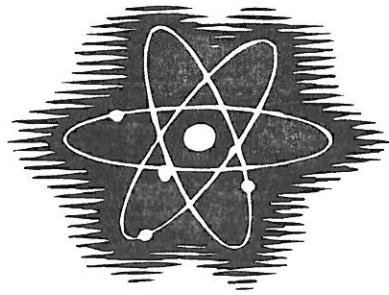
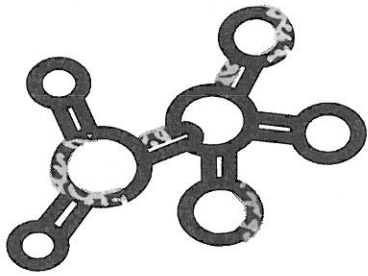


# States of Matter Unit



Name: \_\_\_\_\_

Period: \_\_\_\_\_

Team: \_\_\_\_\_



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# States of Matter Unit Readings

From Glencoe Physical Science and The Story of Science: Newton at the Center

Textbook	Pages	Read by	Topic
Glencoe	214-218		States of Matter
Glencoe	219-220		Thermal Expansion
Glencoe	224-227		Changes in State (includes graph)
Glencoe	228-231		Gases and Gas Laws
Glencoe	246-250		Elements, Compounds and Mixtures
Story of Science	198-207		Early ideas of matter and alchemy
Story of Science	210-215		Boyle, gases, and Boyle's law
Story of Science	216-219		Fundamentals of air and pressure
Story of Science	220-229		Bernoulli and Fluids (Principle – 226)
Story of Science	238-240		Black – Composition and properties of air and gases
Story of Science	241-245		Cavendish, Scheele, Priestly – discoveries of gases
Story of Science	260-274		Lavoisier – Elements and Compounds: the birth of chemistry (Law of Conservation of Mass)
Story of Science	278-287		Dalton – Atoms – Law of Definite Proportions
Story of Science	288-293		Avogadro – Molecules and Moles
Story of Science	312-321		Fundamental ideas of heat (Benjamin Thompson (313-4 and 318-321 most relevant))
Story of Science	370-379		Heat and Atoms (Boltzmann)
Story of Science	380-383		Good summary of ideas on the atom

See Also: Matter and Molecules readings in student textbook



Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

*States of Matter Anticipation Guide*

Directions: Read each statement carefully and decide whether or not you agree or disagree with the statement. Once you've decided, circle either the "A" if you agree or the "D" if you disagree. Next, explain why you chose to agree or disagree with the statement in the area labeled "Explanation" provided below each statement.

Statement	Agree	Disagree
1. All matter is made up of small particles which are too small to be seen with the naked eye (your eye alone) or with a light microscope	A	D
Explanation:		
2. The air is made up of particles which cannot move from place to place but remain stationary (in the same place)	A	D
Explanation:		
3. There are tiny particles which can connect to one another to form structures or shapes (such as a cube)	A	D
Explanation:		
4. All matter is made up from the same "stuff" or type of particle	A	D
Explanation:		
5. Gases are composed of small non-moving particles	A	D
Explanation:		
6. There is a <u>specific</u> temperature at which water ice will melt	A	D
Explanation:		
7. When ice melts and becomes liquid water it loses mass	A	D
Explanation:		

9. If you heat water until it boils and boil it for 10 minutes, the temperature of the water will increase the whole time	<b>A</b>	<b>D</b>
Explanation:		
10. Every substance will melt, freeze, or boil at the same temperature	<b>A</b>	<b>D</b>
Explanation:		
11. In order to boil water it must be heated	<b>A</b>	<b>D</b>
Explanation:		
12. Gases have a definite volume (amount of space) that they will take up or fill	<b>A</b>	<b>D</b>
Explanation:		
13. . Liquids have no fixed volume (amount of space they take up)	<b>A</b>	<b>D</b>
Explanation:		
14 When water changes from ice to liquid or liquid to water vapor it absorbs heat	<b>A</b>	<b>D</b>
Explanation:		
16. When an object is heated it will expand (become larger)	<b>A</b>	<b>D</b>
Explanation:		
17.	<b>A</b>	<b>D</b>
Explanation:		



# LESSON CLUSTER 1

## States of Water

### Lesson 1.1: Solid Water and Liquid Water

You certainly know about liquid water. That's what you drink and take showers in. But have you seen any solid water around recently? Of course you have, only you probably called it ice.

How do you know that ice is really solid water? Can you show it? You probably can, but there isn't much time, so you'll have to hurry!

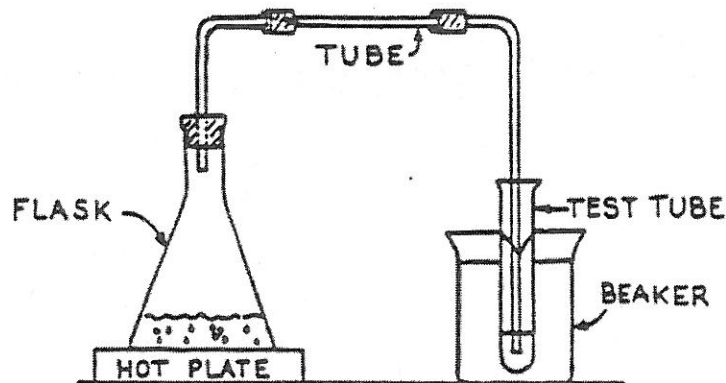
Ice and liquid water look and feel different, but they are still the same substance: ice can change to water and water can change to ice. Scientists call these different forms of water STATES. The solid state of water is ice. The liquid state of water is water. Water also exists in a third state a gas called water vapor. We will discuss water vapor in the next lesson. Since solid water (ice), liquid water, and gaseous water (water vapor) can be changed into each other by heating or cooling, that is a good reason to believe that they must be different states of the same substance.

## Lesson 1.2: Solid, Liquid, and Gas

In the last lesson you learned about solid water and liquid water. In this lesson you will learn about the other state of water, the gas called water vapor. Have you ever seen water vapor? The answer is no. You have never seen water vapor, even though it is all around us and you have felt its effects. In order to learn more about water vapor, watch your teacher do Demonstration 1.2.

As you can see from the demonstration, water vapor is an invisible gas. Liquid water changes to water vapor when it evaporates or boils. The gas inside the bubbles of boiling water is water vapor. Water vapor can change back into liquid water when it cools down.

Water vapor is always invisible. You might think that the “steam” you see rising from boiling water is water vapor, but it is not. The “steam” you see is really tiny drops of liquid water that form when the water vapor cools.



*Water changes from liquid to gas in the flask, then back to liquid in the test tube.*

Because we cannot see it, we are not always aware of the water vapor around us, but it is always there. There is always water vapor in the air around us, and on humid days, the amount is especially high. Dew, and fog, and rain are all made of drops that formed when water vapor in the air changed back into liquid water.

Ice, liquid water, and water vapor are three different states of the same substance. They are water in its solid, liquid, and gas states. They are the same because they are all made of the same "stuff". In the next lesson, you will learn more about the makeup of the three states of water.

### Lesson 1.3: Molecules, the Smallest Pieces of Water

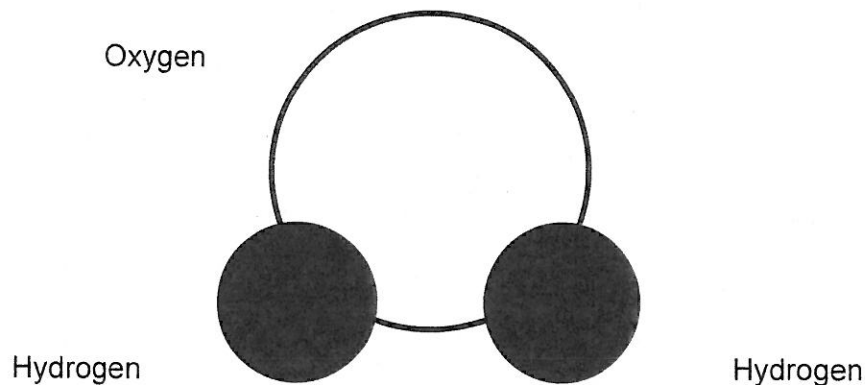
In Lesson 1.1 and 1.2 we decided that liquid water, ice and water vapor are all the same substance. What reasons did we give for that? They are all the same substance since they can change from one state to another by simply heating or cooling. Scientists have another reason for saying that they are the same substance. They are all made of the same tiny pieces or molecules.

What do we mean by that? Well, let's try to answer by thinking of the following question: If you had a pair of magic eyeglasses that showed the tiniest parts of water, what would the water look like?

This question may seem strange to you. After all, water doesn't look like it is made of anything except little drops of water. You know that water can be in little droplets, so maybe you said that water is made of little water droplets. Well, what is a water droplet made of?

We cannot tell what water is made of just by looking at it. But scientists say that water is made of water molecules. That is, if you divide a water droplet into smaller pieces until you can not divide it any more, then we have the tiniest pieces of water. We call these tiniest pieces, water molecules.

Some of you might have heard that water is called  $H_2O$ . We call water  $H_2O$  because one water molecule is made of even tinier parts, called atoms. A single water molecule contains two hydrogen (H) atoms and one oxygen (O) atom. The oxygen atom is larger, and the hydrogen atoms are stuck to it in kind of a V-shape. All water molecules are the same. Each water molecule is  $H_2O$ .



*A molecule of water ( $H_2O$ )*

Every drop of liquid water--and every sliver of ice--is made of trillions of water molecules, and every water molecule contains three atoms (two hydrogen atoms and one oxygen atom).

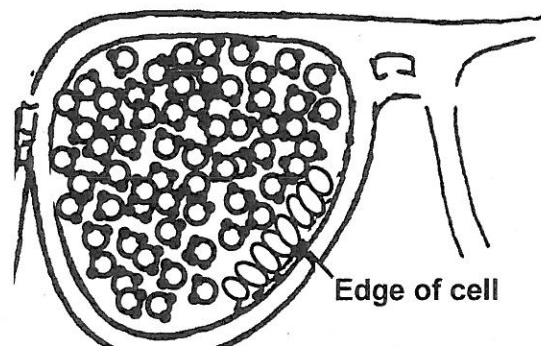
Since we already said that water molecules are the tiniest pieces that make up water, you know that they are very small. But how small are they?

Let's compare them with some other small things. There are some small things that you can barely see, like specks of dust. Water molecules are much, much smaller than that.

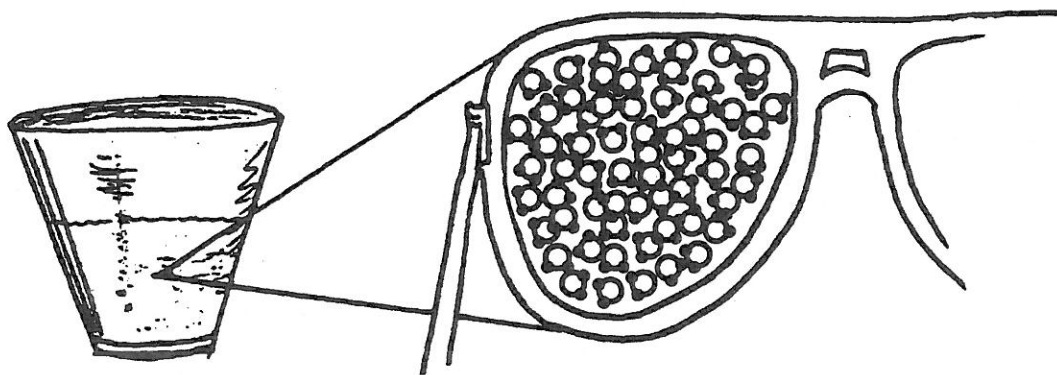
There are other small things that we can see only with a microscope, like germs or the cells our body is made of. Are water molecules smaller than cells or germs?

Yes, much smaller! In fact, a typical cell in your body might be made of 100 trillion (100,000,000,000,000) molecules. (More than half of these are water molecules, but a cell contains many other kinds of molecules, too.)

Suppose our magic eyeglasses could show us a single cell floating in a drop of water. What would it look like? Something like the picture below. (The picture can't show the whole cell because a cell is so much bigger than the water molecules.)



The molecules of liquid water are always moving. They are constantly sliding past and bumping into each other. They never stop. They are moving in all different directions. This movement goes on all the time, even when the water is just sitting in the cup.



The two important points we have talked about in this lesson are: liquid water is made of very tiny, tiny pieces called water molecules, and water molecules are always moving. In Lessons 1 and 2, we said that ice (solid water), liquid water, and water vapor (gaseous water) are the same substance.

Then in this lesson, you learned how all three states of water are the same. They are made of water molecules which are constantly moving. Now, can you guess what is different about the molecules in the three states of water? In Lesson 1.4, you will learn about how ice, liquid water, and water vapor are different. You will also learn how ice, liquid water, and water vapor are alike.





Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

## History of the Atom

The analogy: Cutting the \_\_\_\_\_

If you continue to cut a “brick” of cheese into smaller and smaller pieces, you will end up with a piece so small that it can't be cut any further (and still be called cheese).

### Aristotle

- Greek \_\_\_\_\_
- Believed in 4 basic \_\_\_\_\_ – the 4 “elements”
- Earth, Wind, \_\_\_\_\_, and Water

### Dalton

- Self taught \_\_\_\_\_ and became a chemistry teacher at age \_\_\_\_
- Developed the Law of Definite \_\_\_\_\_ (compare to our hydrolysis)
- Atoms were dense, hard spheres (like billiard balls or \_\_\_\_\_) that could not be broken down any further.

### Thomson

- Developed the \_\_\_\_\_ Ray tube (see lightning ball)
- He saw a \_\_\_\_\_ going from – to +
- He hypothesized the existence of small negatively charged particles that were part of atoms
- (\_\_\_\_\_ model)

### Rutherford

- Gold \_\_\_\_\_ experiments
- He shot tiny particles at gold foil and had many come right back at him and to the side
- (\_\_\_\_\_ model (dense core))

### Bohr

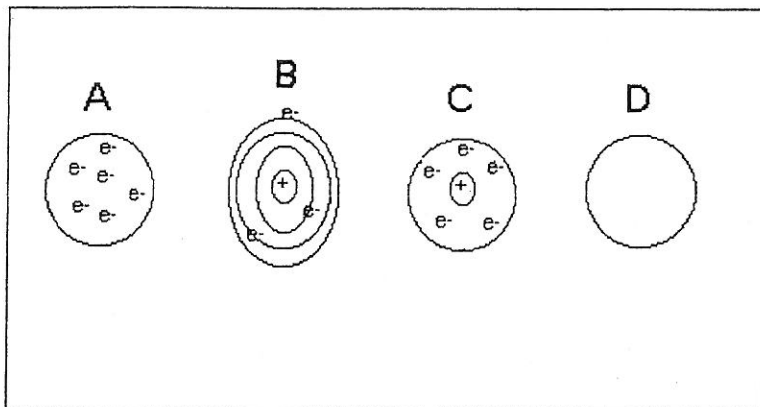
- Developed a model of the atom that stated \_\_\_\_\_ were in distinct orbits (or shells) around the nucleus.
- (\_\_\_\_\_ system model)

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

Models of the atom

Sheet # \_\_\_\_\_

Observe the following 4 drawings that represent models of the atom. Write the name of the person credited with the model to that picture.



A \_\_\_\_\_

B \_\_\_\_\_

C \_\_\_\_\_

D \_\_\_\_\_

Match the following people and the key idea related to atoms.

1. Gold Foil

2. Watermelon model

3. Law of Definite proportions

4. Four basic substances

5. Self-taught chemistry

6. Peach model

7. Solar System Model

8. Earth, Wind, Fire, and Water

A. Thomson

B. Aristotle

C. Bohr

D. Dalton

E. Rutherford

Put the letter of the names in order from oldest to most recent

\_\_\_\_\_

## LESSON CLUSTER 2

### Other Solids, Liquids, and Gases

#### Lesson 2.1: Are Other Substances Made Of Molecules?

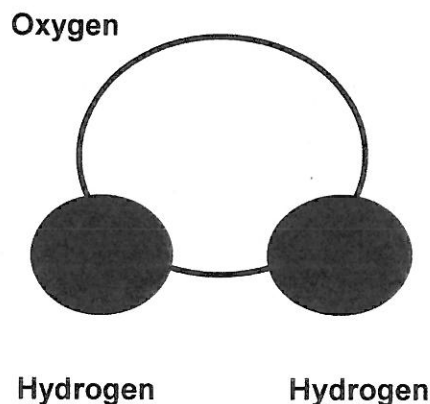
In Lesson Cluster 1 you studied ice, water, and water vapor. All three states of water are made of the same kind of molecules-- $H_2O$ . Each state has molecules arranged differently, but the molecules are the same. Water molecules are the building blocks for ice, water and water vapor.

If you look around, most of the substances you see are solids, liquids, or gases. Most substances can also change from one state to another. For example, lead is usually a solid, but if you heat it hot enough, it becomes a liquid. If you heat liquid lead very hot it becomes a gas. You can change the solid form of a substance into a liquid, or a liquid into a gas. It is possible to do this because all the states of a substance are made of the same kind of molecules.

You could never change ice into glass, though, or water into alcohol, or water vapor into oxygen gas. Even though these substances look similar and are in the same state, one cannot be changed into another? Do you know why?

The answer is that their molecules are different. Each substance is different from every other substance because each is made of its own kind of molecules. In the same way, we can classify all substances as either solid liquid, or gas, but that doesn't mean that all liquids are exactly alike. Each substance is made of its own kind of molecules, with a certain size, shape, and weight.

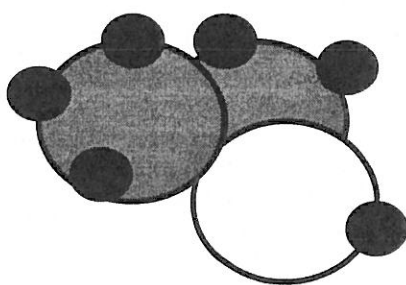
Let's look at some examples of different kinds of substances and their molecules. You have already studied one substance, water, and you have seen drawings of what a water molecule looks like. You learned that a water molecule can be drawn like the picture below.



*A molecule of water ( $H_2O$ )*

If we were able to see the molecules in a drop of pure water, (that is, water that is not dirty, or polluted) we would notice that all of the molecules of water would look exactly the same. They would all have the same structure.

If we could see the molecules of another substance, for example, alcohol, would these molecules look the same as the water molecules we just studied? No, the alcohol molecules are different from the water molecules. That's because each substance has its own kind of molecule, with a certain size, shape, and weight. The molecule of alcohol would look like this:

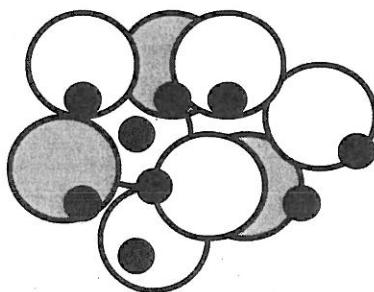


*A molecule of ALCOHOL:  $CH_3 CH_2 OH$*

As you can see, an alcohol molecule looks very different from the molecules of water because it is made of different atoms. If we could use our magic eyeglasses to see the molecules in a drop of alcohol, we would see that all of the alcohol molecules have exactly the same shape, size, and weight.

The world is made of millions of different substances, and every substance is made of its own kinds of molecules! Some molecules, like water molecules, contain only a few atoms. Other molecules have hundreds or thousands of atoms. Even the largest molecules, though, are far too small to see.

Sugar is another substance you probably know. A sugar molecule is made of many atoms. (The formula is  $C_{12}H_{22}O_{11}$ ). This is too complex to draw here. So in this unit, we will make-up a shape for a sugar molecule like this:



*A molecule of SUGAR:  $C_{12}H_{22}O_{11}$*

All substances are made of molecules, but that doesn't mean that everything is made of molecules. Some things are not substances at all. Light, heat, and sound are not substances; they are forms of energy. Thoughts, love, and space are not substances either. Things that are not substances cannot be solids, liquids, or gases, and they are not made of molecules. There are no light molecules, or heat molecules, or sound molecules. There are no temperature molecules, or space molecules, or love molecules. Only matter exists as solids, liquids, and gases. Only matter is made of molecules.



## Lesson 2.2: Pure Substances and Mixtures

You learned in the last lesson that different substances are made of different kinds of molecules. Molecules of each substance have their own size, shape, and weight, and they are different from the molecules of all other substances. We can use this idea to help us study the difference between a pure substance and a mixture. We can tell a pure substance from a mixture by thinking about molecules.

A pure substance has only one kind of molecule. Pure substances can be solids, liquids, or gases. Pure sugar is an example of a pure substance. It is made only of sugar molecules. Lead, water, and alcohol are also pure substances. They each have only one kind of molecule.

A mixture has two or more different kinds of molecules mixed together. Mixtures can also be solids, liquids, or gases. The Kool-Aid that you drink is an example of a mixture: It contains water molecules and other molecules mixed together. Sometimes you can tell that something is a mixture by looking at it, but not always! Try making some mixtures and see!

It is easy to tell that some things are mixtures because you can see the separate particles: salt and pepper, for example. Sometimes, though, the substances when mixed together break up into individual molecules: sugar and water, for example. You can no longer see the different substances, but their molecules are still there, just all mixed together!

Most of the materials around us are mixtures, made of two or more different kinds of molecules. Very few substances are pure substances. Even substances that look pure may actually be mixtures.

For example, you might think that glass is a pure substance because it is clear, and you can see through it. But glass is actually a mixture of many different kinds of molecules. Milk is a mixture, and ocean water, too. Your body is a mixture containing thousands of different kinds of molecules.

What about air and water? Are they pure substances or mixtures? Water is a pure substance, made of only water molecules. Air, on the other hand, is a mixture, made of many different kinds of molecules mixed together. You will study more about air in Lesson Cluster 3, but for now the important point to remember is that it is very hard to tell whether a substance is a pure substance or a mixture just by looking at it, tasting it, or smelling it.

All pure substances are solids, liquids, or gases. But some mixtures such as muddy water are not easily classified as a solid, a liquid, or a gas. This is because mud contains solid particles of dirt mixed with liquid water. So mud is partly solid and partly liquid. Mud and many other mixtures contain two different states of matter.



### Lesson 2.3: Molecules and States of Matter

In Lesson Cluster 1 you studied the three states of a single substance-- water. In this lesson cluster you have studied several other substances: sugar, alcohol, oxygen, and so forth. Try using what you know about these substances to think about these questions:

How are all substances alike?

How are substances different from each other?

You might want to think about these questions for a minute before you read on.

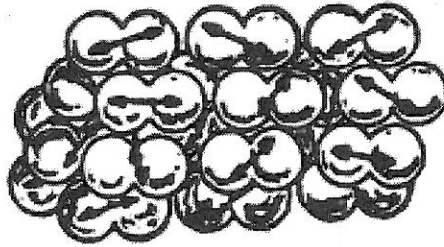
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There are many possible answers to the above questions. Substances are alike and different in many ways. Here are three correct answers that are very important:

1. All substances are alike in that they are all made of molecules.
2. Substances are alike in that they are found in three basic states: Solid, liquid, and gas.
3. Different substances are made of different molecules. (Pure substances like water and sugar are made of only one kind of molecule. Mixtures like air and wood contain different kinds of molecules mixed together.)

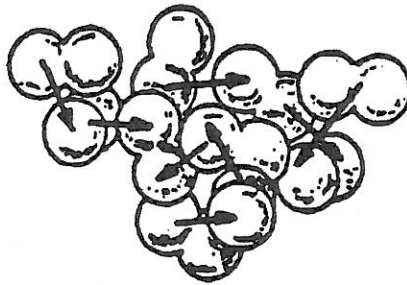
In this lesson you will be thinking about the molecules of solids, liquids, and gases. In what way are the molecules of all solids alike? In what ways are the molecules of different solids different? What about liquids and gases? You can think about these questions by discussing some substances that you are already familiar with.

Let's start with solids. Solids of different substances, like salt, steel, and sugar, are made of different kinds of molecules, but all solids are alike in the arrangement and motion of their molecules. All solids are made of molecules that are close together and locked into a rigid pattern. They move by vibrating in place and bumping into each other.



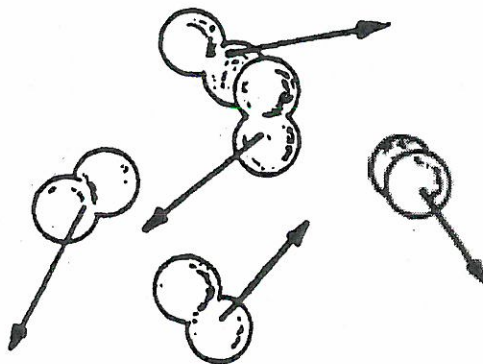
*The molecules of all solids are locked in a rigid pattern and vibrate in place*

Similarly, different liquids such as water, alcohol, and gasoline are made of different kinds of molecules, but all liquids are alike in the motion and arrangement of their molecules. All liquids are made of molecules that move around freely but stay close together. The molecules of liquids slide past each other and are constantly bumping into other molecules.



*The molecules of all liquids slide and bump past each other*

Different gases such as water vapor, oxygen, and carbon dioxide are made of different kinds of molecules, but all gases are also alike in the motion and arrangement of their molecules. All gases are made of molecules that are far apart from each other and moving freely through space. Sometimes gas molecules collide with other molecules or with objects.



*The molecules of all gases are far apart and bounce around freely*

Now you have learned a lot about solids, liquids, and gases of different substances. You have learned that all solids, liquids, and gases are made of molecules. Different substances are made of different kinds of molecules, but the motion and arrangement of molecules is about the same in all solids. All liquids also have molecules that move and are arranged in similar ways. So do all gases.

You also know that some substances are pure substances; all their molecules are the same. Most substances, though, are mixtures, of different kinds of molecules. In the next lesson cluster you will study a gas that is a mixture of several different kinds of molecules. We can't see this gas, but it is very important to us. The gas is air.



## LESSON CLUSTER 5

### Explaining Dissolving

#### Lesson 5.1: How Did the Sugar Get Out?

A long time ago, in Lesson Cluster 2, you studied pure substances and mixtures. Do you remember the difference? Pure substances, like pure water and pure oxygen, are made of only one kind of molecule. Mixtures, like salt water and air, contain several different kinds of molecules.

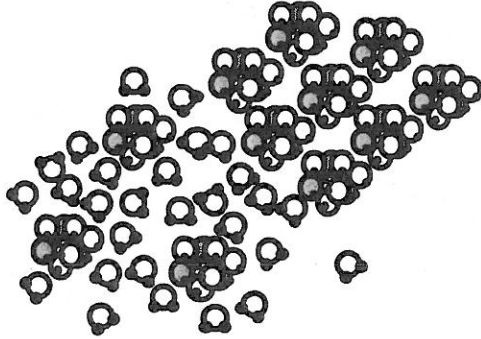
This is a lesson cluster about mixtures. One kind of mixture is formed by dissolving a solid in a liquid. When a solid dissolves in a liquid, the molecules of the liquid hit the solid, breaking apart the solid into invisibly small molecules. These molecules spread evenly throughout the liquid.

In this lesson cluster you will dissolve several solids in water, you will find out how to make solids dissolve faster or slower, and you will learn to explain what happens to the molecules of both the liquid and solid in dissolving. The first step, though, is to watch something dissolve and describe what you see. So let's get started!

Did you say that you could see wavy lines under the tea bag and taste the sugar in the water? That is true. We cannot see the tiny molecules of sugar or the tiny molecules of water; but we can taste the sugar in the water. The sugar did not disappear, but the sugar grains broke into separate, tiny molecules, so that we could no longer see the sugar. Just because we cannot see the sugar does not mean it is not there. The water tastes sweet, so it must still be there.

How did the sugar get out the tea bag? You can answer this question if you think about the size of sugar molecules. The holes in the tea bag are much smaller than a grain of sugar, but much larger than a molecule of sugar or water. As the water molecules enter the tea bag and hit the solid sugar, the molecules of sugar break away rapidly and mix with the water molecules. The tiny molecules of sugar and water easily pass through the holes in the tea bag. The

wavy lines under the tea bag were caused by trillions of sugar molecules streaming from the solid sugar and mixing with the water molecules. As the sugar mixes more completely and spreads throughout the water, the wavy lines disappear.



*Sugar molecules break out of their rigid pattern and mix with water molecules*

Now let's try to organize these ideas into an explanation.

- Question: How did the sugar get out of the tea bag?
- Substance: The water went into the tea bag and dissolved the sugar. Sugar-water came out of the tea bag and mixed with the rest of the water. (The wavy lines were made by the sugar-water coming out of the tea bag.)
- Molecules: The water molecules went through the holes in the tea bag, hit the grains of sugar, and broke off sugar molecules. The mixture of sugar molecules and water molecules went back out through the holes in the tea bag.

## Lesson 5.2: Dissolving Fast and Slow

In the first lesson, you dissolved sugar in water. The sweet mixture of water molecules and sugar molecules is called a solution. Many different substances dissolve in water (or other liquids), so you can make many different solutions. Can you make substances dissolve faster or slower? How?

My friend found a way of making the salt dissolve faster. She stirred one cup. The salt dissolved much faster in the cup that she stirred than in the other one.

Let's try explaining why her method worked, using our guide for explanations.

- Question: Why did stirring cause the salt to dissolve faster?
- Substances: She stirred the mixture and water rushed around the grains of salt.
- Molecules: Stirring caused more molecules of water to hit the salt grains, so the molecules of salt were broken off from the grains faster.





### Lesson 5.3: Complex Solutions

You can make a solution by dissolving both salt and sugar in water. We call solutions like that complex solutions: they contain more than one dissolved substance.

There are many complex solutions. For example, grape Kool-Aid drink has sugar, purple color, and grape flavoring all dissolved in water. Ocean water is another example. It contains not only salt, but many other substances dissolved in it. If you took ocean water, filtered out all the dirt, placed it in a pan, and let the water evaporate, you would get many salt crystals, but you would also get a variety of other kinds of crystals. Each kind of crystal indicates a different kind of substance.

You have also seen many other complex solutions, though you might not have known what they were. Honey is a complex solution. It consists mostly of water molecules and sugar molecules. That's why it is sweet. But the special flavor of honey comes from many other kinds of molecules that are mixed with the water and sugar. Syrup and ginger ale are also complex solutions. They both have water and sugar, plus other substances that give them their special flavors.

A grocery store is full of complex solutions. Sometimes the labels even tell you what substances have been mixed together to make them. You might try looking at the labels on bottles of mouthwash, or soda, or shampoo. They tell you what substances have been dissolved in water to make them.

Even our drinking water has a number of substances dissolved in it. If your city gets drinking water from a well, the water has come into contact with a variety of rocks containing various minerals. Most of these minerals dissolve in water to some extent. If your drinking water comes from a spring, a lake, or a river, the same is true. Most of the water that you see, therefore, has a number of solids dissolved in it. So the water we get from a faucet is not really pure; it is really a complex solution.

This lesson cluster is just about over. Let's end it with a summary of some of the most important ideas. See how much of this summary is like the one you wrote in your answer to the last question.

Lesson 1 was about dissolving sugar. You learned that when sugar dissolves it breaks up into individual molecules. You also learned how dissolving takes place. The water molecules break molecules of sugar off the grains. The water molecules and the sugar molecules intermingle until the sugar molecules are spread evenly through the water.

In Lesson 2 you learned that you can make things dissolve faster by stirring, and you learned that stirring speeds up dissolving because it makes more molecules of water hit the sugar grains and break off sugar molecules faster.

In Lesson 3 you learned that many of the liquids around you are solutions, usually complex solutions that have several different substances in them.

Can you think of a way to make a solid dissolve faster in water without stirring? Without even touching the cup? That is one thing you will learn about in Lesson Cluster 6.

Name \_\_\_\_\_

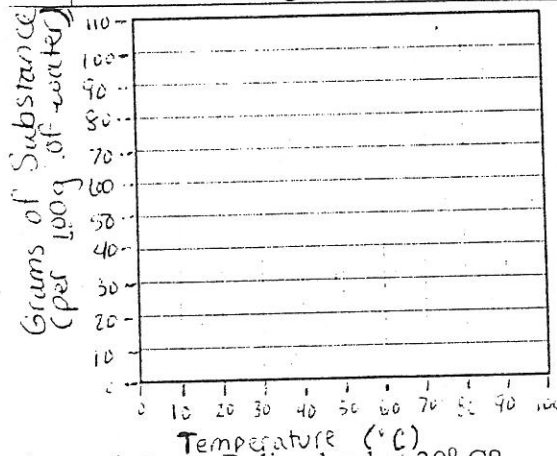
Date \_\_\_\_\_

### Solubility Wksh

Questions:

1. A solution is essentially a \_\_\_\_\_ mixture.
2. If you dissolve food coloring in water, what is the solute? \_\_\_\_\_ solvent? \_\_\_\_\_
3. What is the difference between a saturated solution and an unsaturated solution?
4. A solution that contains only a small amount of solute is called \_\_\_\_\_.
5. A solution that contains a large amount of solute is called \_\_\_\_\_.
6. Name four factors that affect solubility.
7. Use the data in the table and make a solubility graph. Plot the points for substance A first and connect the dots to make a line graph. Then plot the points for substance B and connect the points.

Temperature	Grams of Substance A dissolved	Grams of Substance B dissolved
20 °C	64 g	21 g
40 °C	75 g	30 g
60 °C	86 g	40 g
70 °C	90 g	46 g
90 °C	102 g	60 g



1. Is there more of substance A or substance B dissolved at 30° C? \_\_\_\_\_
2. How much more of substance A is dissolved at 80° C? \_\_\_\_\_
3. What happens to solubility as temperature increases?

**Chapter 8****REINFORCEMENT****● Matter and Temperature**

Answer the following questions in the blanks provided. Use complete sentences where appropriate.

1. What are the three common states of matter?

a. \_\_\_\_\_ b. \_\_\_\_\_ c. \_\_\_\_\_

What is the fourth state of matter? \_\_\_\_\_

2. Complete the following chart describing the shape and volume for the three common states of matter.

State of Matter	Volume	Shape

How does the fourth state of matter differ from the other three? \_\_\_\_\_

3. Use the kinetic theory of matter to explain the behavior of the three common states of matter.

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4. In general, when you heat a substance, it expands. This phenomenon is called thermal expansion. Use the kinetic theory to explain thermal expansion. Give an example of thermal expansion that you have observed. \_\_\_\_\_

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## LESSON CLUSTER 6

### Heating and Cooling, Expansion and Contraction

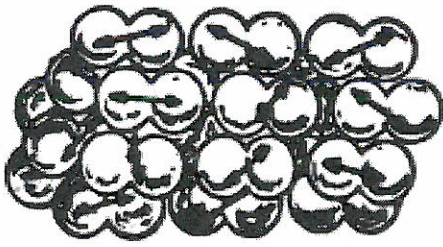
#### Lesson 6.1: Another Way to Make Something Dissolve Faster

In the last lesson you learned one way to make things dissolve faster: you can stir the water. There is another way to make something dissolve faster, though. This way involves no stirring and no moving the cup. Do you know what it is?

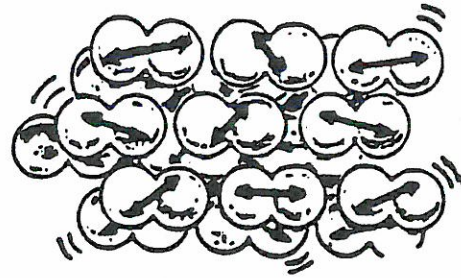
Did you know that when you say that something is “hot” or “cold,” you are actually saying something about the molecules of that substance? Words like “hot” and “cold” describe how fast or slow the molecules of a substance are moving. Hot substances have fast-moving molecules. Cold substances have slower-moving molecules.

Heating any substance makes the molecules of that substance move faster. In hot solids, the molecules vibrate faster in their places. In hot liquids, the molecules move faster as they slide and bump past each other. In hot gases, the molecules move faster through space.

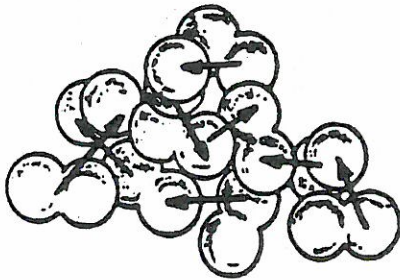
Cooling any substance makes the molecules of that substance move slower. In cold solids, the molecules vibrate more slowly in their places. In cold liquids, the molecules move more slowly as they slide and bump past each other. In cold gases, the molecules move more slowly through space. These differences between hot and cold substances are illustrated on the following page.



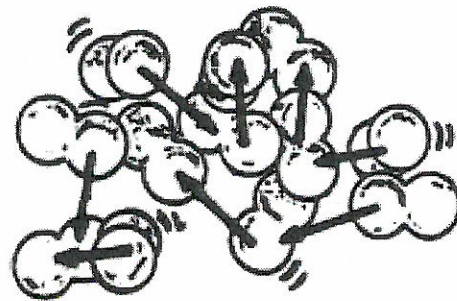
1. Cold solids: Molecules vibrate slowly in place.



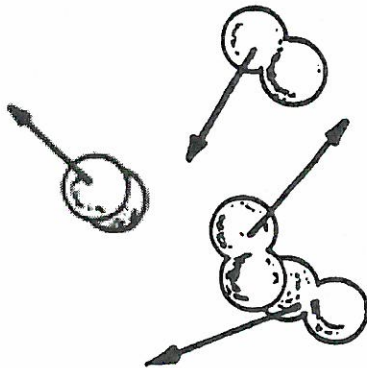
2. Hot solids: Molecules vibrate quickly in place.



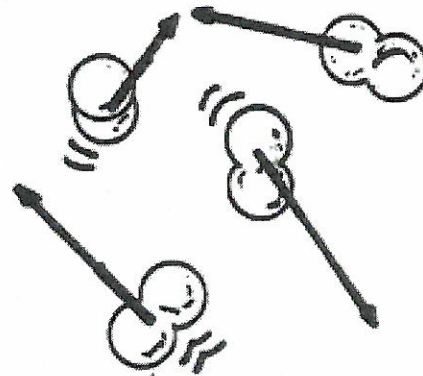
3. Cold liquids: Molecules slide and bump slowly past each other.



4. Hot liquids: Molecules move fast as they slide and bump past each other.



5. Cold gases: Molecules move slowly through space.



6. Hot gases: Molecules move fast through space.

Now let's try using these ideas to explain why the sugar dissolved faster in hot water. We will talk about the cold water, then the hot water. We will answer the question about substances and the question about molecules for each temperature of water.

In the cold water the sugar (substance) dissolved slowly because the water molecules were moving slowly as they knocked off molecules from the pieces of sugar .

In the hot water the sugar dissolved faster because the water molecules were moving faster and hit the sugar more often. That made them knock the molecules off the pieces of sugar more quickly.

Did the explanation about hot water answer both the question about substances and the question about molecules? Find the parts of the explanation that answer each question.

When molecules are moving faster they make substances dissolve faster. Fast-moving molecules cause other effects, too. You will learn about one of those other effects in the next three lessons.





## Lesson 6.2: Heating Solids

Heating a solid, such as a metal ball, makes the molecules vibrate faster. This fast vibration makes the ball feel hot when you touch it. The fast vibration of the molecules has another effect, too, one that is harder to see or feel. When the molecules vibrate faster they actually push each other a little farther apart.

So what happens when all the molecules of a solid push each other a little farther apart? The solid gets a little bigger, or expands. So heating solid objects makes the objects expand. This process is called thermal expansion (“thermal” means “with heat”).

Let’s try using these ideas to explain why a metal ball that barely fits through a ring won’t go through the ring after it is heated. In this explanation we will talk about molecules first, then substances. As long as an explanation answers both questions, though, it is still a good explanation.

Heating the ball made the molecules of the metal vibrate faster, so they pushed each other farther apart. This made the metal ball expand (substance), so it would no longer fit through the ring.

Metal balls are not the only things that expand when heated. All solids expand when they are heated (unless heating causes some of the molecules to break up or makes the solid lose molecules). Concrete, rocks, metal objects, glass, and other solids all expand when they are heated. They all expand for the same reason, too. Their molecules move faster and push each other farther apart.

When solids cool, the molecules slow down. This allows the molecules to move closer together, so the solids contract. Solids expand when they are heated. They also contract when they are cooled; this process is called thermal contraction.

It is hard to see solids expand and contract because the molecules move only slightly farther apart or closer together. We have to measure the solids very carefully to tell that their size has changed.



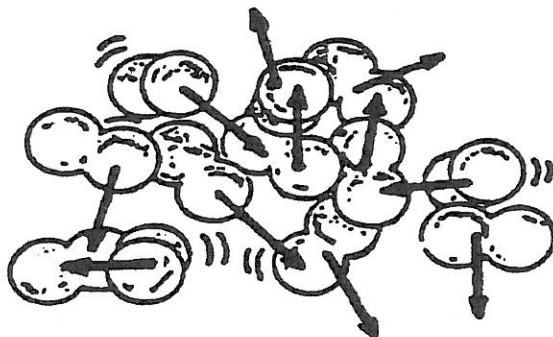
### Lesson 6.3: The Thermometer

In the last two lessons you have learned that the molecules of all substances move faster when the substances are heated, and that solids expand when they are heated and contract when they are cooled. What about liquids? Do you think that they expand and contract the way solids do?

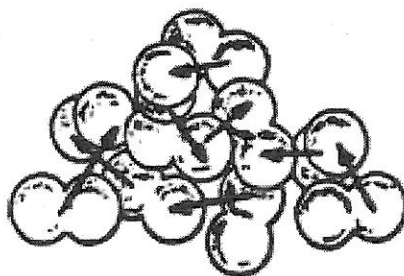
Could you explain why the column of the liquid in the thermometer rose and then fell? You know from Lesson 6.1 that the molecules of liquids move faster when the liquid is heated. That is one way that liquids and solids are alike.

Liquids and solids are also alike in another way. When the molecules move faster, they bump into each other harder and push each other farther apart. So just like solids, liquids expand when they are heated.

Liquids also contract when they are cooled. When the molecules of a liquid slow down, they move closer together. So liquids go through thermal expansion and thermal contraction just as solids do.



*Heating makes the molecules of a liquid move faster and push each other farther apart*

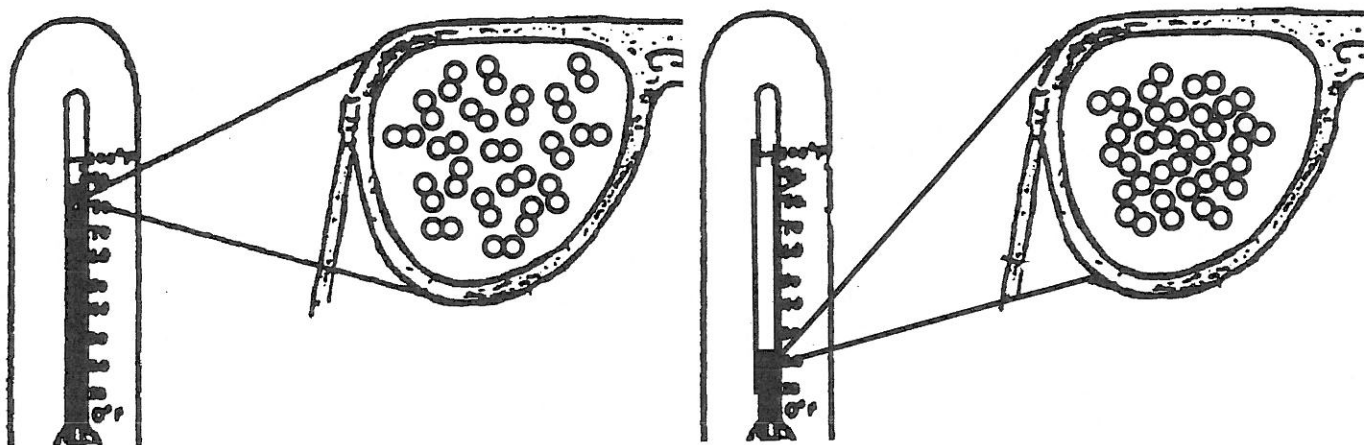


*Cooling slows down the molecules of a liquid  
and they move closer together*

Now we can explain how the thermometer works. Compare the explanations below to the ones you wrote in your Activity Book. Did you answer the questions about substances and the questions about molecules in the same way as the explanations below?

When you place the bulb of the thermometer in hot water, the molecules of the colored liquid move faster and push each other farther apart. This causes the colored liquid to get larger or expand. The colored liquid expands up through the thermometer tube which gives a higher temperature reading.

When you place the bulb of the thermometer in cold water, the molecules of the colored liquid move slower and come closer together. This causes the colored liquid to get smaller or contract. The contraction makes the column of colored liquid move down toward the bulb. This gives a lower temperature reading.



## Why Worry About Whipped Cream and Soda at Your Campfire?

Real whipped cream is made by whipping sugar and heavy cream, hence the name "whipped cream". If you have actually seen this done you will have observed that the cream started out as a liquid, not unlike milk or coffee creamer in consistency. As the mixture of cream (fat and milk proteins) is whipped with sugar it creates a foam. The foam consists of denatured proteins that trap air, fat and sugar in the cells formed by the protein matrix. The cream has greatly expanded in volume due to the air trapped in the protein matrix which acts to make it light and fluffy. Manufacturers can put whipped cream in a can for easy dispensing. As you read on, you'll see how pressure is important in this process.

The can's contents consist of a liquid phase (cream and sugar) and a compressed gas phase. Air, a gas, contains relatively few molecules. Under pressure these molecules can be squeezed together creating high pressure on the inside of the can. Releasing the pressure by opening the valve has the same effect as manual whipping of the cream. It forces the air and cream components to mix in the presence of rapidly expanding gas, trapping the gas in the protein matrix.

A slightly simpler example is in evidence nearly every day. The next time you open a bottle of Pepsi, give it a good shake first. When you start to unscrew the cap there will be a pressure release followed by this foam shooting out of the lid. The gas is carbon dioxide, used to give the "fizz" to the soda. It is under pressure inside the liquid phase of the pop. When you release the pressure by unscrewing the lid the gas and liquid come rushing out, the result being a short lived Pepsi foam, very light and full of trapped air.

Temperature also affects the can's contents and pressure. As the can warms up, the molecules increase in motion and press more on the container. If the pressure becomes great enough, which often happens when liquids in the can change to gases, the container may burst open. You may have experienced a similar situation at a campfire. Often people take moist rocks and place them around a campfire to keep the fire in one place. Moist rocks can be dangerous, however, as the moisture in the rocks may change to gas when the rocks are heated. This can cause the rocks to explode and pieces to fly out towards people.

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

Answer the following questions by highlighting the portion of the text where you got your answer and by writing the number of the question next to the area you highlighted. In some cases, several parts of the reading could help you answer one question. In that case, place the question number next to all the parts that apply.

1. The main idea of this article is that
  - A. rocks are dangerous.
  - B. liquid and gases interact depending on pressure.
  - C. liquids are often converted to gases.
  - D. whipping sugar and cream creates foam.
  
2. Which of the following is an opinion?
  - A. Molecules can be squeezed together by pressure.
  - B. Shaking a bottle of soda causes foam.
  - C. Real whipped cream is fluffier than whipped cream in a can.
  - D. Heat can cause rocks to explode.
  
3. An aerosol can should not be stored
  - A. near a stove.
  - B. in a refrigerator.
  - C. under the sink.
  - D. in a high cupboard.
  
4. Which of the following would you expect to have happen as air gets trapped in cream during the process of making whipped cream?
  - A. The **volume** of the cream will **increase**.
  - B. The **volume** of the cream will **decrease**.
  - C. The **mass** of the cream will **increase** greatly.
  - D. The **mass** of the cream will **decrease** greatly.
  
5. When gases are compressed in a closed container, they will
  - A. be under high pressure.
  - B. decrease in temperature.
  - C. be under low pressure.
  - D. increase in temperature.

#### Lesson 1.4: Molecules and the Three States of Water

You have learned how ice, liquid water, and water vapor are the same. They are all made of water molecules, and those water molecules are always moving. Then, how are ice, liquid water, and water vapor different? Why do they look different? Why do they act differently? How can we explain the differences in terms of molecules? You will learn about these topics in this lesson.

The differences among the three states of water are not in the molecules themselves. Water molecules are all the same. The differences are in the way the molecules are arranged and the way they move. Can you think of ways that water molecules might be arranged differently in the three states of water? If you can, discuss your ideas with your classmates.

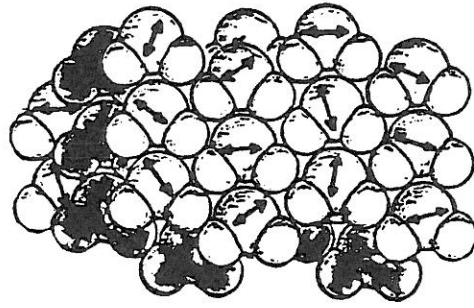
Here is how scientists explain the differences among the three states of water. In solid water (ice), water molecules are close together, locked in a rigid pattern, and thus they are not moving past each other. They vibrate, but they stay in place. Remember, molecules are constantly moving and never stop, even in a solid.

In liquid water, water molecules are moving faster. They are still close together, but they are no longer stuck in a rigid pattern as they are in ice. Water molecules in liquid water are constantly sliding past and bumping into each other; they keep moving from one place to another.

The molecules of water in water vapor are far apart and moving freely. They have lots of empty space between them. They move rapidly through this empty space, hitting and bouncing off each other.

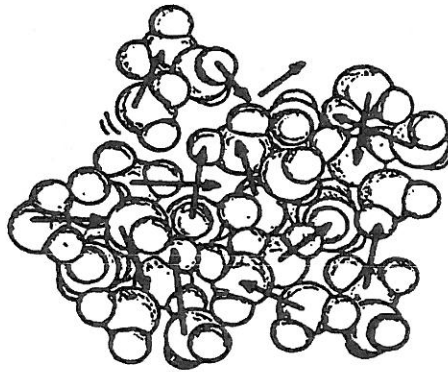
The pictures on the next page give a rough idea of how water molecules look in ice, liquid water, and water vapor. (Though you could never really see them--they're much too small!)

Ice:



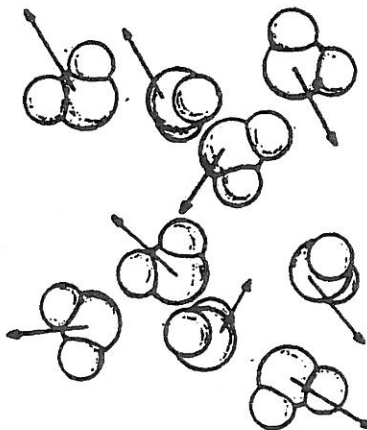
*Water molecules are locked in a rigid pattern, vibrate in their places*

Liquid water:



*Water molecules slide and bump past each other*

Water Vapor:



*Water molecules bounce around freely in space*



For the last four lessons you have been learning about a single important substance, water. You have learned that water exists in three states: ice, liquid water, and invisible water vapor. You have learned that the three states are the same in that they are all made of very tiny water molecules that are always moving.

Finally, you have learned how the arrangement and motion of water molecules are different in the three states. In ice the molecules are stuck rigidly together and vibrate in place. In liquid water they slide and bump past one another. In water vapor they are much farther apart and they bounce around freely.

Water is not the only substance in the world, though. We can see thousands of other substances all around us.



### Supplemental Reading: The Miracle of Water

Water is the most abundant liquid on earth and is needed by all living things. Rivers, oceans and lakes cover about three fourths of the surface of the earth. Besides this, there are large amounts of underground water. In many places, you can tap into this underground water by drilling wells. A water well is a hole in the ground from which you can pump water. Many people get their drinking water from these wells. Your body is about 71% water. Fruits and vegetables contain about 90-95% water.

Water, this very common liquid that you use every day, has many uncommon properties. Many of these uncommon properties are essential to life on earth. One of water's properties is that it dissolves more solids, liquids, and gases than any other liquid. This uncommon property of water allows your blood to carry oxygen and food to every cell of your body and to carry carbon dioxide and waste materials from each cell of your body. This property also allows you to wash your face, wash your clothing, cook your food, and to stay alive. It is for these reasons that water is called the universal solvent. (A solvent is a liquid that dissolves other solids, liquids, and gases.)

Another uncommon property of water is that it takes a lot of heat to increase its temperature, and it gives off a lot of heat when it cools down. If it were not for this uncommon property, life as we know it would only exist near the equator. The sun heats the earth, including the water, near the equator and as the water moves north and south from the equator it keeps the earth warm enough to support the living things that you are aware of. This uncommon property also helps you maintain your body temperature. In other words, this helps you stay warm in the winter and cooler in the summer.

One of the most surprising uncommon properties of water is that it expands when it freezes. Almost all other liquids contract when they solidify or freeze and expand when they melt. When you cool down water, it contracts just like any other liquid until it is 4 degrees Celsius. From 4<sup>0</sup>C to 0<sup>0</sup>C, the

temperature at which water freezes, it expands. Ice, then, acts like any other solid and expands when heated and contracts when cooled.

This special property of water is truly a miracle because it makes possible life on earth. Because water expands when it freezes, ice is light enough to float on top of liquid water. Scientists predict that if water contracted instead of expanding when it freezes, the ice would build up from the bottom of the lakes until eventually the lakes were made of solid ice. This would mean that states like Michigan, Wisconsin, Indiana, Ohio, Pennsylvania and New York would be much colder in the summer time than they are now.

Because water expands when it freezes, it also helps to loosen the soil and break up rocks to make soil. Over thousands and thousands of years, this process has helped to make some of the richest farmlands in the world.

Another uncommon property of water is that it changes from one state to another within a relatively narrow temperature range. This enables us to have solid water in the freezer, liquid water to drink, and boiling water to cook our food.

The title of this section is "The Miracle of Water" because these uncommon properties of water make life possible on earth, make most portions of the earth warm enough for people to live, provide water in the form of rain far from lakes and rivers to help provide more food for people and help us have an abundance of a convenient liquid to wash our clothes, cook our food, and cool our drinks. As you study more about water, you will see that the combination of unique properties of water is truly a miracle

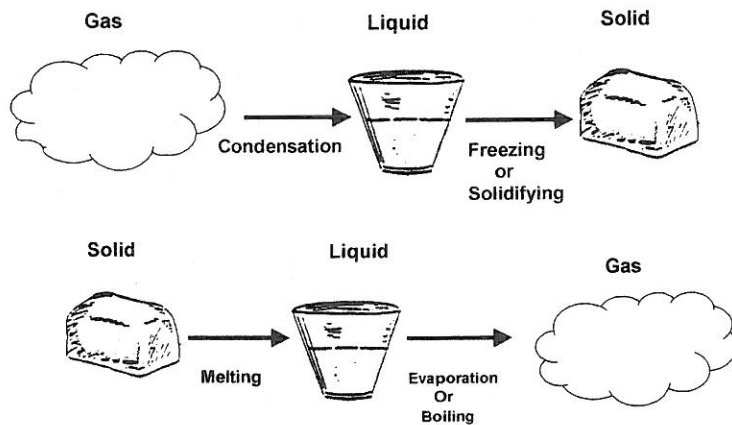
# LESSON CLUSTER 7

## Explaining Melting and Solidifying

### Lesson 7.1: Melting Ice and Freezing Water

Do you remember the first experiment you did in this unit? It was an ice melting race. You learned then about the states of water: ice, liquid water, and water vapor. You also learned how water molecules are arranged and how they move in each state. What you did not learn in the first lesson cluster was how or why water changes from one state to another.

This lesson cluster, as well as Lesson Clusters 8 and 9, is about changes of state in water and other substances. You have seen changes of state many times, and you probably know most of the words that we use to describe them. When a solid changes into a liquid, we call it melting. When a liquid changes into a solid we call it freezing or solidifying. Changes from the liquid state to the gas state are called evaporation or boiling. Changes from the gas state to the liquid state are called condensation. This drawing summarizes all the different changes of state:



Now let's go back to melting ice. When ice melts, one substance (water) is going through a change of state (melting). Can you explain how and why it happened? You already know how molecules are arranged and how they move in solids and liquids. You also know something else important: Molecules move faster when a substance is heated. Let's try putting these ideas together in an explanation of how ice melts.

When ice is warmed it melts into liquid water. The water molecules in ice are locked into a rigid pattern, but as they vibrate faster they break out of that rigid pattern and begin sliding and bumping past each other. Solid ice has melted into liquid water!

(Did the explanation above answer both the question about substances and the question about molecules? Check it and see!)



*Ice melts when the water molecules vibrate fast enough to break out of their rigid pattern*

Water freezes when it is cooled down and the water molecules move slower. To completely explain how water freezes there is one other thing you need to know about molecules. Water molecules are attracted to each other. This attraction makes the molecules stick together in a rigid pattern if nothing breaks them apart.

But the attraction between molecules keeps them stuck in a rigid pattern only if the molecules are moving slowly. When water molecules are moving fast, their motion keeps them from sticking together. They jiggle apart rather than settling into a rigid pattern. When water gets cold, though, the molecules slow down. Then the attraction between them makes them stick together in a pattern. Liquid water has changed into ice!

Water is not the only substance that melts and solidifies. You will learn about some other substances in the next lesson. First, though, try answering some questions about what you have learned.

## Lesson 7.2: Melting and Solidifying of Other Substances

If you can explain how water melts and freezes, then you can also explain how other substances melt and solidify. Different substances are made of different molecules, so they melt at different temperatures. But the processes of melting and solidifying are about the same for all substances.

Whenever any substance melts, its molecules are moving fast enough to break out of their rigid pattern. Whenever any substance solidifies, its molecules have slowed down enough so that they start sticking together in a rigid pattern.

Can you explain how melting is different from dissolving? In some ways melting and dissolving are alike. Both involve the molecules of a solid breaking out of their rigid array. But the causes of melting and dissolving are very different. Melting is caused by heat: When the molecules of a solid move fast enough, they break out of their rigid pattern. Dissolving, on the other hand, occurs when the molecules of a liquid knock the molecules of a solid apart and carry them away.

Melting is also different from thermal expansion. Both are caused by heat, but in the case of thermal expansion the motion of the molecules just moves them farther apart. Their pattern stays the same. Melting occurs when the motion of the molecules makes them break out of their rigid pattern.

(There are some materials that do not melt and solidify because their molecules break apart when they are heated. This is especially true of substances made from living things, like wood or cloth or paper or meat. When wood is heated, for example, its molecules break apart into smaller molecules. The wood burns if there is oxygen around it. If there is no oxygen, the wood is changed into new substances made of smaller molecules, including charcoal, water, and other liquids.)

One place where you often see materials melt and solidify is in your kitchen. Have you ever melted butter? What about cheese? Chocolate? Caramel? Sugar? Try some activities with kitchen materials that you can melt and solidify.

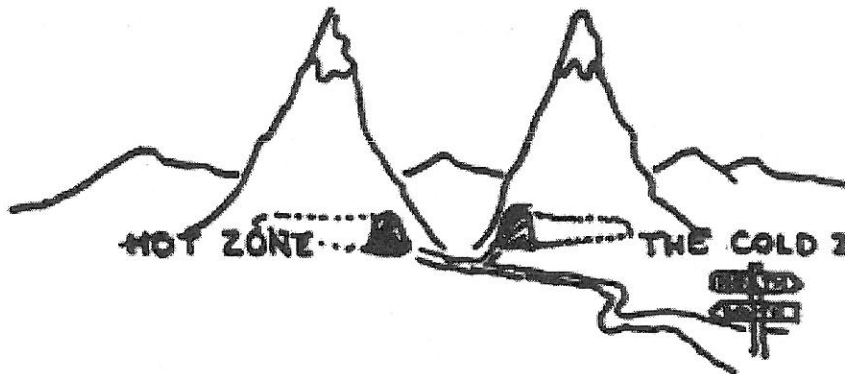




### Lesson 7.3: Adventure into the Hot Zone and the Cold Zone

You can see some substances going through changes of state, like water and other things in the kitchen. Other substances, though, always seem to be the same state. Oxygen and nitrogen, for example, always seem to be gases. Steel and rocks always seem to be solids. Can those substances melt and solidify? In order to find out you will have to venture into the hot zone and the cold zone. Get ready!

As you explore the valleys between the highest Himalayan mountains you stumble across two large caves. One is in the north side of the valley, the other in the south. Each cave is marked by a rock column and a message in Hanzi. After conferring with your guide you understand that the column to the north says "The Cold Zone" and the column to the south "The Hot Zone." The guide further explains that the deeper you go into the tunnel on the north side the colder it gets



and the further you go into the tunnel on the south side the hotter it gets.

You decide to go into the south tunnel first. As you step inside the tunnel there are two rock columns with weird looking clothing suspended between them. After the guide reads the message in Hanzi on the stone pillars, he informs you that unless you wear the special clothing you cannot survive in the tunnel.

After carefully dressing in the special clothing you proceed into the tunnel. You proceed slowly because you can tell that it is quite hot at the end of the tunnel, but just beyond the pillars you recognize a large rock of ice slowly dripping water on your clothing. A little distance beyond the ice rock there is a rock of sugar that is also melting. Beyond that there are a number of familiar metals. First is solder (similar to what plumbers or electricians use). Beyond that

is a huge chunk of aluminum that is melting. It glistens like silver, but it is not quite the same as silver. You can tell

because just beyond the aluminum is silver and then pure gold. The silver and gold have melted and resolidified so that there are beautiful configurations on the walls and on the bottom of the cave. Beyond this you can see sandstone and a variety of rocks melting.

As you keep going, more and more substances melt. There aren't any solids left! By the time you reach 2700 degrees Celsius, all metals are liquids, and so are all rocks. You are swimming now in your magic suit! You put on your magic eyeglasses and see that the molecules are really moving fast. No wonder they won't stay in a pattern! You look forward and the cave back goes on and on into higher and higher temperatures. Some of the liquids are turning into gases and forming bubbles, boiling up out of sight. But it is time to turn back before your suit loses its magic and you become a bunch of liquids and gases!

You come out of that cave and look across the valley toward the north. The cold zone seems very inviting because you are still very hot. As you step inside the cold zone cave, you again see two pillars with very different clothing than you had in the hot zone. It takes you a long time to put this clothing on and it is so heavy that it is difficult to walk. There is also a special light that you will need in the cold zone.

After you make sure that your clothing is adjusted properly and you figure out how to operate the special light, you proceed into the cold zone. And immediately you find a very familiar rock--ice. But just beyond this ice rock, there is something that you hardly believe. It is solid antifreeze. You had thought that antifreeze would not freeze. But it does, and it makes up a beautiful rock. When you get beyond the antifreeze you see another rock that looks like silver. It is hard like silver, too, but it is mercury. Now, mercury is normally a liquid at room temperature, but it is a solid in the cold zone. Deeper in the cave you find solid carbon dioxide or dry ice. You've seen this before, but not nearly as much as in the cold zone.

By the time you reach  $-219^{\circ}\text{C}$ , there is no more air to breathe. You look around you and see why: Oxygen and nitrogen have turned into liquids, and now

they are solids. The last gas, helium, becomes a liquid at  $-272^{\circ}\text{C}$ . It is the only liquid left. Every other substance has solidified!

You look up and see that the cave stops at  $-273^{\circ}\text{C}$ . It doesn't go on and on like the hot zone. Your magic eyeglasses show you why. The molecules have almost stopped moving. You have reached absolute zero, the point at which molecules can go no slower. It is time to turn around and go back. You slowly make your way to the two stone columns again. You take off the clothing from the cold zone, hang it on the two pillars, and are eager to get out into the warm sun light between the two Himalayan mountains.

While resting with your guide you express surprise that gases like nitrogen, oxygen, and hydrogen could be solids. He assures you that all substances can be solid if they are cold enough. As you breathe the fresh mountain air, you have more appreciation for the nitrogen, oxygen, and carbon dioxide in the air, because for the first time in your life, you have seen them. You have seen them as solids. The hot zone was not nearly as surprising as the cold zone, because you had seen pictures of volcanoes spewing out liquid rock on television. But the trip to the cold zone was something you will never forget.



## LESSON CLUSTER 8

### Explaining Evaporation and Boiling

#### Lesson 8.1: Where Did the Water Go?

You see things drying out around you all the time; puddles dry up; clothes dry on a clothesline or in a dryer; your hair dries out after a shower; towels dry when they are hung up. Have you ever wondered what happens to the water when something dries up? It takes trillions of water molecules to make something wet. Where do they go when something dries out?

You probably already know the answer to this question. The water does not just disappear; things dry out when water changes from liquid water to water vapor. This is called evaporation. The liquid water changes to water vapor that mixes with the air.

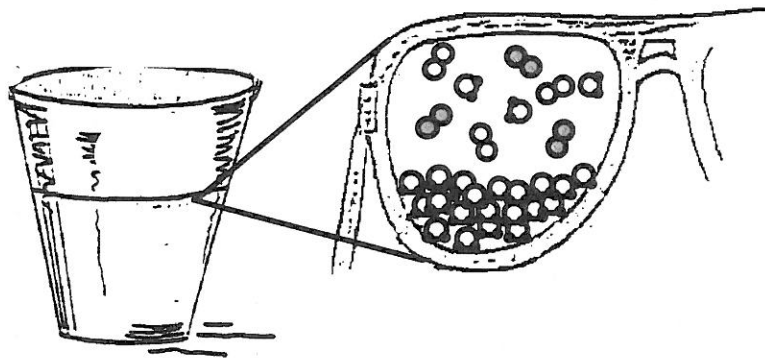
You probably also know that clothes and towels dry out more slowly when the air is humid. Sometimes you feel sticky because sweat evaporates from your skin more slowly. What do we mean when we say that the air is humid?

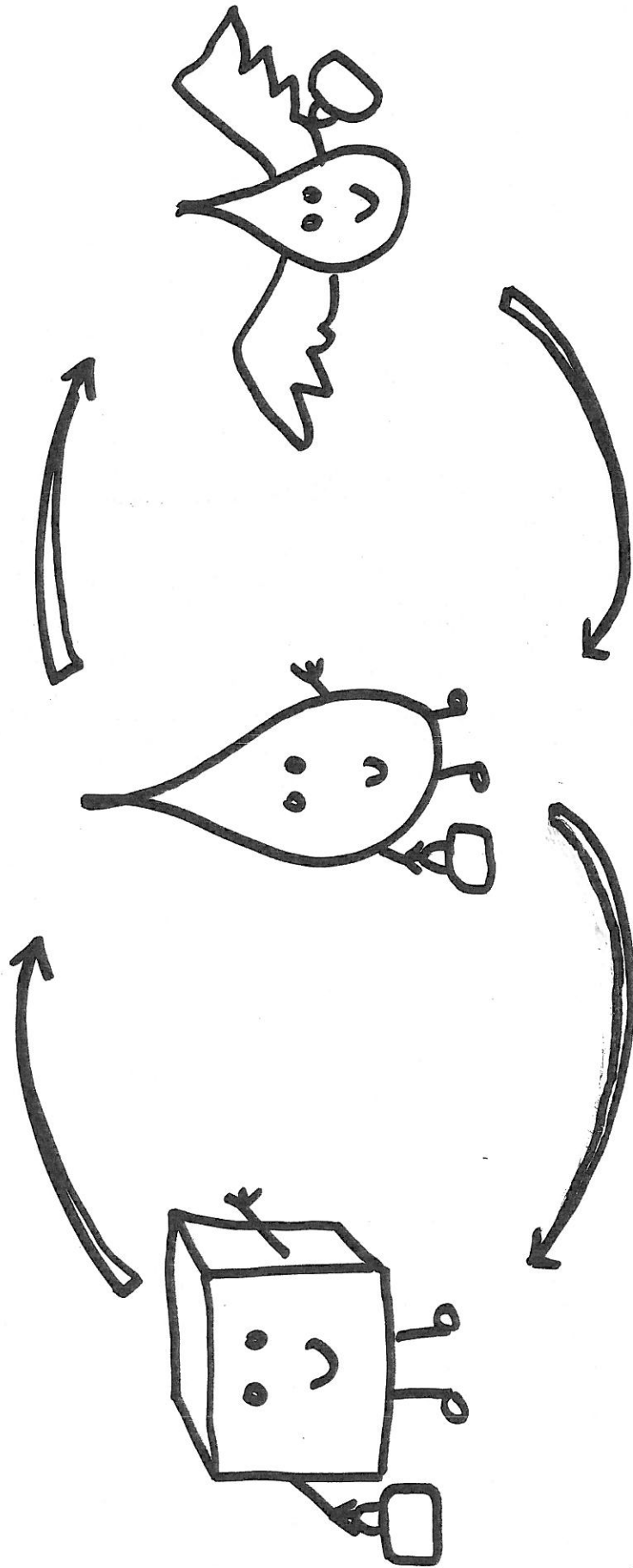
The air is humid when there is a lot of water vapor in the air. You may remember from Lesson Cluster 3 that there is always some water vapor in the air. After a summer rain, you may say that it is hot and humid. That means that the temperature is high and the amount of water vapor in the air is also high. Sometimes, there is so much water vapor in the air that our homes become uncomfortable. We may use a device called a dehumidifier, which takes some of the water vapor out of the air.

In the wintertime, there is usually less water vapor in the air, and we may become uncomfortable because water is evaporating too fast from our skin, causing our skin to feel dry. To become more comfortable, we may add water vapor to the air. That is why many furnaces have a humidifier, which adds water vapor to the air when the air is very dry. This makes us feel more comfortable.

How does evaporation happen? Let's try explaining it in terms of molecules. You know that the molecules in liquid water are constantly moving. In a liquid, though, the attractive forces between molecules keep them close together. What you might not know is that the molecules in a liquid move at different speeds. Some molecules are moving very fast, while other molecules are moving more slowly.

What do you think would happen if a fast-moving molecule reached the surface of a drop of water? Yes, it would escape! It would break away from the strong attraction of the other water molecules and become a molecule of water vapor in the air. If all the water molecules escape in this way, we say that something has "dried out." The liquid water has turned into water vapor in the air, and the water vapor makes the air more humid.





Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_





## STUDY GUIDE

### PHASE CHANGES

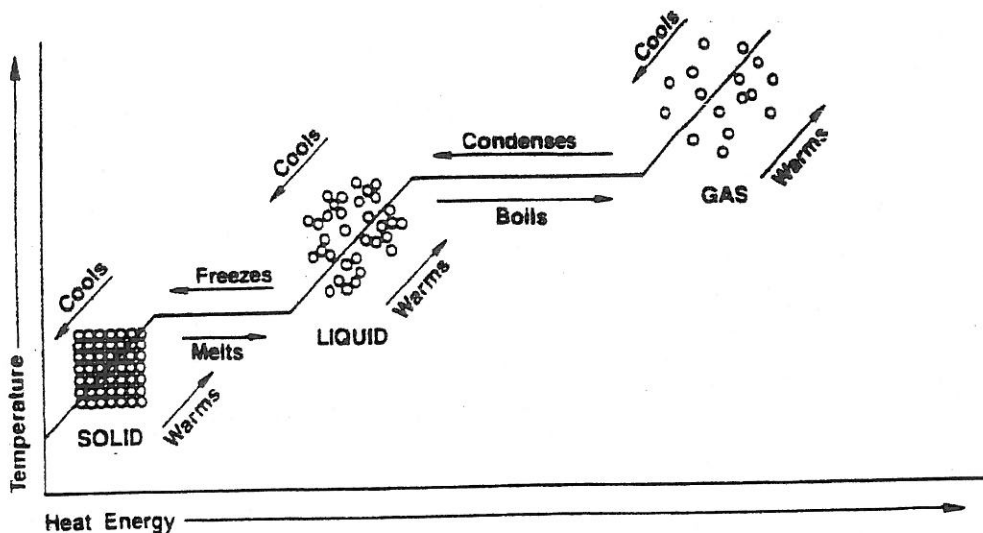
Substances can change from one phase to another. When they do, energy (usually heat) is gained or lost. In this way, solids turn to liquids and liquids to gases when heat energy is gained or absorbed. When heat energy is lost (given off) gases change to liquids and liquids change to solids. All phase changes require a gain or a loss of heat energy. The energy change allows the particles to have a new arrangement thereby creating a new phase. These phase changes can only happen at certain fixed temperatures for each type of substance.

Changes in phase from solid to liquid (**melting**) and from liquid to gas (boiling) require energy. When solid ice melts and becomes a liquid, the particles of the substance move farther apart and heat energy is gained. When water boils, it forms steam (a gas). The change from liquid water to steam (a gas) is a change in phase and requires the gain of heat energy. This energy can be gained (taken in) from the environment. When you put rubbing alcohol on your skin, it makes your skin feel cold. Your skin feels cold because, when the alcohol changes from a liquid to a gas, it absorbs heat energy from your skin, and the alcohol molecules move further apart. This process is called evaporation. **Evaporation** takes place when liquids turn to gases. Heat energy must be added to the liquid.

Phase changes that require a loss in energy are condensation and freezing. When a liquid becomes a solid (**freeze**), heat energy is generally lost (given off). Energy is also released when a gas becomes a liquid. Condensation happens when gases turn to liquids. Heat energy is given off. The particles slow down, and a liquid forms. Water vapor in the air condenses to form clouds. The droplets of water seen on the outside of a pitcher of cold fruit juice come from water vapor in the air. Water vapor cools enough to condense and collect on the pitcher.

Another type of phase change occurs when a solid changes directly into a gas. This is called **sublimation**. It requires a gain in heat energy. "Dry ice" (solid carbon dioxide) never turns to a liquid before it turns to a gas. Moth balls sublimate making them safe for use next to clothing in storage trunks and closets.

The accompanying graph shows the relationship between temperature and heat energy during the phase changes of water. Study the graph and answer the questions.



1. Does the temperature increase during melting? \_\_\_\_\_

2. Is energy required for each phase change? \_\_\_\_\_

3. Can both liquid water and steam exist at  $100^{\circ}\text{C}$ ? \_\_\_\_\_

4. What must be changed, temperature or heat energy, during condensation?  
\_\_\_\_\_

5. How would you describe the change in the arrangement of the particles in the above diagram, as heat energy and temperature increase?  
\_\_\_\_\_  
\_\_\_\_\_

6. What rule can you state about the relationship between phase changes and temperature?  
\_\_\_\_\_  
\_\_\_\_\_

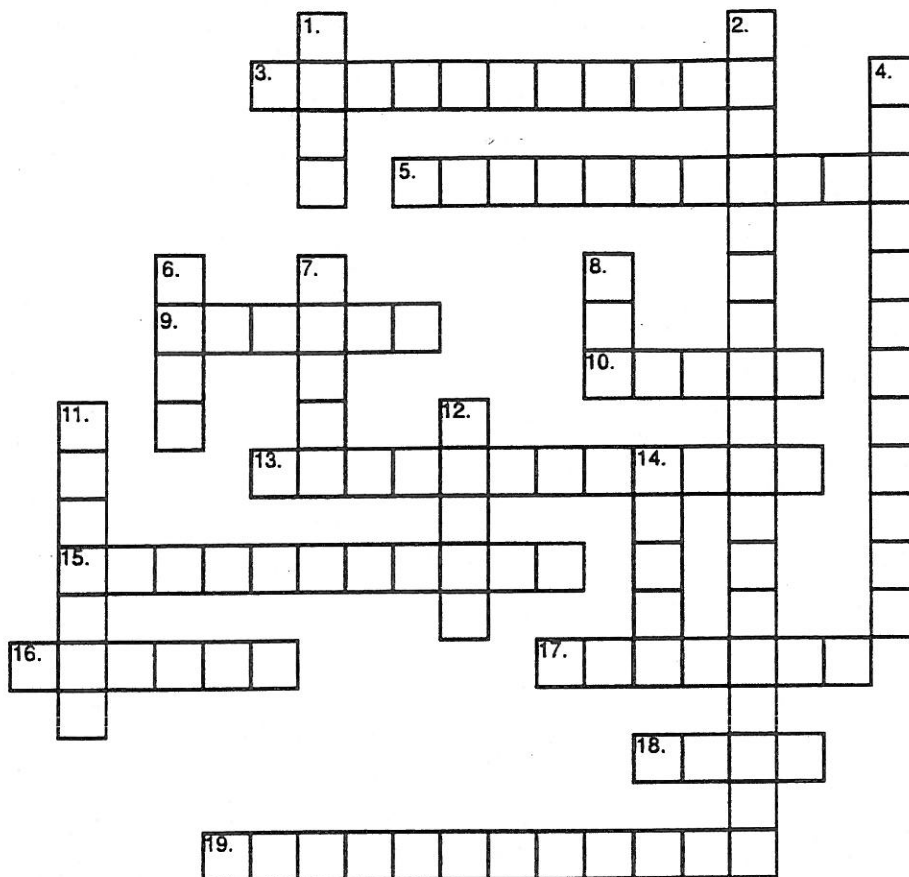
Between phase changes and heat energy?  
\_\_\_\_\_  
\_\_\_\_\_

## Chapter 8

Use with Text Pages 224–227

## TUDY GUIDE

## ● Changes in State



Across

Down

3. The state of a material depends on this.
5. change of a solid directly to a gas
9. When ice melts, the particles of solid water \_\_\_\_\_ energy.
10. gaseous water
13. energy needed to change a material from solid to liquid (3 words)
15. change of a liquid to gas below the boiling point
16. has definite volume but no definite shape
17. The kinetic energy of a substance is the \_\_\_\_\_ kinetic energy of its particles.
18. to change from a liquid to a gas at temperatures above those normal to the liquid state
- \_\_\_\_\_ process that occurs during boiling
1. to change from solid to liquid
2. energy needed to change a material from liquid to gas (3 words)
4. occurs when a gas cools and changes to a liquid
6. Liquids have a definite volume and \_\_\_\_\_.
7. a unit of heat
8. no definite shape, no definite volume
11. theory used to explain changes of state
12. has a definite volume and shape
14. determined by motion and spacing of particles

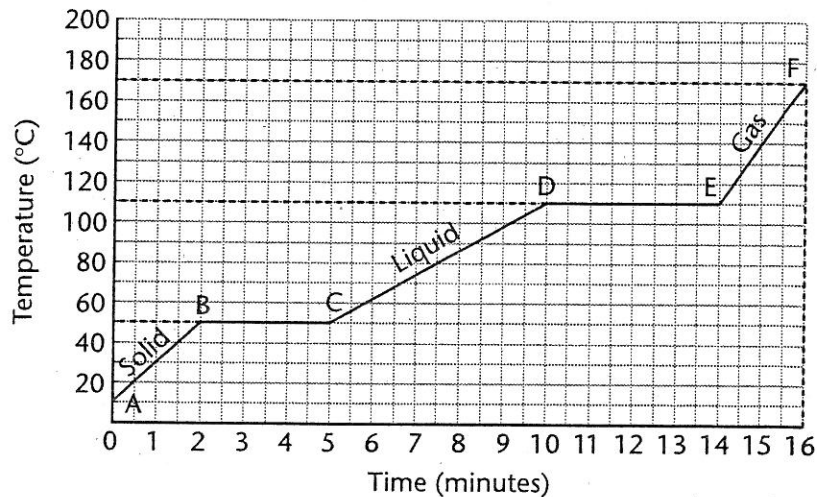
## Chapter 8

Use with Text Pages 224-227

## REINFORCEMENT

# Changes in State

Look carefully at the graph. It was drawn from the data collected when a substance was heated at a constant rate. To heat at a constant rate means to add heat evenly as time passes. Use the graph to complete the paragraphs that follow.



At the start of observations, Point A, the substance exists in the \_\_\_\_\_ state. The temperature at this point is \_\_\_\_\_. As energy is \_\_\_\_\_, the temperature of the substance rises at a constant rate for two minutes. At Point B, the temperature is \_\_\_\_\_, and the solid begins to \_\_\_\_\_. The temperature remains constant until the change from solid to \_\_\_\_\_ is complete. It has taken three minutes to add enough energy to melt the solid completely. From Point C to Point D, the substance is in the \_\_\_\_\_ state. Its temperature rises at a constant rate to \_\_\_\_\_. The temperature remains constant while the liquid changes to a \_\_\_\_\_. At Point E, the substance exists as a \_\_\_\_\_. Its temperature rises \_\_\_\_\_ as energy is added.

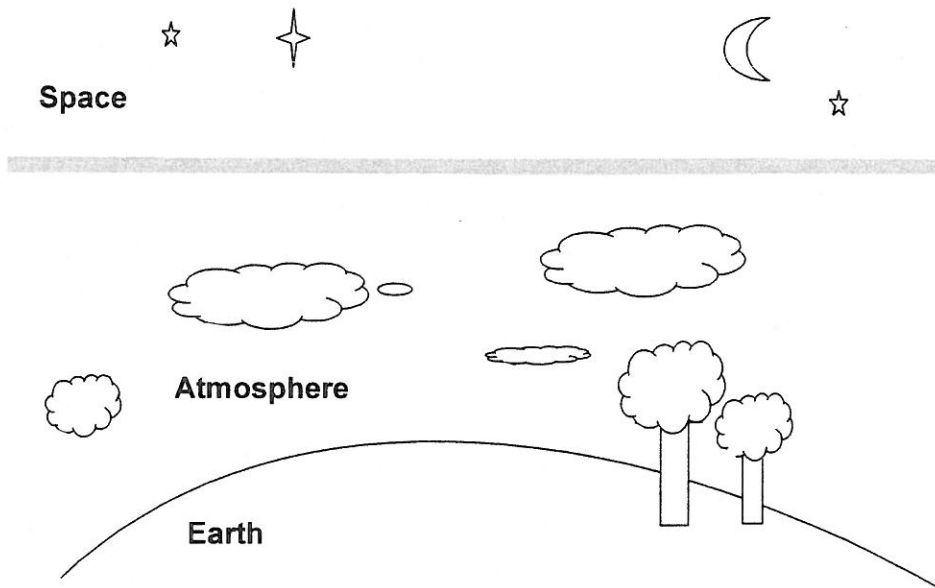
When the gaseous substance is allowed to cool, it \_\_\_\_\_ energy. The cooling curve will be the reverse of the warming curve. Energy will be released as the substance changes from a \_\_\_\_\_ to a \_\_\_\_\_ and also from a \_\_\_\_\_ to a \_\_\_\_\_. The amount of energy released during condensation will be the same as the amount \_\_\_\_\_ during vaporization.

### Lesson 3.2: What is Air Made of?

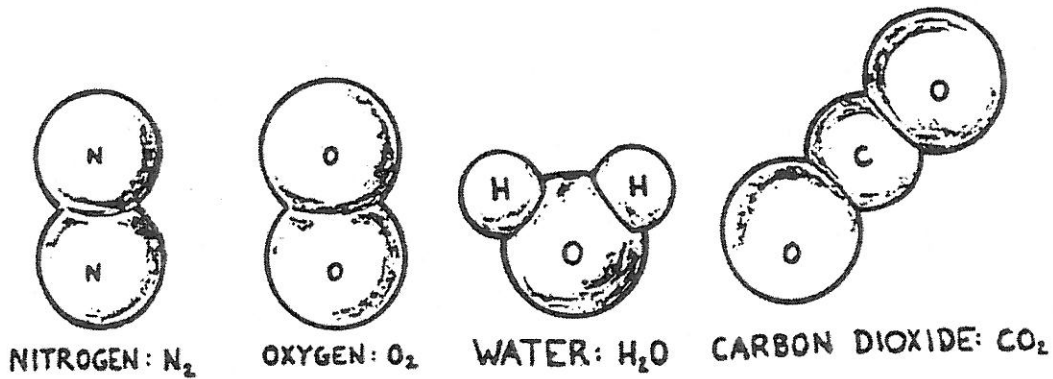
Air is not a liquid or a solid. Air is a gas. Like all gases, air is made of molecules that are far apart. That is why you cannot see air.

All the molecules of air are moving all the time, even when there is no breeze. The molecules never stop moving. They are far apart so they move freely, but they bump into each other and into other things, bouncing back and forth. Air is all around us, all the time. Even though you can't feel them, molecules of air are always hitting you. You breathe in molecules of air and breathe them back out.

The air that is all around the earth is called the atmosphere. The atmosphere goes up past the clouds, higher than mountains. As you go higher in the air, the molecules of air get farther and farther apart, and the air gets thinner and harder to breathe. If you keep going up, you finally get to space, where there are no air molecules at all.



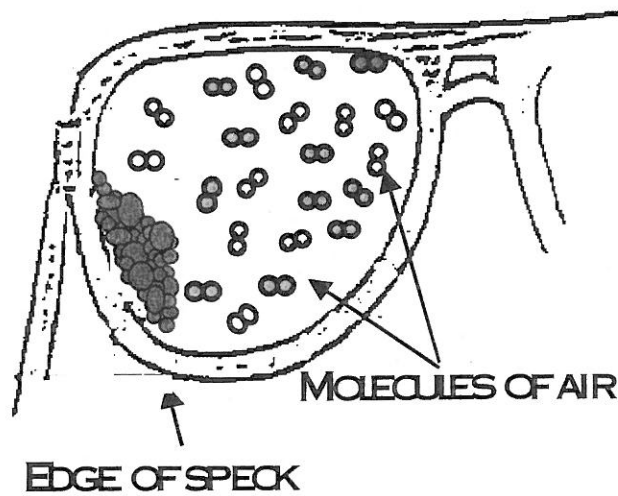
What are molecules of air like? First of all, let's imagine clean air without any germs, bacteria, dirt, dust, smoke, or pollution in it. Clean air is a mixture of different kinds of molecules, including nitrogen molecules ( $N_2$ ), oxygen molecules ( $O_2$ ), carbon dioxide molecules ( $CO_2$ ), and water molecules ( $H_2O$ ). These molecules "look" something like the pictures on the next page, though they are really too small to see.



*Air is made mostly of nitrogen, oxygen, water, and carbon dioxide*

How are these molecules alike and how are they different? All the nitrogen molecules are alike, but they are different from the oxygen molecules. All the oxygen molecules are alike, but they are different from water molecules. These molecules move freely and mix together to make air. AIR IS MADE OF THESE MOLECULES.

How big or small do you think these molecules of air are? Different molecules have different sizes. Oxygen molecules are slightly bigger than nitrogen molecules. Nitrogen molecules are slightly bigger than water molecules. But how does the size of any kind of a molecule compare with a very, very small object you can see with your eyes, like a speck of dust? Which is bigger, a molecule or a speck of dust? How much bigger? If we compare the size of a molecule and that of a speck of dust, it would look like the picture below:

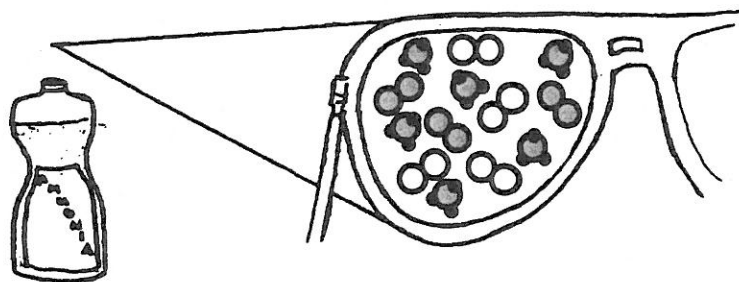


As you see in the picture, a speck of dust that you can barely see with your eyes is much, much, bigger than a molecule (trillions of times bigger!). The speck of dust is made of trillions of molecules itself; it is a solid while air is a gas.

If you look at the air molecules in the picture, you will see that they are mostly nitrogen and oxygen molecules. Air is about  $\frac{4}{5}$  nitrogen and  $\frac{1}{5}$  oxygen. Water, carbon dioxide, and other gases make up only two or three percent of the molecules in the air. Can you think of any substances other than dust that mix in air? There are many, including dirt, germs, bacteria, smoke, and many other substances. Most substances that you can see in the air, like dust or smoke, are made of solid particles that contain trillions of molecules each. But sometimes substances that you can't see also mix with air.

What else is sometimes in the air? Did you think of smell?

What is the smell of perfume? First of all, smell is a gas and made of molecules. When a bottle of perfume is opened, some molecules of the perfume leave the bottle, go into the air, and mix in the air. These molecules of perfume in the air are constantly moving, so they spread out. They spread out until the perfume molecules reach and affect your nose. Then you can smell them.



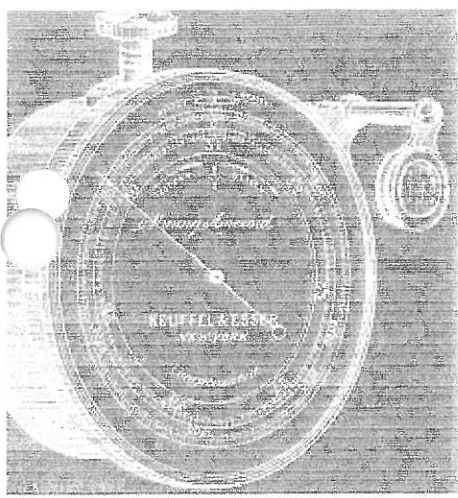
**Ammonia molecule**

*You smell ammonia when you breathe air with ammonia molecules in it.*

The same thing happens when you open a bottle of ammonia or you cut into a lemon. Molecules of the ammonia or lemon spread out in the air until they reach your nose. Ammonia, lemon, and perfume molecules are smelly because they affect your nose.

In this lesson you answered questions such as "What is air made of?", "What are smells?", and "How do smells travel?"





## Atmospheric Pressure

Put Mt. Everest (28 deg North) at the latitude of Mt. McKinley (63 deg North) in the United States and it is likely that no climber would ever have been able to reach the summit breathing the natural air. Everest would feel, physiologically, as if it were an additional 3,000 feet higher. The air would be so thin that even the best climber would have no choice but to use supplemental oxygen. Why? Because of the many factors which affect atmospheric pressure.

Pioneering scientists discovered atmospheric pressure (also known as barometric or air pressure) in the 17th century, and determined a startling new fact -- that air actually has weight. Evangelista Torricelli, one of the first to discover atmospheric pressure, once said, "We live submerged at the bottom of an ocean of the element air." The Earth's gravitational field is pulling on air, and this pull, or "pressure" of air, is called atmospheric pressure. Toricelli also went on to develop the mercury barometer, an instrument used to measure atmospheric pressure.

A barometer also monitors variations in atmospheric pressure. As air becomes thinner, the density of air decreases, and so too does the pressure of air. Many different factors affect the density of air. Most measurably, as altitude increases, air becomes less dense, decreasing atmospheric pressure. Standard altitude-pressure tables allow mountaineers and aviators to determine their approximate height by measuring atmospheric pressure. This relationship also works inversely. The height of a mountain determines, approximately, the density of air on its summit. As air becomes less dense, it contains less gases per unit of volume, and therefore less oxygen. Physiologists use this information to predict the oxygen deprivation a mountaineer faces at high altitude.

For the most part, this relationship works quite well. But factors other than altitude also effect the density of air. For one thing, water molecules have less mass than other gas molecules in air; so as water vapor increases, the density of air decreases. Temperature also changes the density of air. As air gets warmer it expands and becomes less dense, causing atmospheric pressure to fall.

In addition, air within the atmosphere can rise and fall, changing the atmospheric pressure. In fact, meteorologists monitor atmospheric pressure at the Earth's surface in order to determine whether the pressure is rising or falling, which helps to predict weather patterns. High pressure often represents stable air, while low pressure can signify instability. On a cold, sunny day there will be a significantly higher atmospheric pressure than when a big storm is moving in on a hot and humid day.

But the density of the atmosphere varies at different points around the globe as well. At the poles, the atmosphere is much thinner than at the equator. Because of these variations, two mountaineers climbing at the same altitude but on different mountains could experience different atmospheric pressures and therefore different physiological effects. One climber might have no trouble breathing, while the other can barely pull in enough oxygen to survive. The small amount of oxygen on the top of Everest puts this peak near if not at human's physiological limit. And this is why Everest, if it were at a higher latitude, could very well be beyond the physiological limits of someone trying to climb without oxygen.

Only one direct measurement of atmospheric pressure has ever been made on the summit of Mt. Everest, in 1981. The present expedition has a small hand-held barometer and we hope it may be possible for them to make the second measurement.



Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

Answer the following questions by highlighting the portion of the text where you got your answer and by writing the number of the question next to the area you highlighted. In some cases, several parts of the reading could help you answer one question. In that case, place the question number next to all the parts that apply.

1. The main idea of this story is
  - A. Atmospheric pressure is important for determining weather patterns.
  - B. Air pressure varies greatly due to many factors.
  - C. Air pressure changes based upon temperature.
  - D. Air pressure keeps mountain climbers from reaching the summit of some mountains.
  
2. Which of the following is an opinion?
  - A. Mountain climbers who fail to reach the summit haven't tried hard enough.
  - B. Temperature affects barometric pressure.
  - C. Sunny weather often happens during high pressure days.
  - D. Earth's gravity pulls on the air around the Earth.
  
3. In what century did Torricelli discover the concept of air pressure?
  - A. 15th
  - B. 17th
  - C. 19th
  - D. 21st
  
4. If all other factors remain the same, what happens to the air pressure if air is cooled?
  - A. The pressure will remain the same.
  - B. The pressure will decrease.
  - C. The pressure will increase.
  
5. What gives aviators the ability to determine their height above the Earth's surface?
  - A. Cloud base heights
  - B. Barometers
  - C. Standard air pressure tables
  - D. P and S wave travel time graphs

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

### Clear liquids and graduated cylinder measurement

In this activity, you will be mixing liquids to determine the resulting volume of liquid. In each case, you'll need to make sure you're using the correct liquid and be sure to accurately measure using the graduated cylinder. You'll need to be checked by your teacher before mixing the liquids.

#### Part 1: Clear Liquid A

- 1) Measure out 50 ml of Liquid A into the first graduated cylinder.
- 2) Measure out 50 ml of Liquid A in the second graduated cylinder.
- 3) Have your teacher check your graduated cylinders to make sure they are 50 ml each. Your teacher will initial here \_\_\_\_\_ if your measurements are correct (remember to measure using the bottom of the meniscus).
- 4) Carefully pour the 50 ml from the second graduated cylinder into the first graduated cylinder.
- 5) Record the volume of the mixed liquids in the first graduated cylinder here: \_\_\_\_\_ (remember tenths place and units).

#### Part 2: Clear Liquid B

- 6) Measure out 50 ml of Liquid B into the first graduated cylinder.
- 7) Measure out 50 ml of Liquid B in the second graduated cylinder.
- 8) Have your teacher check your graduated cylinders to make sure they are 50 ml each. Your teacher will initial here \_\_\_\_\_ if your measurements are correct (remember to measure using the bottom of the meniscus).
- 9) Carefully pour the 50 ml from the second graduated cylinder into the first graduated cylinder.
- 10) Record the volume of the mixed liquids in the first graduated cylinder here: \_\_\_\_\_ (remember tenths place and units).

#### Part 3: Clear Liquid A and Liquid B

- 11) Measure out 50 ml of Liquid A into the first graduated cylinder.
- 12) Measure out 50 ml of Liquid B in the second graduated cylinder.
- 13) Have your teacher check your graduated cylinders to make sure they are 50 ml each. Your teacher will initial here \_\_\_\_\_ if your measurements are correct (remember to measure using the bottom of the meniscus).
- 14) Carefully pour the 50 ml from the second graduated cylinder into the first graduated cylinder.
- 15) Record the volume of the mixed liquids in the first graduated cylinder here: \_\_\_\_\_ (remember tenths place and units).

#### Part 4: Making Molecules

- 16) Take two of the same color gumdrops from your bag. These will represent hydrogen.
- 17) Take one gumdrop of a different color to represent oxygen.

- 18) Using the toothpicks, combine these gumdrops to make a model of a water molecule as shown by your teacher.
- 19) Place it on the paper towel until after you complete the questions.
- 20) Obtain 6 of the same color gumdrops from your bag. These will represent the hydrogen atoms.
- 21) Obtain 2 of the same color gumdrops to represent the carbon atoms.
- 22) Obtain one gumdrop of another color to represent oxygen.
- 23) Using the toothpicks, combine these gumdrops to make a model of an ethyl alcohol molecule as shown by your teacher.
- 24) Place it on the paper towel until after you complete the questions. Then, eat them!

#### Questions

1. Draw the gumdrop models of water and alcohol below.

Water

Alcohol

2. Looking back at your data for the volume of the mixed liquids (steps 5, 10 and 15) and the models of the alcohol and water molecules you made, what hypotheses can you develop to explain any differences you saw?
3. After watching the demonstration of the mixing of the marbles and BBs, what does this tell you about liquid substances?
4. What is the difference between an atom and a molecule?
5. What are some benefits to scientific models? What are some drawbacks?

Benefits

Drawbacks

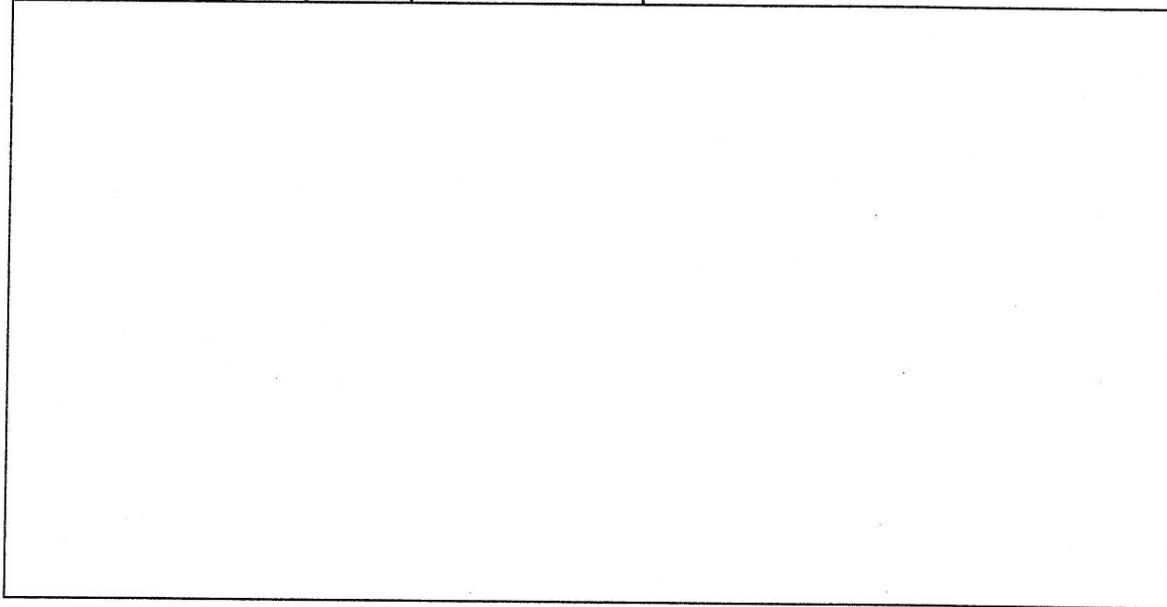
Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

### Salt Water Lab

#### Procedure

- 1) Obtain 10-15 grams of the water softener pellets or rock salt.
- 2) Place water softener pellets or rock salt into **one test tube**.
- 3) Pour 50-60 ml of water in both test tubes.
- 4) Stopper the test tubes.
- 5) Mark the level of the water in both test tubes using a *water-soluble marker*.
- 6) Record the mass of the each tube using the triple beam balance in the table below.
- 7) Carefully mix the tubes for approximately two minutes holding the rubber stopper as you invert the tube. **Be careful that you do not wipe off the mark as you mix.**
- 8) Take and record the mass after mixing.
- 9) Repeat steps 7-8 until salt is completely dissolved. (or until you reach 6 minutes of mixing)

Labeled diagram of your experimental set-up



Mass Table

	Control Test tube	Salt and Water Test tube
Initial Mass		
After 2 minutes		
After 4 minutes		
After 6 minutes		

Questions to ponder (and complete):

- 1) What is the purpose of the test tube with water only?
- 2) What happened to the water level in the water test tube?
- 3) What happened to the water level in the water and salt test tube?
- 4) What could have happened in the salt-water test tube to cause the result you observed?
- 5) In what ways can we test the idea(s) that you presented in question #4?
- 6) Could the salt be soaking up the water? Why or why not?
- 7) Has the water in the salt-water test tube evaporated? Why or why not? (Give two reasons to support your answer)

8) In the following 3 boxes, draw the arrangement of molecules in a solid, liquid, and gas.

Solid	Liquid	Gas

9) How can you use the diagrams from question 8 to explain your observations of the salt-water test tube.

10) As with most rules in life, there are exceptions. Water is an exception to the drawings you made in question 8. What happens to the volume of water when it changes from a liquid to a solid? Explain why water is an exception to the 3 drawings from question 8.

11) Explain, after class discussion, what is meant by the Law of Conservation of Mass.





Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

## Sugar Solubility Lab

We've been talking about independent and dependent variables with each of the activities that we have done so far this year. In addition, we've been discussing the importance of sharing information from many researchers. Today, we are going to collect data about the time it takes for sugar to dissolve in water of different temperatures. Each set of "researchers" will record data about a specific temperature. Together, we will determine the relationship between the temperature of the water and the time it takes for the sugar to dissolve.

### Procedure:

1. Determine the temperature for your group based on our class discussion and write that temperature below.

Our experimental temperature is \_\_\_\_\_ °C.

2. Using your graduated cylinder, measure 200 milliliters of water and place it into your beaker.
3. Carefully place the beaker onto the wire mesh of the ring stand and place the thermometer assembly at the top of the ring stand with thermometer submerged in the water.
4. Carefully light the burner according the way we practiced.
5. Heat the water to the temperature specified in the class discussion for your group.
6. When the water reaches your temperature, turn off the burner.
7. Carefully add the sugar cube while your partner begins timing with the stopwatch.
8. When the sugar is no longer visible, record the time in the table below for group data (on next page).
9. When all groups have recorded their data, fill out the class data table (on next page).
10. Complete the class data graph (use graph paper provided).
11. Complete the questions.

### Questions (complete these on a separate sheet of paper only):

1. What is the independent variable of this experiment? Explain why the variable you chose is the independent variable.
2. What is the dependent variable of this experiment? Explain why the variable you chose is the dependent variable.
3. Do we have a control in this experiment? Explain why or why not.
4. What are 4 constants in this experiment?
5. What are two possible sources of error in this lab?
6. Observe your graph for the class data. What is relationship between the temperature of the water and the time it takes for the sugar to dissolve?
7. Draw a picture of the spacing of the molecules of water before you heat the water and then draw a picture of the spacing of the water particles after you heat the water. How are they different? How are they similar?

Group Data

Temperature of the Water ( C)	Time It Takes to Dissolve

Class Data:

Group #	Temperature of Water	Time for Dissolving
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

### Ice water to boil lab (Phase change)

In this lab, we are going to take ice water and heat it for 21 minutes.

**Safety Precaution:** In this lab you will be working with fire and heat. Use extreme caution as you can get burned if you are not careful. **BEAKER and RING STANDS MAY BECOME HOT.**

**Materials:** Ring stand, wire gauze, butane burner, Flint Striker, beaker, thermometer, stirring device.

#### Procedure:

- 1) Get Safety goggles and put them on.
- 2) Fill the beaker with ice and water so it is filled to the 200 milliliter mark.
- 3) Check to make sure the level is at 200 ml on the beaker. Adjust it as needed.
- 4) Place the beaker on the wire gauze on the ring stand as instructed by your teacher.
- 5) Lower the thermometer in the ice water by turned the clamp bolt where it meets the ring stand.
- 6) The thermometer should be submerged into the water with about 3 centimeters of space between the bottom of the beaker and the thermometer.
- 7) Tighten the bolt for the thermometer clamp.
- 8) Wait until the temperature on the thermometer is stable.
- 9) Record the temperature of the thermometer at the zero minutes and zero seconds mark.
- 10) Light the burner.
- 11) Start the stopwatch as soon as the burner is lit.
- 12) Record the temperature every 30 seconds for 21 minutes total.
- 13) After 21 minutes, shut off the burner.
- 14) Check the water level and note if it is the same, lower, or higher.
- 15) Let the water and equipment stand until cooled.

Time in Minutes and sec.	Temperature (°C)
0:00	
0:30	
1:00	
1:30	
2:00	
2:30	
3:00	
3:30	
4:00	
4:30	
5:00	

5:30	
6:00	
6:30	
7:00	
7:30	
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10:00	
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13:30	
14:00	
14:30	
15:00	
15:30	
16:00	
16:30	
17:00	
17:30	
18:00	
18:30	
19:00	
19:30	
20:00	
20:30	
21:00	

After collecting the class data above, answer the following questions. Later, you'll be instructed to make a graph.

1. What is the independent variable in this experiment? How do you know?
  
2. What is the dependent variable in this experiment?
  
3. What is happening to the particles of the water (the molecules) of the water as they are being heated?
  
4. What happened to the water level from the beginning to the end of the experiment?
  
5. At what temperature did the temperature remain fairly constant?
  
6. What are the possible explanations or hypotheses about why the water reaches a constant temperature? (come up with two)
  - 6a)
  
  
  
  
  
  
  
  
  
  
  - 6b)
  
7. Complete questions 7a, 7b and 7c after you make the graph.
  - 7a) What does a positive slope on a temperature –time heating graph tell us about the substance?
  
  
  
  
  
  
  
  
  
  
  - 7b) What does a negative slope on a temperature –time heating graph tell us about the substance?

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

## The Candle Snuffer



On the right hand side of the page is a commercially produced “candle snuffer” used for putting out candles when you want to avoid getting melted wax everywhere. You might want to call this device a fire blanket instead because they work on the same principle. People will probably think you are weird if you do that.

This activity is fairly simple, but does involve a number of safety concerns. Read the procedure carefully and then decide on the 5 most important safety rules (from page 2 of your notebook) that you would include. Write them in the space provided below.

Top Five Safety Rules

The teacher is going to instruct on using matches. After you have been given that instruction, answer the questions below.

Matches and safety: Questions

M1: Is it necessary to wear goggles when using just matches?

M2: What are two ways you can light matches from a “book” of matches?

M3: After you light the object (the candle or a burner, etc.) what is the next important step with the match?

Materials: Read the procedure carefully and then make a list of all the materials you will need to complete this investigation in the space below.

Materials:

Procedure:

1. Obtain all the materials listed in the box labeled materials above.
2. Obtain a beaker of water from the sink in the back of the room.
3. Place a small piece of clay near the center of the tray to hold your candle.
4. Place the candle in the clay so it firmly stands up straight.
5. Fill the tray with water so the water level is about 2 centimeters from the bottom of the tray.
6. Empty any remaining water in the sink.
7. Put on your safety goggles.
8. Light the candle using the matches.
9. Place the beaker upside down over the burning candle.
10. Find the water level height inside of the beaker by using your ruler to measure from the outside.
11. Record the height in the appropriate space in your data table.
12. After the beaker has cooled off, lift off the beaker being careful not to spill water on the candle.
13. Repeat the steps 4-12 again using two candles.
14. Repeat the steps 4-12 again using three candles.
15. Clean up your work area.

Data Table

Number of candles used	Height of water inside the beaker (centimeters)
One	
Two	
Three	

Questions

These answer should be placed on a separate sheet of paper and be in complete sentences. You may write down notes during the lab in the spaces below to help you write your complete answers later.

1. What observations can you make regarding the water level before the candle burns out and after?
2. Specifically, state the steps that happened from when you lit the candle to when you lifted off the beaker.
3. Using your answer to questions 1 and 2 above, explain a possible explanation (a hypothesis) that may account for the change in water level.
4. Why do you think the candle burns out?

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

### Air Pressure Lab

Scientific analysis involves close observations then hypothesis development. In this lab, you will study a very simple system that demonstrates some interesting scientific principles.

**Observations:** Study the soda bottle apparatus before doing anything with it and draw a picture below.

(Draw the soda bottle apparatus sideways and label the top and bottom)

**Predict:** What do you think will happen when the soda bottles are flipped?

**Observations Continued:** Now flip the soda bottle (according to the way your teacher demonstrates) and record observations about what you see in sentences below.

- 1.
- 2.
- 3.
- 4.

**Second Drawing: The Soda Bottle Apparatus in Action.**

Use colored pencils to show the water and air. Color the water blue and the air with green. Show the direction of the water flow with dark blue arrows. Show the direction of the airflow with dark arrows in green.

(Draw the soda bottles sideways and label the top and bottom)

Now, using your observations, develop a paragraph that explains how this system may work. This paragraph should include all your observations to help explain your hypothesis about how the fountain works.



Name: \_\_\_\_\_ Date: \_\_\_\_\_

Lab: The Case of the Crazy Can Period: \_\_\_\_\_

A friend tells you of a bizarre situation that happened at his home. He was helping out doing the dishes while dinner was cooking on the stove. He had also just about finished drinking a soda that he left to close to the stove. The liquid in the bottom of the can began to boil. Unsure how to get it away from the stove, he decided to use a large spoon to knock it into the soapy water in the sink. When he did so, he saw a bizarre result. The can fell into the water top first and... you'll have to try it for yourself to see.

At your lab station, you will repeat what happened at your friend's house in a more controlled environment. All during the experiment, you will record observations and the outcome. After seeing the result, you'll decide on the possible variables that may affect the result and you'll develop a hypothesis as to why the can reacts in this way. Then, you will design and try a new experiment to test your hypothesis.

#### Materials:

1 soda can (with a little soda in the bottom)

Burner set up

Plastic tray with cool soapy water

Tongs

Safety Goggles

#### Safety Reminders:

Be very careful working with heat and flames.

Be very careful not to touch hot surfaces. They may remain hot for some time.

Keep all papers away from the burners

Keep long hair tied back and long sleeves pulled up.

Do not lean in your chairs.

Keep the noise level reasonable.

#### Procedure:

1. Put on safety goggles.
2. Light the burner using the method you have been taught.
3. Use tongs to place the soda can onto the wire mesh screen.
4. Bring the soda in the can to a boil.
5. Record observations of the can as it boils.
6. Allow the soda to boil at least 30 seconds and then use the tongs to quickly place the top of the can into the soapy water (be careful not to splash the hot soda on yourself or anyone around you).
7. Record your observations after inverting the can (placing it upside down) in the soapy water.
8. Develop a list of the items you could change (variables) to see if you would get the same result. Hint: anything that is a constant could now be placed as a variable.
9. Develop a hypothesis to explain how the variables may affect the result.
10. Develop your new experiment by listing the steps you would change and how you would change them on the new procedure below.

**Observations of the can as it is boiling** (Remember – observations can be any of your senses – as long as you are mindful of the safety rules)

- 1.
- 2.
- 3.

**Observations of the can after inverting it into the cool, soapy water**

- 1.
- 2.

**Possible variables that may cause the observed result:**

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.

**Hypothesis:**

I think that the \_\_\_\_\_ affects how the can reacts when flipped over.

**New Experiment:**

Make changes to the following procedure below by crossing out parts and putting new information in such that it will test your hypothesis from above.

1. Put on safety goggles.
2. Light the burner using the method you have been taught.

3. Use tongs to place the soda can onto the wire mesh screen.
4. Bring the soda in the can to a boil.
5. Record observations of the can as it boils.
6. Allow the soda to boil at least 30 seconds and then use the tongs to quickly place the top of the can into the cool, soapy water (be careful not to splash the hot soda on yourself or anyone around you).
7. Record your observations after inverting the can (placing it upside down) in the soapy water.

Questions:

1. What happened to the can in the first experiment?
2. Which variable did you test in your experiment?
3. Did the same thing happen to the can in your experiment as it did in the first experiment?
4. If we count the first experiment as your control, then it acts as a standard for comparison for your experiment (you can compare what happened in your experiment to the first experiment to determine if the variable you changed affected the result). Using that information, answer the following:
  - a. Define experimental **control**:
  - b. What is the **control** in this lab:
  - c. Define **constant**:
  - d. What are **three constants** from this lab?
    - 1.
    - 2.
    - 3.

e. Define **Independent Variable**:

f. What was your **Independent Variable**?

g. Define **Dependent Variable**:

h. What was your **Dependent Variable**?

5. Using the class discussions and reading, explain what happened to the can. Be sure to explain the role of phase change in your answer.

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

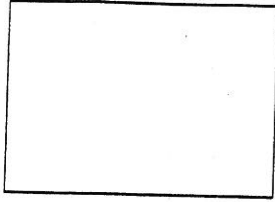
Can lab follow-up

Below is a partial list of some of the variables that may have been tested in your class. For each variable, there is a space for CRUSHED, SOMEWHAT CRUSHED, and NOT CRUSHED. By using your control as a comparison and the class data, you should be able to arrive at a conclusion as to why the can was crushed initially. Extra spaces have been left to fill in if a different variable was tested in you class.

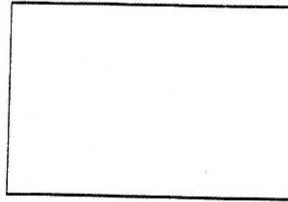
Variable Tested	Crushed	Somewhat Crushed	Not Crushed	Other Observation
No soap in pan				
Water instead of soda in the soda can				
No fluid in the soda can				
Cold water used in the pan				
Hot water used in the pan				
Fluid in the soda can not brought to a boil				
Two holes in soda can (extra hole made in side of can)				
Different type of can used				

# Why did the can crush?

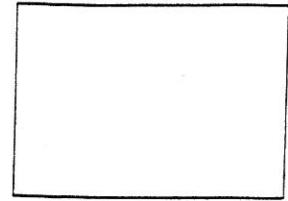
To understand why the can crushed you need to understand molecular motion. How are the molecules arranged in the 3 states of matter? Draw a molecular arrangement using circles.



**SOLID**



**LIQUID**



**GAS**

What happens to molecular motion when heat is added, or when cooled (heat taken away)?

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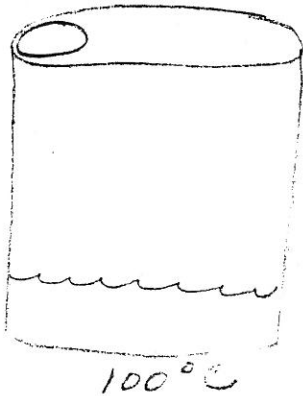
Complete the drawing below to help explain why the can crushes.

Draw red water vapor (gas) molecules.

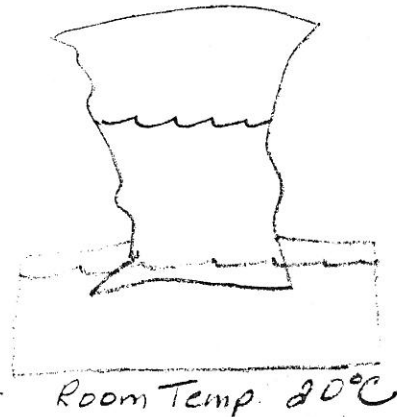
Draw blue water molecules.

Draw arrows to represent the air pressure inside and outside of the can.

**BEFORE**



**AFTER**



Name \_\_\_\_\_

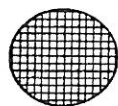
Date \_\_\_\_\_

## Molecule Models: Model to Formula

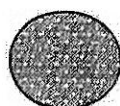
Using the model key for each element, write the chemical formula for each molecule.



Hydrogen- H



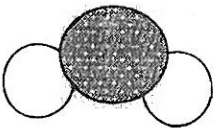
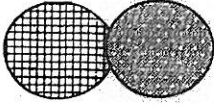
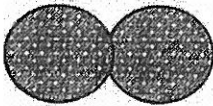
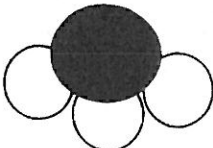
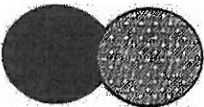

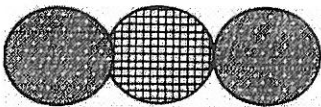
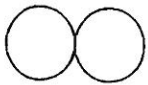
Carbon- C



Oxygen- O



Nitrogen- N

1.  H <sub>2</sub> O  	2.    _____
3.    _____	4.    _____
5.    _____	6.    _____
7.    _____	8.    _____

Name \_\_\_\_\_

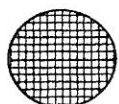
Date \_\_\_\_\_

## Molecule Models: Formula to Model

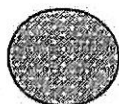
Using the model key for each element, draw the model of each molecule.



Hydrogen- H



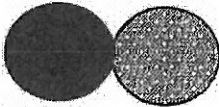
Carbon- C



Oxygen- O



Nitrogen- N

1. <b>NO</b> 	2. <b>CO</b>
3. <b>N<sub>2</sub></b>	4. <b>H<sub>2</sub>O</b>
5. <b>CO<sub>2</sub></b>	6. <b>NO<sub>2</sub></b>
7. <b>NH<sub>3</sub></b>	8. <b>O<sub>2</sub></b>



## Elements, Compounds, and Mixtures

Classify each of the pictures below by placing the correct label in the blanks below:

A= Element

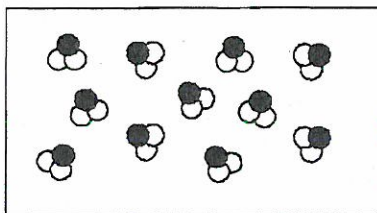
D= Mixture of compounds

B= Compound

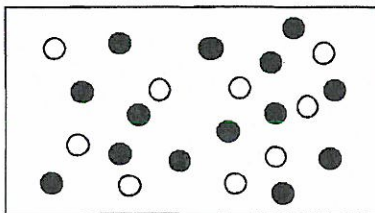
E= Mixture of elements and compounds

C= Mixture of elements

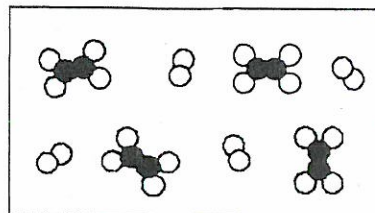
Each circle represents an atom and each different color represents a different kind of atom. If two atoms are touching then they are bonded together.



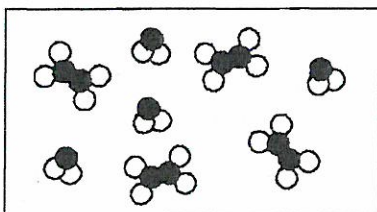
1) \_\_\_\_\_



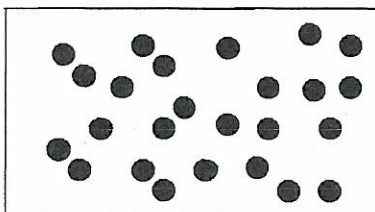
2) \_\_\_\_\_



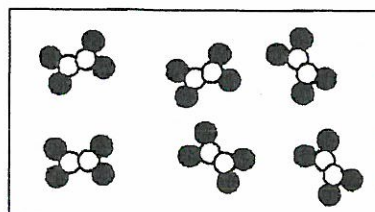
3) \_\_\_\_\_



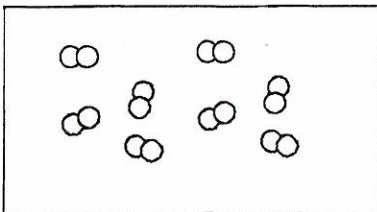
4) \_\_\_\_\_



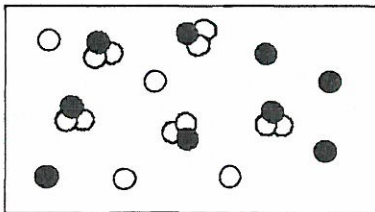
5) \_\_\_\_\_



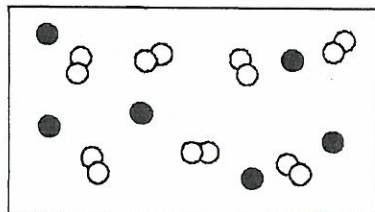
6) \_\_\_\_\_



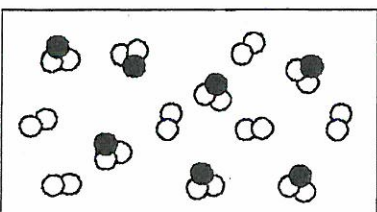
7) \_\_\_\_\_



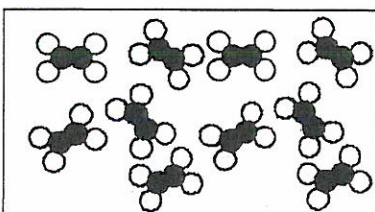
8) \_\_\_\_\_



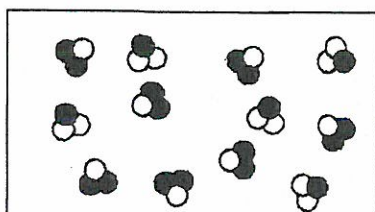
9) \_\_\_\_\_



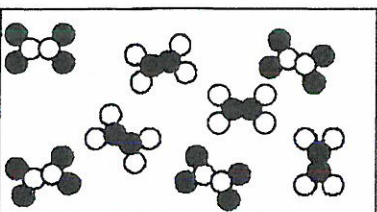
10) \_\_\_\_\_



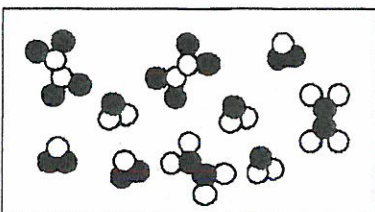
11) \_\_\_\_\_



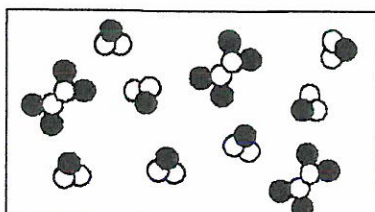
12) \_\_\_\_\_



13) \_\_\_\_\_



14) \_\_\_\_\_



15) \_\_\_\_\_

