Lesson 2.1: Atoms, Molecules, Compounds and Mixtures

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2	12-13	I can use a chemical formula to count the total number of each type of atom.
3	14-15	I can create models using marshmallows to describe how the particles in an element, molecule, compound, and mixture compare.
4	16-17	I can use text evidence to describe how an "oxygen tank" might compare to an "air" tank.
5	18-19	I can plan an investigation to demonstrate that mixtures are combinations of substances that can be separated by physical means.

Task 1 Learning Target: I can describe what happens when more than 1 atom comes together.

The particles in an element, molecule, compound and mixture look different.

Use the resources on the following pages to complete the graphic organizer below:

a. Video Link Resources- see page 3
b. Text Resources- see pages 4-11

	Definition	Picture	Other Notes
Element/Atom			
Molecule			
Compound			
Heterogenous Mixture			
Homogenous Mixture			

Video Links:

https://sites.google.com/a/ps207tigers.org/207sci/atoms

https://www.brainpop.com/science/matterandchemistry/compoundsandmixtures/

https://www.youtube.com/watch?v=1doJzI8qGcY

https://www.youtube.com/watch?v=4WR0_gEEZ9I&amp=&list=PLqOO1COTFHBtV_jPHcG_6ys0yN-_eANLJ&amp=&index=27

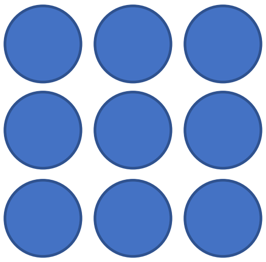
Atom - the smallest amount of an element that is a basic building block of matter

Element - a basic substance made of 1 kind of atom that can't be simplified (hydrogen, oxygen, gold, etc...an atom's "name tag")

1 atom

Many atoms of the same type

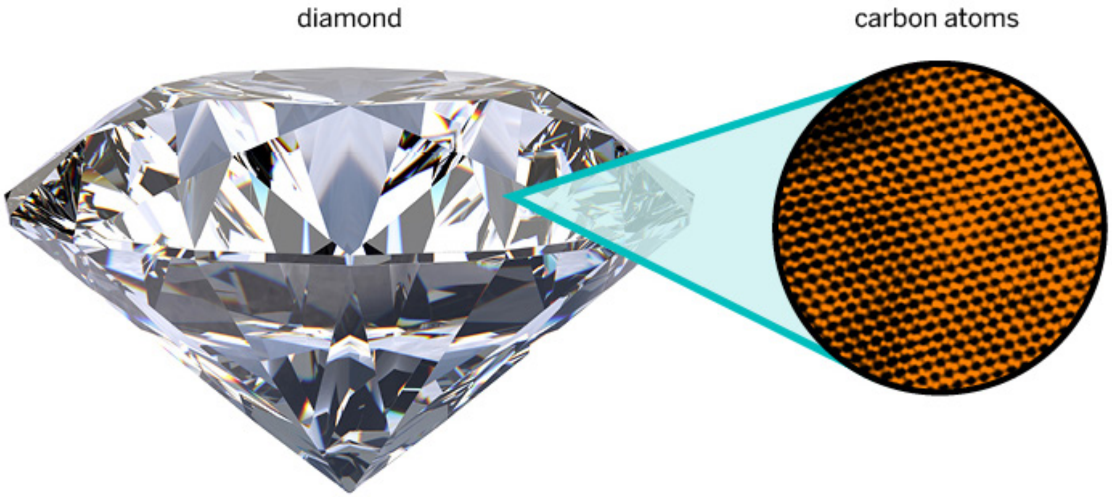
The element is the name of the atom: aluminum



Pure elements are made up of all 1 kind of atom.

Notice the 2nd picture, there are a bunch of identical atoms just sitting next to each other. The atoms in an element are NOT bonded to one another.

Elements have atoms that are chemically the same.



Diamonds are made of just one kind of atoms, called carbon atoms.

Atomic Zoom-In

Comparing Substances at a Very Small Scale

Imagine you're eating breakfast. The wooden table you're sitting at is hard, your orange juice smells sweet, and the sugar in your sugar bowl is white. The day has just begun, but you've already come into contact with many substances, each of which has its own set of properties. What is it that gives these substances their different properties? To understand where these differences come from, scientists observe substances at a very small scale—much smaller than we can observe in our daily lives. Let's zoom in and see what we find. What is matter actually made of?

In the 1800's, John Dalton was the first to propose the idea that all matter is made of tiny pieces called atoms. Today we call this "the atomic theory." Since it is a theory it may sound like scientists are not sure about it, but a scientific theory is an idea that has a lot of evidence that many scientists have gathered over a long time. Even today scientists continue to gather evidence that all matter is made of atoms!

Atoms are too small for us to see, but scientists currently know of 118 different types of atoms in the universe, including oxygen, carbon, silver, and gold. Every substance is made of a unique combination of atoms. Substances can be made of just one type of atom or a specific group of atoms that repeats over and over. Chemists represent these groups of atoms using chemical formulas: letters and numbers showing the types and numbers of atoms that repeat to make up a substance. Substances have different properties because they are made of different types and numbers of atoms that repeat.

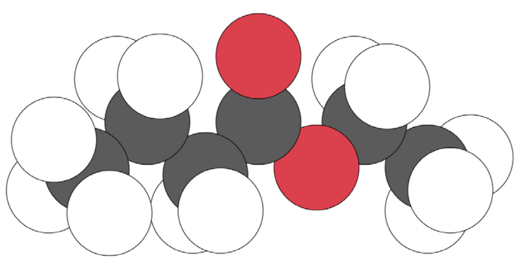
How Atoms Make Your Orange Juice Smell Good and Your Socks Smell Bad

Have you ever noticed how good orange juice smells when you pour yourself a glass? You may be surprised to learn that for many brands of orange juice, the aroma is added. Orange juice is often kept in big tanks for a time before it is packaged and shipped. The juice needs to be processed in order to keep it from spoiling. This processing can cause the pleasant orange scent and flavor to fade. To address this problem, chemists add a substance that makes the packaged juice smell and taste like fresh-squeezed oranges. That substance is called ethyl butyrate (EH-thul BYOO-tuh-rate).

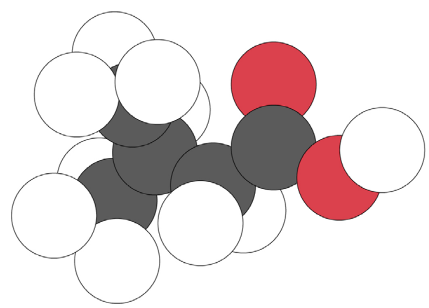
Ethyl butyrate is a naturally occurring substance found in many fruits. If you examined a sample of ethyl butyrate, you might observe that it is a clear liquid with a strong smell of pineapple or orange. It has a chemical formula of $C_6H_{12}O_2$, which means it is always made of groups of 6 carbon atoms, 12 hydrogen atoms, and 2 oxygen atoms. This group of different atoms forms a pattern—it repeats over and over again to make up the substance. The more times the pattern repeats, the more ethyl butyrate you have.

Even very small differences at the atomic scale can have important effects on the properties of a substance. One substance that is similar to ethyl butyrate at the atomic scale is called Isovaleric (EYE-so-vuh-LAIR-ick) acid. If you were to observe the properties of Isovaleric acid, you would see that it is also a colorless liquid, but you would never get it confused with ethyl butyrate. Why? Instead of the pleasant smell of citrus, you would smell something similar to sweaty gym socks. Gross!

Why do these two substances have different properties? Looking more closely at the atoms in Isovaleric acid, you can see that it is made of groups of 5 carbon atoms, 10 hydrogen atoms, and 2 oxygen atoms, so its chemical formula is $C_5H_{10}O_2$. Ethyl butyrate and Isovaleric acid have different properties because the atoms that make up each substance are grouped differently. Isovaleric acid has one fewer carbon atom and 2 fewer hydrogen atoms. These atoms are also arranged in a different

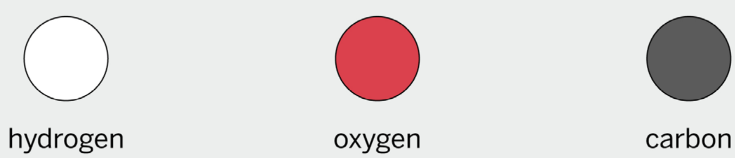


ethyl butyrate

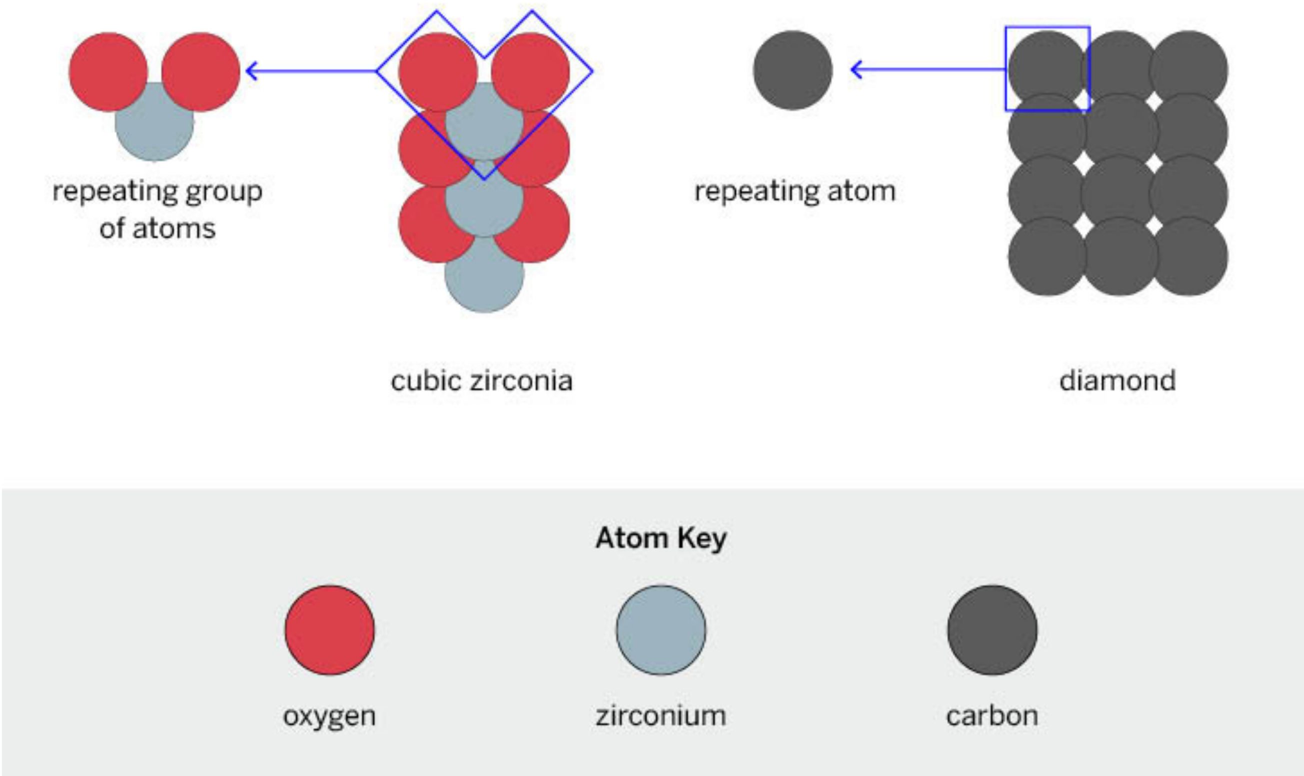


isovaleric acid

Atom Key



Ethyl butyrate (left) and Isovaleric acid (right) are both made up of repeating groups of carbon, hydrogen, and oxygen atoms. However, one smells like citrus and the other smells like sweaty gym socks!



Diamonds are made of carbon atoms stuck together in a repeating pattern, while cubic zirconia is made of zirconium and oxygen atoms stuck together in a repeating pattern.

pattern. At the atomic scale, these seem like small differences, but even small differences are enough to give the two substances very different properties.

Are These Diamonds Real? Chemistry in Jewel Trading

Diamonds come from deep inside Earth and are often polished and used in jewelry. Because they are very popular, they are also very expensive! Due to the high price of diamonds, jewelry makers sometimes use substances that share some of the same properties as diamonds, but cost less. One of these substances is a human-made material called cubic zirconia. At first glance, cubic zirconia and diamond look very much alike: both are clear, shiny, and solid at room temperature. However, diamonds and cubic zirconia do not share all of the same properties. For one thing, diamonds are the hardest naturally occurring substance that we know of, so they are very hard to scratch. In fact, diamonds are often used in saws to cut very hard things, like stone. Cubic zirconia is not as hard as diamond—it can be scratched easily, and isn't nearly hard enough to cut through stone. Diamond and cubic zirconia are also different in other ways, such as melting point.

Diamond and cubic zirconia have different properties because they are made of different atoms. Diamond is made of carbon atoms packed together tightly, and its chemical formula is a single letter, C, which stands for carbon. Diamond is always made of carbon atoms stuck together in a repeating pattern. Cubic zirconia is made of groups of one zirconium atom and two oxygen atoms. Its chemical formula is ZrO_2. This atom group repeats to make up a cubic zirconia gemstone. If a gemstone is made of atoms other than carbon, chemists can tell that it isn't a real diamond.

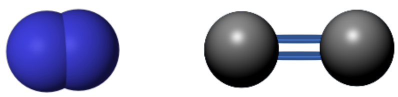
Fresh orange juice smells good because it contains a certain molecule.

Substances are made of atoms or groups of atoms that repeat. The number and type of atoms that repeat are different for different substances. Diamonds are made of just carbon atoms repeating. Cubic zirconia is a different substance because it has a different group of atoms that repeat.

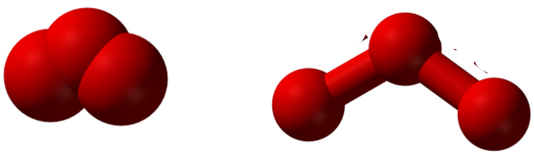
All substances are made of groups of repeating atoms, but these groups can take different forms. In some cases, like ethyl butyrate from orange juice and Isovaleric acid from sweaty socks, these repeating atom groups form separate units called molecules. Individual molecules are not connected to the molecules next to them. Many of the substances that you encounter every day, such as air and water, are made of individual molecules. In other cases, like cubic zirconia and diamond, these repeating atom groups link together to form large networks known as extended structures. In extended structures, the atom groups repeat over and over again with all of the atoms connected to their neighbors. Besides diamond and cubic zirconia, there are many other substances made of atoms that form extended structures, such as graphite, metal, and even salt crystals. However, whether they form individual molecules or extended structures, atoms are the basic ingredients that make up every substance and determine its specific properties. Differences at the atomic scale are what make substances look, smell, and feel the way they do.

Molecule: more than one atom bonded together
If you look at the particles in a substance, there are many ways that a molecule can be shown. Below are a few examples.

Oxygen (O_2)



Ozone (O_3)

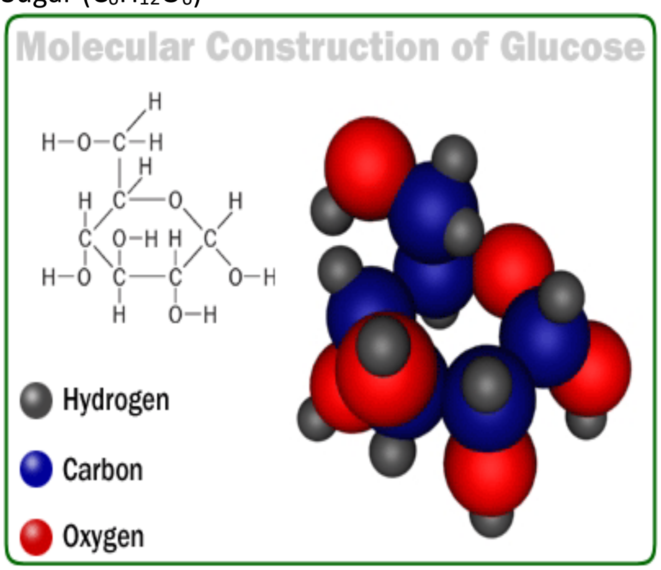


Sometimes molecules are shown by drawing them as balls stuck together. (the first picture of oxygen and ozone)

Sometimes molecules are shown by drawing them as balls connected by sticks. The balls are the molecules and the sticks are the bonds holding them together.

Notice how in both examples, there is more than one atom that is connected in some way. This is different than the element that did not have the atoms connected.

Molecules can have more than one element.
Sugar ($C_6H_{12}O_6$)



Glucose has carbon, hydrogen, and oxygen atoms bonded together. Because there is more than one kind of atom, it is a molecule. Molecules can be made up of more than one of the same kind of element or of more than one different kind of element.

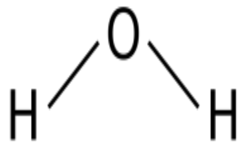
You can tell this because there is more than one chemical symbol (C, H, and O). Each chemical symbol represents a different element.

You can also often tell there are different molecules because the color or shading of the "balls" are different to show they are different kinds of atoms.

The small numbers are called subscripts. These tell how many atoms of each element are bonded together. In $C_6H_{12}O_6$, there are 6 C's (carbon atoms), 12 H's (hydrogen atoms), and 6 O's (oxygen atoms).

Compounds: More than one ***different*** element bonded together

Water (H_2O)



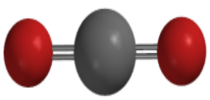
Water, H_2O, has two hydrogen and one oxygen atom. It is important to draw it in a triangle shape.

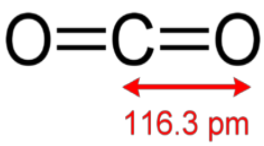
You can tell it is a compound because there are two different chemical symbols (H and O).

You can also tell it is a compound because there are two different colored/shaded balls that are connected by a bond.

Carbon Dioxide (CO_2)

Notice again that there are two different elements involved so it is a compound.





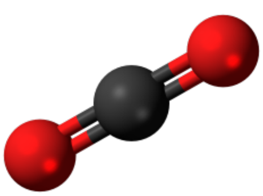
Sodium Chloride or Salt (NaCl)

Table salt is a kind of compound.

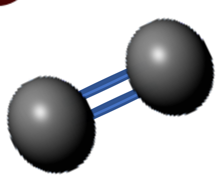
Notice again that there are two different kinds of elements, Na and Cl. This makes it a compound.

Each new capital letter in the chemical symbol means it is a new element.

All compounds are also molecules! (But not all molecules are compounds.)



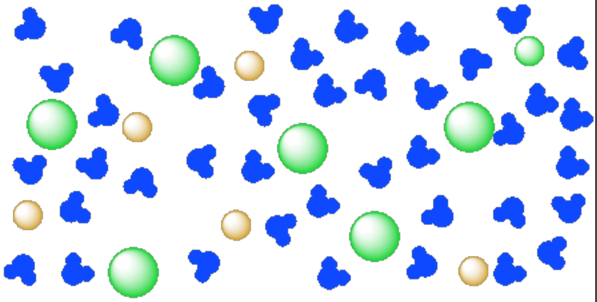
Carbon dioxide (CO_2) is a molecule and a compound. Because there is more than one atom bonded together it is a molecule. Because the two atoms are different (notice the shading of the balls is different), it is also a compound.



Oxygen (O_2) is a molecule. It is not a compound. Because there is more than one atom bonded together it is a molecule. Because the two atoms are the same (notice the shading of the balls is the same), it cannot be a compound.

Mixtures: A mix of compounds and molecules that can be separated by physical means (ex. By sifting/straining, magnets, dissolving, evaporating, etc)

Saltwater (NaCl dissolved in H_2O)



Mixtures have multiple molecules that are mixed together, but not bonded together.

A chemical reaction does not occur when salt and water are combined; They just form a mixture. The molecules of salt and water did not change into new combinations when they were mixed.

Notice in the beaker of salt water to the right that there are salt molecules and water molecules, but they are not connected together. Salt water is a solution. It has one thing dissolved into another.

Additional Vocabulary:
Solute- the "thing" that gets dissolved

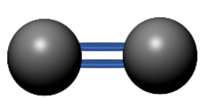
Solvent – the "thing" that does the dissolving

There are two types of mixtures.
Heterogeneous: mixtures that are not the same throughout
Ex: blood; oil and water

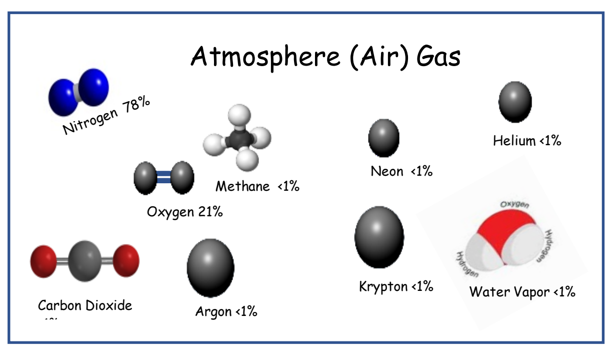
Homogeneous: mixture that is the same throughout
Ex: coffee with milk and sugar; air

Oxygen, Oxygen, and Air

This is oxygen the element. It is not bonded or mixed with any other atoms.



This is oxygen (O_2) the molecule. It is bonded with another oxygen atom. This is the oxygen we breathe. This is the oxygen that we use during cellular respiration and that plants produce during photosynthesis.



Air is a mixture. There are many molecules mixed together but not bonded together. Notice that Oxygen (O_2) is one of these molecules but it is not the only molecule in air. IMPORTANT: Oxygen is NOT air!!!!

Task 2 Learning Target: I can use a chemical formula to count the total number of each type of atom.

Background Information: HOW TO COUNT ATOMS

-subscripts: the little numbers that tell how many atoms there are

(ex: In 3 H_2O, the **2** is the subscript)

-coefficients: regular-sized numbers that tell how many molecules there are

(ex: In 3 H_2O, the **3** is the coefficient)

3 H_2O

The subscript **2** in the example above comes after the H.

This means there are **two H's** (hydrogen atoms) in **each** molecule.

The coefficient **3** shows that there are **three** of the H_2O molecules.

Step 1: **Write** the chemical formula

H_2O

Step 2: **List** all the atoms

H:

O:

Step 3: **Count** the number of atoms of each element in **1** molecule.

H: 2

O: 1

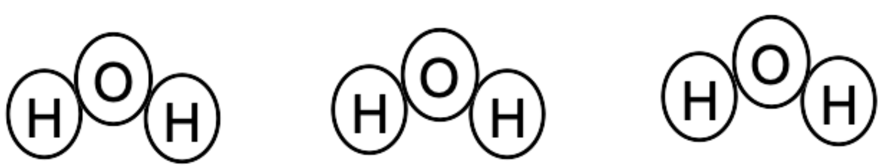
Step 4: **Multiply** the number of atoms of each by the **coefficient**.

H: 2 x 3 = 6

O: 1 x 3 = 3

Step 5: **Check for reasonableness**

I can use a picture to draw **3** H_2O molecules.



Practice Counting Atoms

Step 1: **Write** the chemical formula
Step 2: **List** all the atoms
Step 3: **Count** the number of atoms of each element in **1** molecule.
Step 4: **Multiply** the number of atoms of each by the **coefficient**.
Step 5: **Check for reasonableness**

6 C_2H_5OH (Ethanol)

4 $C_6H_{12}O_6$ (Glucose - Sugar)

5 $Ca(OH)_2$ (Calcium Hydroxide)

Task 3 Learning Target: I can create models using marshmallows to describe how the particles in an element, molecule, compound, and mixture compare.

1. In this activity, the different colored marshmallows represent atoms and toothpicks represent bonds between atoms. Each element will be color coded and should be represented correctly in each section: Oxygen = blue; Carbon = red; Chlorine = purple; Hydrogen = yellow; Sodium = green

2. Divide your paper into four sections as shown:

Elements	Molecules
Compounds	Mixtures

3. In the Elements section of the paper, draw one oxygen, carbon, chlorine, hydrogen, and sodium atom (marshmallow). Under each marshmallow, label it with its element name.

4. Using marshmallows and toothpicks, create the following items:

**Be sure to reference the notes pages so that you use the correct number and type of atoms and represent the correct number and shape of bonds.

a. Hydrogen diatom (H_2): occurs when one hydrogen atom bonds to another hydrogen atom
b. Oxygen diatom (O_2): is unique because it is formed with a double bond.
c. Water (H_2O)
d. Carbon dioxide (CO_2)
e. Methane (CH_4)
f. Saltwater

5. Draw and label each model in the appropriate section of the 4-section chart. Briefly describe your reasoning for placing the item in the section of the chart. If an item belongs in more than 1 section, redraw the item in the other section(s).

6. Respond to the following prompts:
   a. Which section of the chart did not have any toothpicks? Why?
   b. If you were looking at the particles of a molecule, what is one thing you could you see that you would not see in a compound?
   c. In the mixture section, should the water and the salt be connected with a toothpick? Explain.

Check Your Work:

a. Hydrogen diatom (H_2): occurs when one hydrogen atom bonds to another hydrogen atom. A yellow marshmallow connects to another yellow marshmallow with a small toothpick.

b. Oxygen diatom (O_2): is unique because it is formed with a double bond. A blue marshmallow connects to another blue marshmallow with two small toothpicks to show a double bond.

c. Water (H_2O): is formed when one oxygen atom bonds with 2 hydrogen atoms. As you read in the notes page, a water molecule is in the shape of a triangle with the oxygen in between the hydrogen molecules. A triangle shape is made with 2 yellow marshmallows placed on two sides of a blue marshmallow using one small toothpick on each side. There should not be a toothpick that connects the two yellow marshmallows.

d. Carbon dioxide (CO_2): is formed when a carbon atom is double bonded to two oxygen atoms. There is 1 blue marshmallow on 2 opposite sides of a red marshmallow. This molecule should have marshmallows all in a straight line using 2 toothpicks for each bond.

e. Methane (CH_4): is formed when one carbon atom bonds to four hydrogen atoms. The key is that the carbon is connected to each of the hydrogen atoms. Four small toothpicks are stuck into a red marshmallow (one on each side). It should look like an x or a + sign. A yellow marshmallow is stuck to the end of all of the toothpicks.

f. Saltwater: occurs when salt dissolves in water. These molecules mix, but to not bond together. To make a salt molecule (NaCl) a green marshmallow is connected with a small toothpick to a purple marshmallow. The salt molecule and the water molecule are placed next to each other but are not connected.

<u>Remember</u>:
If my item is made of only 1 kind of atom, it is an **element**.
If my item is made of more than 1 atom bonded together, it is a **molecule**.
If my item is made of more than one *different* element bonded together, it is a **compound**.
***All compounds are also molecules! (But not all molecules are compounds.)
If my item is made of multiple molecules that are mixed together but not bonded together, it is a **mixture**.

Task 4 Learning Target: I can use text evidence to describe how an "oxygen tank" might compare to an "air" tank.

This boy is diving underwater with an air tank for breathing.

This Is Not an Oxygen Tank

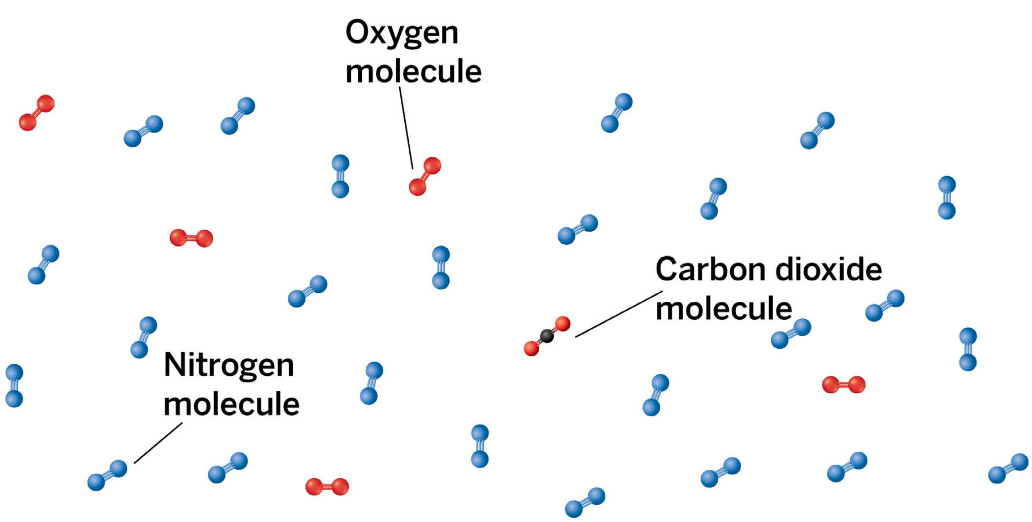
To breathe underwater, divers like this one use oxygen tanks—right? Actually, this is NOT an oxygen tank. Most diving tanks contain compressed air, and air is not the same thing as oxygen. Oxygen is one of the gases that make up the mixture we call air, but there are many other gases in air as well, including nitrogen and carbon dioxide. In fact, air isn't even mostly made up of oxygen—there's much more nitrogen in air than oxygen. Oxygen is a substance, while air is a mixture of different substances.

Every substance is made up of just one type of atom or a specific group of atoms that repeats over and over, such as a molecule. As a substance, oxygen gas is made up of oxygen molecules—two oxygen atoms stuck together—and nothing else.

Most matter in the world is made of many different substances mixed together. Milk, soil, steel, and air are examples of mixtures. A mixture contains different kinds of atoms or molecules. It's easy to see that some mixtures (like a piece of granite rock) have different substances in them. For other mixtures, it's not so easy to tell they are mixtures just by looking at them. Apple juice is a mixture, even though it looks completely uniform. You can't see that it's made up of different substances, but apple juice is a mixture of water, sugar, malic acid, and many other substances. The molecules of these substances mix together so completely that they look like a clear orange liquid.

Why should you care whether your diving tank contains oxygen or a mixture of gases? It makes a big difference. By itself, oxygen can be a dangerous substance. Oxygen gas catches fire easily, so it's difficult to handle, and oxygen can be unhealthy to breathe underwater without other gases mixed in. Divers learn which gas mixtures to use for diving. For some dives, they might use the already-existing mixture of gases found in air. For other dives, people make special blends of oxygen, nitrogen, and helium. Safe diving is all about finding the right mixture!

It may not look like one, but apple juice is a mixture.



Mixtures are made of many different kinds of atoms and molecules. Air is made of many different kinds of molecules, including nitrogen, carbon dioxide, and oxygen.

<u>Reflection Question</u>:

How does an "oxygen tank" compare to an "air" tank?

Task 5 Learning Target: I can plan an investigation to demonstrate that mixtures are combinations of substances that can be separated by physical means.

Task: Develop and carry out a procedure for separating a mixture of sand, sugar, iron filings, and wax.

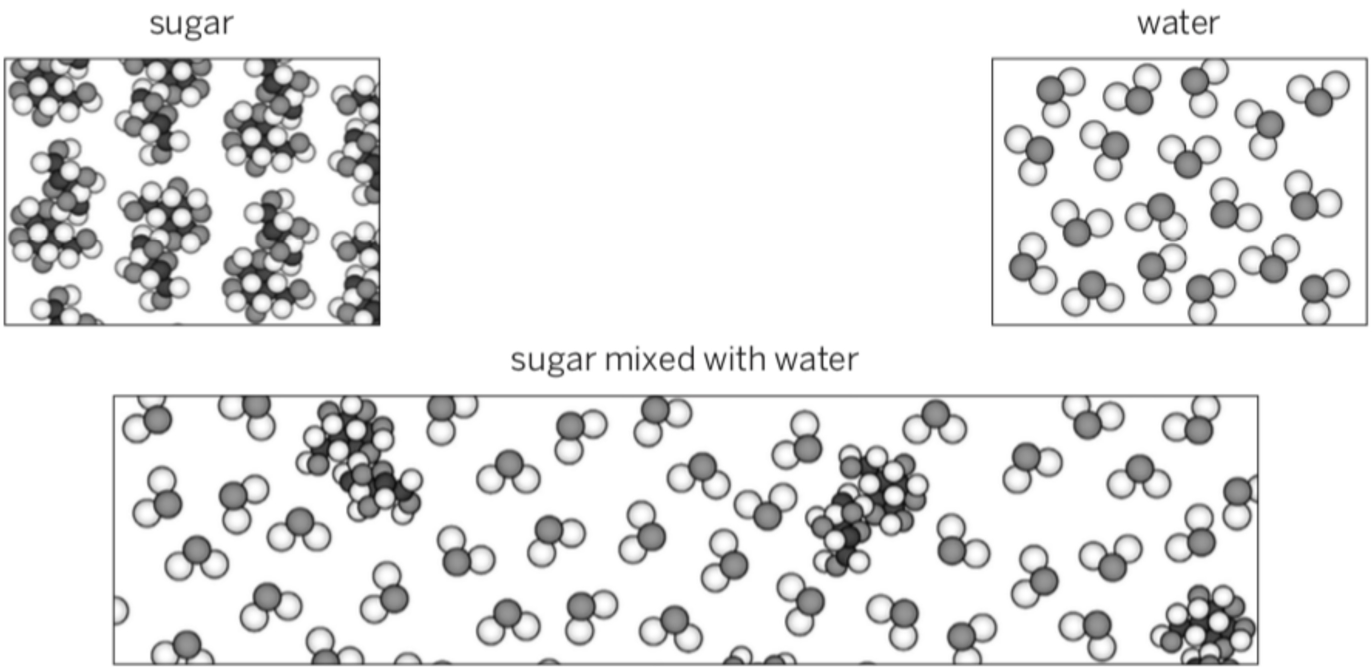
1. Describe properties of each separate substance.
2. After the substances are mixed, has a chemical reaction occurred? Explain.
3. With your group, design a method for separating the substances in the bag. The bag contains sugar, iron, wax, and sand. Describe each step of your method and list what substances are separated by each step.

Description of step:	**Substance(s) separated:**	**Why did the substance separate?**

a. Which mixtures were heterogenous?

b. Which mixtures were homogenous?

c. When sugar and water are combined, does a chemical reaction occur or does it just form a mixture of sugar and water? Use evidence from the atomic scale diagrams.



d. What might happen to the drops of the sugar mixed with water after being left alone in a cup for 2 days?