATER IS ADHESIVE AND COHESIVE

Wrap tape around the ends of two or three fingers of each student so that the sticky part is facing outward.

Read to the children: Bring your fingers close together. Now spread them apart. What happens to the fingers that have tape around them? Pause for response. Touch the table with your taped fingers. What do you notice? Pause for response. Now, think of each piece of tape around your fingers as a water molecule. Water molecules tend to stick to each other and may stick to other objects. Because water molecules are polar, they tend to stick to each other through hydrogen bonds. This property of water is called cohesion. The prefix “co” means together, like in the word “cooperate.” Water molecules cooperate by sticking together. Water also has the tendency to stick to other surfaces. This property is called adhesion. You may know that another name for tape is “adhesive,” and we usually stick tape to other things. Hence, “adhesion” refers to two different things that stick together.

Activity: Vocabulary Words

Place the vocabulary words COHESION and ADHESION on the science wall. Read and discuss the words and definitions.

Can you think of any surfaces to which it might be more difficult for tape to stick? [fabric, bark, etc.] Similar to tape, water is less likely to stick to certain surfaces. Whether or not water will stick to certain surfaces depends on the properties of that surface. Do you remember what we learned about a meniscus? Pause for response. Show the children the page titled "Water is Adhesive and Cohesive — Images." Point to Image E. Water forms a concave meniscus when in a glass. Water forms a meniscus because glass is more polar than water. The water molecules are more attracted to glass because the adhesive force is stronger than the cohesive force.

Place a glass on a cookie tray. Then have a child use a pitcher of water to carefully fill the empty glass. Have the child try to form a bulge of water at the top of the cup without it spilling over. Water tends to form a “skin” at its surface. This is because the
water molecules at the surface of the water are held together through cohesion. The hydrogen bonds between the molecules are stronger than the pull of molecules in the surrounding air. This is unlike water’s interaction with glass, where glass is more polar than water and will pull the water molecules closer to the glass. The ability for water to stick together and resist rupture at its surface is called surface tension. Point to Image F. We can also see this in nature. Have the child slowly pour some more water into the glass until it spills over. The additional water added stress to the molecules, and the water spilled as a stronger force took over – gravity! Surface tension is what allows small insects to rest on top of water. Point to Image G. The insect is held up by water’s ability to resist the added stress.

Have the children complete the section titled "Property #3 – Water is Adhesive and Cohesive."

PROPERTY #4: THE PHYSICAL STATES OF WATER

Read to the children: We have already learned that water can exist as a solid, liquid, or gas. However, the fact that water naturally exists in these three states at normal temperatures found on earth is not typical for molecules similar to water. Because water is polar and wants to stick together, it requires a lot more energy (heat) in order to break the hydrogen bonds between the molecules. This property is essential to our body’s ability to cool off. As water evaporates from our skin, it takes a lot of heat with it.

It is unusual to find a carbonless compound that is liquid at room temperature. However, this is the case with water! We know that water molecules are held together by hydrogen bonds. This should not be confused with the covalent bonds that form between atoms to create a water molecule. Do you remember what happens to water molecules when they freeze? Pause for response. It takes fewer water molecules to fill a space in its solid form than to fill that same space in its liquid form. The colder molecules expand, and the frozen water increases in volume by about 9%. It increases in volume, but not in mass, meaning the number of water molecules is not increasing, so its density is less. Do you recall the formula for density? Pause for answers. [mass divided by volume equals density] If frozen water is less dense than liquid water, which will float? [ice]

This unusual property of water that causes it to expand when frozen, whereas most other substances contract when frozen, is essential to life on earth. During cold winter months in areas where ponds, lakes, and rivers freeze, the surface freezes and ice floats, while the water underneath the ice remains liquid. As the ice forms a shield, it insulates the water underneath. If this was not the design of God, all living aquatic creatures would be trapped in ice and would die when temperatures drop below freezing.

Have the children complete the section titled "Property #4 – The Physical States of Water."

☐ Read to the children:

As we study different areas of science, our eyes and minds are opened to the infinite and marvelous details of God’s work. We are left feeling amazed and humbled at His great knowledge of the elements and His work of creation. Notice the world around you, the light and warmth of the sun, the air we breathe, your body—each of these involve atoms of the elements you learned about in this unit. The sun is powered by nuclear reactions, the air is composed of a mixture of compounds, and your body performs chemical reactions on a daily basis to keep you alive. As young scientists, you can notice inspiring things like these examples and research to better understand them. It will not only help you in your educational pursuits, but it will bring you closer to God as you appreciate His work.
Water Molecules are Polar — Images

Image A

Image B
Water is a Universal Solvent — Images

Image C

Image D
Water is Adhesive and Cohesive — Images

Image E

Image F

Image G
The Special Properties of Water

Property #1: Water Molecules are Polar.

What does polar mean?
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

Property #2: Water is a Universal Solvent.

Why is this property important for living things?
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

Property #3: Water is Adhesive and Cohesive.

Draw a picture to represent adhesion. You may draw the molecular structure of water, or how it is seen with the naked eye (e.g., you may choose to draw a puddle of water spreading out on a surface or a meniscus).

Draw a picture representing cohesion. You may draw the molecular structure of water, or how it is seen with the naked eye (e.g., you may choose to draw water droplets, water beading on a surface, or surface tension).

Property #4: The Physical States of Water.

Draw a picture and/or write about something you learned about water’s states of matter.
Carbon is a very common element. Carbon is found in specific kinds of molecules that make up about 18% percent of your body. Pure carbon can be found in different forms. The brittle lead in a pencil is actually not made out of lead but a type of carbon called graphite. While graphite may break under pressure, another form of carbon produces one of the strongest rocks found on Earth—diamonds!

The images above are the molecular structures of (a) diamonds and (b) graphite. The round circles represent carbon atoms, and the connecting lines represent bonds. Graphite occurs in sheets that are weakly held together and will easily pull apart, whereas diamonds form strong structural bonds.

Oxygen is one of the most abundant elements on earth! Your body is also mostly comprised of oxygen. An oxygen atom that has bonded to another oxygen atom forms $O_2$, which is in the air we breathe. If a third oxygen atom bonds, it forms another gas called ozone, which is found in Earth’s upper atmosphere as a protective layer from the sun’s ultraviolet rays. Oxygen is considered to be very reactive, meaning it will readily bond to other elements. When oxygen bonds to other atoms or molecules, it is called oxidation. Oxygen is also a big contributor to combustion reactions, which are reactions involving burning.

Rust (also called iron oxide) is formed from the corrosion of a metal, like iron, when oxygen molecules bond to iron molecules, causing oxidation.