Christian Kids Explore

Chemistry

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Christian Kids Explore Chemistry, 2nd Edition
by Robert W. Ridlon, Jr. and Elizabeth J. Ridlon
A part of the Christian Kids Explore series

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Unit Five
Organic Chemistry

A NOTE FROM THE AUTHOR

Exploring chemistry can be an exciting adventure — just like exploring some mysterious ancient ruins. Chemistry, like other sciences, gives us a glimpse into the wonders of God's creation.

Don't Be Afraid!

Chemistry has had a reputation of being an almost out-of-reach activity only for a few "special" people. Much of that reputation comes from the unfamiliar words, rules, tools, and procedures that define it. Although chemistry isn't simple, we believe that it can be made easy to understand.

Don't Be Intimidated!

We learn new and complicated things every day — from computer programs and games to new moves in a sport to a new song on a musical instrument. We are always learning. Chemistry is no different — it takes time and perseverance.

Additional Notes

Chemistry Can Be Fun and Exciting!

Just like getting to know music, sports, or even a new board game, we will learn some terms, some notations, and some rules. Each of our lessons develops a progressive understanding of chemistry that will build confidence. Kids and parents can explore and develop a firm and lasting foundation for the future.

We hope you will be encouraged by these words from Proverbs: "Trust in the Lord with all your heart and lean not on your own understanding; in all your ways acknowledge him and he will make your paths straight" (Prov. 3:5-6).

Robert W. Ridlon, Jr.
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HOW TO USE THIS BOOK

This book contains 30 lessons. Each lesson is designed to be completed in one week. If you teach science twice weekly, allow for about 60 to 90 minutes each day.

Some of the lessons may seem a little more challenging than others. Less advanced students may have some difficulty with fully comprehending all the material in these few challenging lessons. Don't worry! It is quite satisfactory if the student can just learn the foundational concepts that are represented by the Review It questions at the end of the lesson. Don't rush! You may have to read the lesson slowly and more than once. If some words are too difficult, use a dictionary or other source to help clarify meanings. This work will pay off when it's time for the upper level classes or when other challenges come along that require perseverance.

Step by Step
Lesson Activities

The following activities are included in each lesson and unit:

Additional Notes

Preparation

The 30 lessons are divided into five units. The book begins with some overview lessons in the first unit and then presents the components and behavior of chemistry in the next three units. The last unit, organic chemistry, explores a type of chemistry that is concerned with carbon compounds.

Each unit begins with a short note about the material covered in the unit lessons and a list of unit objectives, vocabulary words, and necessary materials. You may want to write the unit objectives on a piece of paper and keep it handy. Referring to the objectives will help give you confidence that the student is getting something from the material.

Teaching Time

Each lesson presents a topic that builds an understanding of chemistry layer by layer. Older or more advanced students can read the lesson material themselves. For very young or less advanced students, it is a good idea to read the lesson in advance and then explain it at their level. The student should be on the lookout for the vocabulary words that were identified in the unit introduction. Also, encourage the student to take a few notes to help them remember important ideas.

Review It

Do the review exercises. After the teaching time, each lesson has five Review It fill-in-the-blank exercises. The key to ensuring the student is ready for the upcoming hands-on activity and the next lesson is the successful completion of the fill-in-the-blank exercises. These are almost always exact quotes from the lesson and the answers are unambiguous. Once these are answered correctly, you should be confident that some important principles of chemistry have been learned. For your convenience, there is a Review It answer key in the back of this book, starting on page 346.

Additional Notes

Hands-On Time

This is the fun stuff. Each lesson ends with a hands-on activity. These activities have a two-fold purpose: they reinforce some of the concepts from the lessons, and they will be a chance for a student to experience being a chemist.

Coloring Pages

There is one coloring page per unit and all of these, plus a few extra, are found after the glossary. These may be photocopied. Children of all ages will enjoy these beautiful drawings.

Think about It

This is a critical thinking exercise regarding the results of the hands-on activity. It isn't absolutely necessary to do, but it offers a more advanced student the opportunity to respond to some questions that require some creative thought. This also might be an alternative to the coloring page for the older student.

Unit Wrap-Up

At the end of each unit, there is an opportunity for the student to show what they have learned. The questions are in a multiple-choice format and are taken almost exactly from the lesson review exercises. So, a great way to prepare is to go over each review exercise for the lessons in that unit. The answer keys for the Unit Wrap-Ups start on page 315.

What's Important?

Building a Foundation

The important thing to keep in mind is that God is at the center of everything — including the study of chemistry. The more advanced or older student may get more chemistry from the book

Additional Notes

than a younger or less advanced student. It might be good to repeat this course every other year. Build a foundation. Things learned early will last a lifetime. Do your best— and have fun and learn!

Unit Four

States of Matter

We now know a little about what matter is made of and how it acts under certain conditions, but there is something else we should explore. Matter can change its state, meaning it can be a solid, liquid, or gas. Even when the state of matter changes, it remains the same chemically; physically, it's in a different state.

Additional Notes

Upon completing unit 4, the student should understand:

- The three states of matter
- Two very important gas laws
- How states of matter are changed from one to another
- How and why things dissolve

Unit 4 Vocabulary Words

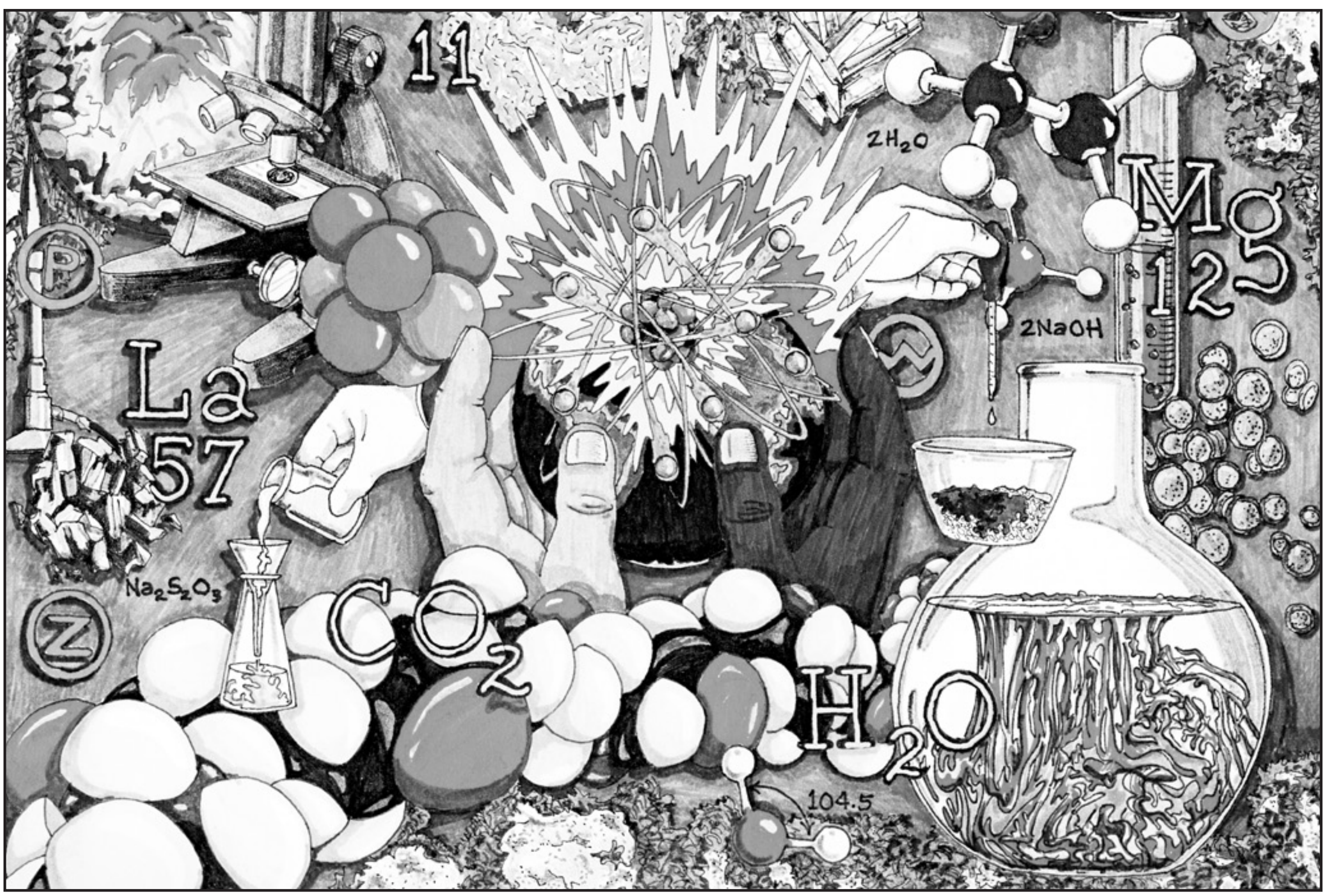
- solids
- liquids
- gas
- states of matter
- state change
- melting point
- freezing point
- boiling point
- solution
- solvent
- solute
- dilute solution
- saturated solution

Materials Needed for This Unit

- measuring cup with metric markings (milliliters or ml) that will measure at least 500 milliliters
- water
- salt
- sugar
- three rocks approximately the size of a ping-pong or golf ball
- laundry marking pen or crayons

- 3x5 index cards
- element cards that have already been started from lessons 4 and 8
- pencil
- small glass bottle (such as a Perrier water bottle) with a narrow neck (don't use plastic)
- two balloons
- a 2-quart saucepan or bowl
- six paper cups
- measuring spoon
- table salt
- thermometer that can measure the temperature of the freezer (optional)
- paper adhesive labels
- 1 cup of table sugar
- glass measuring cup
- safety goggles and lab smock

Additional Notes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La
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$Na_2S_2O_3$
CO_2
H_2O
104.5

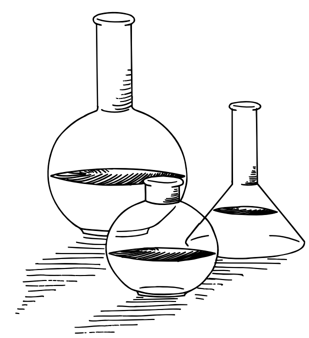
Lesson 19

SOLIDS AND LIQUIDS

Teaching Time :

Slow Solids and Lively Liquids

Did you know that molecules are always in motion? You might think they just rest quietly, but actually they are always moving around. Just how much molecules move depends on the amount of energy they have. The more energy they have, the more they move around. This idea of molecules moving around is important in explaining the difference between solids and liquids. Do you know the difference between a solid and a liquid? A liquid can be poured from one container to another, but a solid cannot. Let us look in more detail about the differences between solids and liquids.



Name It!
solid
Any kind of matter that has a definite shape.

Solids

Any kind of matter that has a definite shape is a **solid**. Definite shape means that the shape doesn't change. Consider a piece of

Name It!

liquid

A state of matter in which the substance flows (like water), has a constant volume, and takes on the shape of its container.

gold. It has a definite shape. If it is a piece of jewelry, it may be shaped like a ring, and when you place it on a finger, it keeps its shape. Can you name some other examples of matter that have definite shapes? It shouldn't be too hard to do since there are thousands of examples. Another important characteristic of solids is that they have definite volume. Volume is the amount of space something occupies or how much space there is. Let's think about a brick — the kind you might find in a building or a sidewalk. We can measure its length (7 inches); we can measure its height (2 inches); and we can measure its width (3 inches). By multiplying these three dimensions, we can figure out the volume: 7 x 2 x 3 = 42.

This means that the volume of the brick is 42 cubic inches of volume. Sometimes we represent volume using a metric system of measurement, which would result in the volume being described in milliliters instead of cubic inches, but it is still the volume. So solids are characterized by their definite shape and definite volume. Just remember that even if something is solid and keeps its shape, the molecules that it is made of are still moving, even if they are only moving a little.

Liquids

We said that the molecules in all matter move around. In solids, they move very little and that explains why the solid has a definite shape. In liquids, the molecules move much faster because they have more energy. This is why **liquids** don't have a definite shape. Liquids can take on different shapes depending on the shape of the container, but liquids do have a definite volume, and the volume can be measured. Let's look at liquid water for example. If we put some water into a measuring cup, we are able to look at the marks on the side of the cup and read the volume. This reading represents the exact volume of the liquid water. Try it. The volume is definite, but the shape is not definite. Let's say the volume of water is exactly 8 ounces. In the measuring cup, the water takes on the shape of the mea-

Additional Notes

suring cup. If we pour the water from the cup into a bowl, the water takes on the shape of the bowl. If you put the 8 ounces of water in a flower vase, the water takes the shape of the vase. Even though the shape changes, the amount of liquid obviously stays the same. So, liquids have definite volume but indefinite shape. In lesson 22, we will learn more about the energy changes that can take place between the solids, liquids, and the "goofy gases."

Review It

1. Molecules are in ________________.
2. Any kind of matter that has a definite shape and definite volume is a ________________.
3. In liquids, the ________________ move much faster because they have more energy.
4. Liquids have an indefinite ________________ but a definite ________________.
5. Molecules move more when they have more ________________.

Additional Notes

Hands-On:

Determining the Volume of a Solid

In this lesson we emphasized that one important characteristic of solid matter is definite volume. We could easily measure a brick and calculate its volume, but not every object is that easy. For example, a sphere, such as a golf ball, is round, so the calculation is a little different, but it can be calculated using a special formula. However, if we wanted to know the volume of something like a rock that has an unusual shape, the calculation could get complicated. Even if the shape of the rock is unusual, it still is solid and therefore has a definite shape. In this activity, we are going measure the volume of rocks to learn how to determine volume of unusually shaped objects. You may want to refer back to lesson 2 and review measuring — especially the discussion about interpolating.

Equipment Needed

- measuring cup with metric markings (milliliters or ml) that will measure at least 500 milliliters.
- water
- three rocks approximately the size of a ping-pong or golf ball
- laundry marking pen or crayons

Activity

1. Using the crayon or laundry marker, mark each rock with a different letter (A, B, and C).

Rock Sample	Water-Level Measurement without Rock	Water-Level Measurement with Rock	Volume of Rock Sample (Subtract 300 from the measurement with rock)
rock A	300 ml		
rock B	300 ml		
rock C	300 ml		
other			

2. Fill the measuring cup with exactly 300 ml of water.

3. Add the rock marked A; then record the measuring cup reading on the chart above. Remember from lesson 2, it is sometimes necessary to interpolate (or read between the lines) when measuring.

4. Remove rock A, letting all the water drip back into the measuring cup.

5. Check to be sure the water level returns to the 300 ml mark. If it doesn't, then carefully add a little more water until it is exactly 300 ml.

6. Repeat the steps with the other rocks, recording the readings on the chart.

7. Complete the calculation indicated on the chart.

Scripture

There is a mine for silver and a place where gold is refined. Iron is taken from the earth, and copper is smelted from ore. (Job 28:1-2)

Discovery Zone

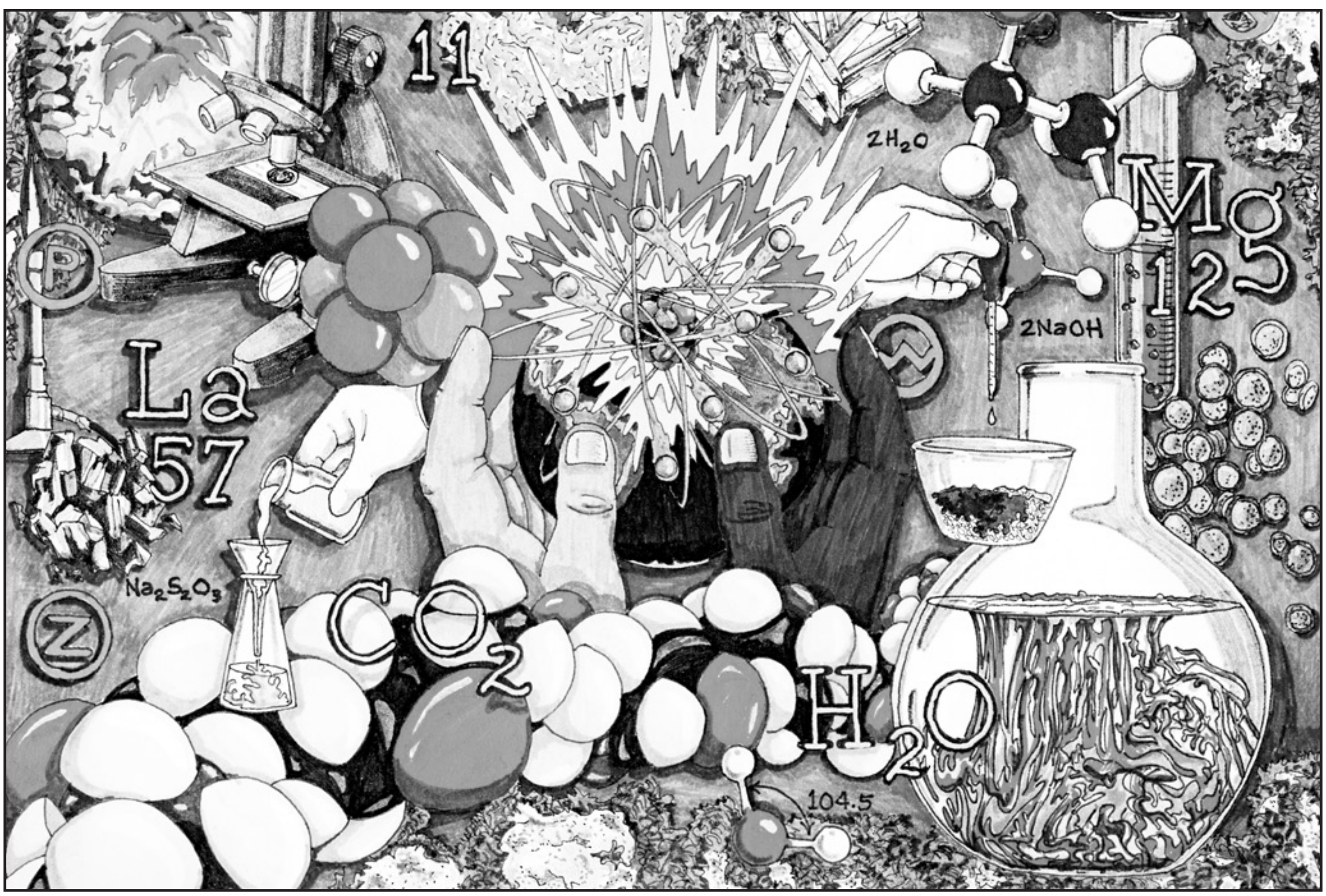
Water weighs about one pound per pint. So, if you want to quickly gain a pound (temporarily), just drink a pint of water.

Additional Notes

Think about It

1. Were you surprised at how easy it is to determine the volume of a solid that has an unusual shape?

2. Could this technique be used to figure out the volume of a person? Explain the way you would measure the volume of a person.



11
$2H_2O$
Mg
125
2NaOH
La
57
$Na_2S_2O_3$
CO_2
H_2O
104.5

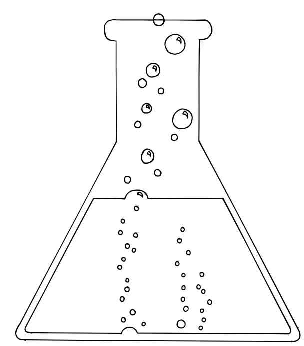
Lesson 20

GASES

Teaching Time:
Goofy Gases

Remember that we said that the molecules in solids move — but not very fast. We learned that molecules in liquids have more energy and move faster than molecules in solids. Well, the molecules in gases move the fastest. This is because molecules in a **gas** have a lot of energy. The slow-moving molecules in solids allow them to keep their shape. The molecules in a liquid have more energy, so the liquid can be poured, but it still stays inside its container. The molecules in a gas have a great deal of energy and move very fast. As a result, gases tend to spread out; they don't stay in one place very long. Gases do not have a definite shape or volume, but they will stay inside a container as long as it is closed tightly.

Can you think of any containers that have gas inside of them? One very common container is a balloon. Sometimes we blow air into a balloon to fill it up. This air is a mixture of many gases in our atmosphere, such as oxygen (O_2), nitrogen (N), and carbon dioxide (CO_2). Or people fill balloons with helium (He). This gas



Name It!

Gas

A state of matter in which the substance is airlike and does not have a definite shape or a definite volume.

Additional Notes

is very light compared to the normal air mixture and that's why it rises. If you tried to put helium gas in a cup it would escape into the air. Gases behave nicely inside a balloon, but those gas molecules have a lot of energy and want out. See what happens if you take a balloon and put a tiny hole in it. The molecules soon escape from the hole into the air.

When we talk about a gas, we are referring to a substance that is a gas at normal room temperature. Besides helium, oxygen, nitrogen, and carbon dioxide, there are many other elements that are gases at room temperature. Can you think of any? Of course there is hydrogen (H) and all the noble gases that we mentioned when we looked at the periodic table of the elements. There are many gases that we will be talking about when we study the organic chemistry in the next unit. These gases are dangerous and explosive.

Review It

1. The molecules in a gas have a lot of ________________.

2. ________________ tend to spread out; they don't stay in one place very long.

3. Gases do not have a definite ________________.

4. The air is a mixture of many gases in our atmosphere such as ________________ (O_2), ________________ (N), and ________________ ________________ (CO_2).

5. Helium (He) is a gas that is very ________________ compared to the normal air mixture, and that's why it rises.

Additional Notes

Hands-On:

Catch Up on Element Cards

It's time to catch up on the element cards for this unit. Check out your cards and add any information that may be helpful in understanding the elements. Boiling point, melting point, and freezing point may be interesting and helpful facts to add. Also, we've been talking about gases in this unit. Using the Internet, science books, or encyclopedia, look up the noble gases that we first discussed in lesson 9, and see how much information you can find on them.

Equipment Needed

- pack of 3x5 index cards
- element cards that have already been started from lessons 4 and 8
- pencil

Activity

1. Add new elements that we have studied and update the ones you already have.

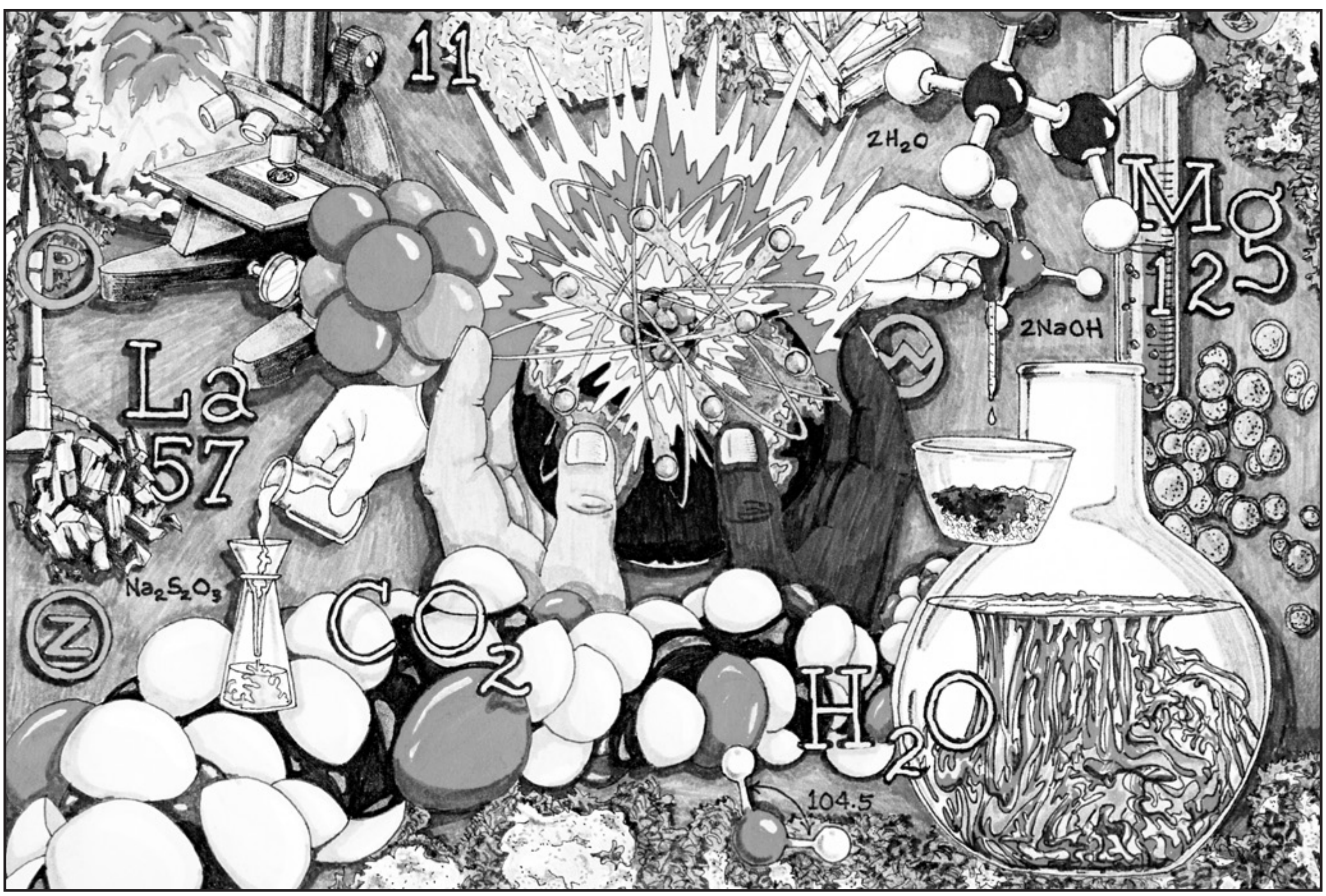
2. Complete as much information as you can for each element. For some this may only be the element name and symbol.

3. Review the cards and think about what you know about each element.

Scripture
Give thanks to the Lord, for he is good; his love endures forever. (Psalm 107:1)

Discovery Zone
One of the most important things the element calcium does in our bodies is to help our heart work correctly.

4. Keep the cards in a card box or bound with a rubber band and remember to update them as we continue our study of chemistry.



11
$2H_2O$
Mg
125
$2NaOH$
La
57
$Na_2S_2O_3$
CO_2
H_2O
104.5

Lesson 21

GAS LAWS

Teaching Time:

The Gas Police

What do we mean by gas laws? Do gas molecules really obey them? Yes, gas molecules really do obey these laws, but the molecules actually do not have any other choice; they are simply created that way by God. Gas laws and other laws in chemistry are an example of the order that God has created in the physical world of matter. In this lesson, we will discuss two gas laws — Boyle's law and Charles's law. These laws have to do with the temperature, volume, and pressure of a gas. **Pressure** is a word that is used to mean some amount of force that is applied to something. For example, you can put pressure on a certain area of your arm by squeezing it, and the amount of pressure on your arm could be measured. Or, when you fill a bicycle tire, it is important to know the pressure reading because too much air can make the tire explode. The same is true of car tires and even balloons. When we talk about a gas, we say that there is a specific amount of pressure placed on the gas. In other words, the gas is under pressure.

Additional Notes

Boyle's Law

In 1662, a British chemist and physicist named Robert Boyle discovered that if gas is put under a great amount of pressure, the volume of the gas would decrease as long as the temperature of the gas stayed the same. So, when much pressure is placed on gas, it can fit into a smaller space or volume. Let us say that you have a bottle filled with 2 liters of helium and it is has a pressure of 20 pounds per square inch (PSI). If the pressure is increased to 40 PSI, the gas will squeeze into a smaller amount of space — one liter. If you put the gas under 80 PSI of pressure, it will occupy a space of only one-half liter. So, Boyle's law says that if the pressure is increased, the volume will decrease.

Charles's Law

In 1787, a French scientist named Jacques Charles figured out how temperature affects the volume of a gas. Charles's law says that as the temperature of the gas is increased, the volume of the gas increases also. If our balloon contained 2 liters of helium (or any gas) at 100°K and the temperature is then doubled to 200°K, the volume of the gas in the balloon would be doubled to 4 liters. If we increase the temperature to 400°K, the volume of gas would expand to 8 liters. Of course, the balloon would have to withstand a pretty high temperature (but you get the idea). So, Charles's law says if the temperature is increased, the volume will increase.

(NOTE: Kelvin temperature [K] is a measurement of absolute temperatures. It is a way for scientists to measure temperature other than Celsius or Fahrenheit.)

Additional Notes

Review It

1. Gas laws and other laws in chemistry are an example of the order that God has ________________ in the physical world of matter.
2. ________________ is a word that is used to mean the amount of force that is applied to something.
3. Boyle's law says if the pressure is ________________, the volume will decrease.
4. Charles's law says if the temperature is ________________, the volume will increase.
5. Gas molecules really do obey the ________________ ________________.

Hands-On:

Testing Charles's Gas Law

If what Jacques Charles said about gases is true, we should be able to demonstrate it. There are some hard ways to check this out and some easy ways. One easy way is to trap some gas in a container, add some heat, and see if the volume of gas

Additional Notes

increases or not. Whether it is a single element gas, such as oxygen, or a mixture of gases in the air (nitrogen, oxygen, and carbon dioxide), the gas laws still apply. By putting a lid on the container, we have essentially trapped the gases inside. So, if we use a balloon as a lid over the top of the container, the gases are trapped. The advantage to a balloon is that we can *see* the volume of gases increasing as the balloon fills when heat is applied and the temperature of the gas increases.

Equipment Needed

- small glass bottle with a narrow neck, such as a Perrier water bottle. (Don't use plastic.)
- balloon
- 2-quart saucepan or bowl
- water
- safety goggles and lab smock recommended

Activity

1. Place the glass bottle into the refrigerator and leave it there for an hour.

2. Using the hottest water possible from the sink faucet, fill the 2-quart pan or bowl about three-fourths full of the hot water and set aside.

3. Retrieve the glass bottle from the refrigerator and quickly place a balloon over the mouth of the bottle. Ensure that it is sealed tightly.

4. Carefully place the bottle with the balloon in the hot water. You can also carefully allow hot water to run over the lower part of the bottle.

5. Observe the balloon.

6. Change the hot water to cold water and observe the change in the balloon.

7. Place the bottle, with the balloon still attached, back into the refrigerator.

8. Observe after an hour.

Think about It

1. About how much did the balloon fill up when the bottle was placed into the hot water? Can you explain the change in the balloon?

____

____

2. Where did the air that filled the balloon come from?

____

____

3. Why do you think the bottle was first put into the refrigerator?

____

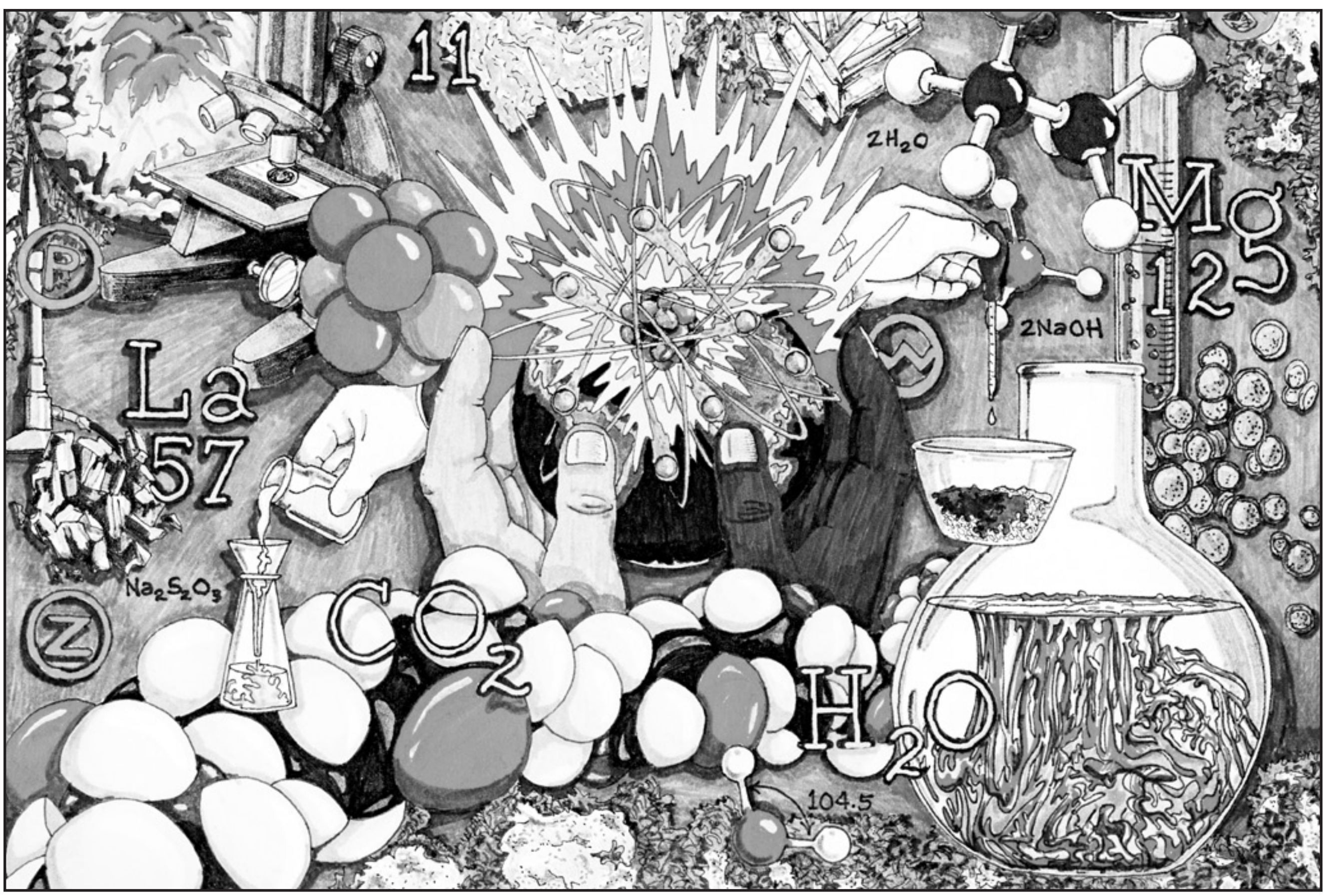
____

Scripture

Great are the works of the Lord: they are pondered by all who delight in them. (Psalm 111:2)

Discovery Zone

Diamonds are actually a pure form of carbon.



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$2H_2O$
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CO_2
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104.5

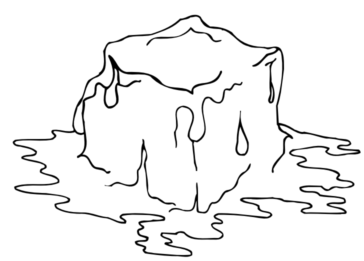
Lesson 22

STATE CHANGE

Teaching Time:

Some Statements about States

The difference between solids, liquids, and gases is really the difference in the amount of energy the molecules have. We know that the molecules in a liquid move much faster than the molecules in a solid, and the molecules in a gas move faster than the molecules in a liquid. So, if it is only a matter of energy level, what happens to a solid if we give it some energy? Wouldn't the molecules move faster? Yes! There are three states of matter: solid, liquid, and gas. Matter that is solid is said to be in a solid state. When it is liquid, it is in a liquid state. When it is a gas, it is in a gas state. When matter changes from one state to another, we call it a **state change**.



Name It!

state change
When matter changes from one state to another.

Name It!

melting point
The temperature at which a solid melts.

freezing point
The temperature at which a liquid freezes.

Melting Point — Solid to Liquid

If a solid is heated, the molecules receive energy and this makes them move faster. Heat is energy that can be put into matter. After heating a solid to a certain temperature, it melts and becomes a liquid. The temperature at which a solid melts is called the **melting point**. Water in the solid form (ice) melts at 32°F to the liquid form of water. Something like iron (Fe) melts at a much higher temperature, 2795°F. At that temperature, iron is a very hot liquid and it has a great deal of energy. If the temperature goes below 2795°F, the iron will become solid again. Aluminum is another metal solid with a high melting point — about 1220°F.

Freezing Point — Liquid to Solid

If the temperature of a liquid is lowered, heat (energy) is taken away from the molecules, causing them to move slower. After lowering the temperature to a certain point, the energy level is so low that the liquid freezes into a solid. The temperature at which the liquid freezes is called the **freezing point**. Another term for freezing point is solidification point. Water in its liquid form will freeze into solid ice at 32°F. It is also the point at which the solid water, the ice, will turn back into water. The freezing point and melting point of a substance are the same. It is the point at which the state will change to solid with a little less heat or to a liquid with a little more heat. We said the melting point of iron is 2795°F. Therefore, you could say that it is the freezing point as well because with a little less heat the iron begins to solidify again.

Boiling Point — Liquid to Gas

When even more heat is applied, liquid molecules get even more energy and move even faster. Eventually those molecules have enough energy to escape from the liquid and move into the air as a gas. It may be hard to imagine, but even iron can be turned into a gas if enough heat is applied. Those molecules would get so much energy, they would just fly away into the air. The temperature at which a liquid becomes a gas is called the **boiling point**. The boiling point for water is 212°F. This means that as soon as some of the water molecules reach that temperature they become water vapor. We know that iron is a solid. We also know that iron will melt at 2795°F. Do you think iron could actually turn into a gas? Of course it can. It takes a very powerful heat source, but by heating iron to 4982°F, it becomes a gas and floats off into the air. So, we say the boiling point for iron is 4982°F.

Name It!
boiling point
The temperature at which a liquid becomes a gas.

Review It

1. The difference between solids, liquids, and gases is the difference in the amount of ________________ the molecules have.
2. If a solid is heated, the molecules are getting energy to move ________________. Heat is ________________ that can be put into matter.
3. The temperature at which the solid melts is called the ________________ point.
4. The temperature at which the liquid freezes is called the ________________ point.
5. The temperature at which the liquid becomes a gas is called the ________________ point.

Additional Notes

Hands-On:
Evaluating the Freezing Point of NaCl in Water

Every substance has a solidification point (freezing point), a melting point, and a boiling point. These are the temperatures at which the state will change between solid, liquid, and gas. These are some of the physical properties that we talked about in lesson 3. Pure water has a freezing point of 32°F. However, when the compound sodium chloride (table salt) is dissolved in water, the freezing point of the water is lowered, which means that it won't freeze at 32°F. The reason for the difference in freezing point is a little complicated, but it has to do with the molecular structure and interaction of the Na and Cl ions in the water. Sometimes when ice forms on streets and sidewalks, sodium chloride and other salts like calcium chloride are used to melt the ice and keep the surface from becoming slippery and dangerous. We will see this chemistry in action in this Hands-On.

Equipment Needed

- two paper cups
- measuring spoon
- measuring cup
- table salt
- thermometer that can measure the temperature of the freezer (optional)
- paper adhesive labels

Activity

Additional Notes

1. Label one paper cup "NaCl and H_2O" and label the other cup "H_2O Only."
2. Fill a measuring cup with 50 milliliters of water.
3. Pour the water into the "H_2O Only" paper cup.
4. Fill the measuring cup again with 50 milliliters of water.
5. Add 3 teaspoons of salt to the water in the measuring cup.
6. Using a spoon, stir vigorously for about two minutes or until the salt is almost completely dissolved in the water.
7. Pour the contents of the measuring cup into the "NaCl and H_2O" paper cup.
8. Place both of the cups in the freezer.
9. Place the thermometer anywhere inside the freezer.
10. Wait about four hours.
11. Read the temperature of the freezer (optional).
12. Remove the cups from the freezer and observe the contents.
13. Return the cups to the freezer, wait 24 hours, and examine the contents again.

Scripture
Shout for joy to the Lord, all the earth. (Psalm 100:1)

Discovery Zone
Chemists who study analytical chemistry try to figure out what things are made of.

Think about It

1. Were you surprised that there were no differences in the condition of the contents of the cups after 24 hours?

____

____

2. What was the temperature of the freezer? Therefore, what was the temperature of the NaCl dissolved in water?

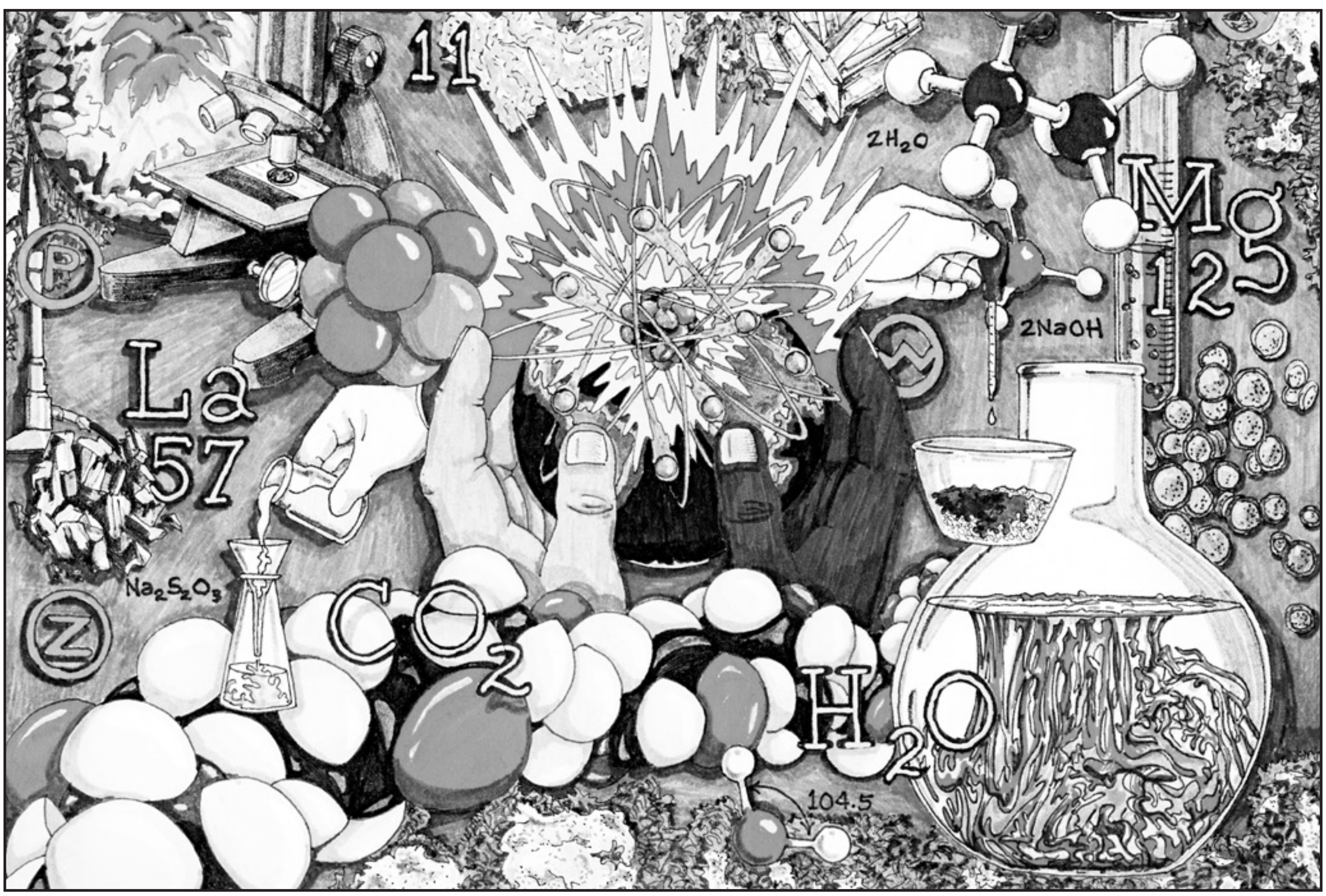
____

____

3. Do you think the water would freeze if less NaCl was in it? Try using 2 teaspoons, 1 teaspoon, and ½ teaspoon.

____

____


11
$2H_2O$
Mg
125
2NaOH
La
57
$Na_2S_2O_3$
CO_2
H_2O
104.5

Lesson 23

SOLUTIONS

Teaching Time:

A Salute to Solutions

What do you think of when someone says the word *solution*? In chemistry, a **solution** means that two or more substances (either a compound or an element) are mixed very well together so that all the different atoms and molecules are evenly distributed.

There are two types of ingredients in a solution, the solvent and the solute. The **solvent** of the solution is the substance present in the solution in the greatest amount. The **solute** is the substance present in a lesser amount. We sometimes say the solute is dissolved in the solvent. For liquid/solid solutions, the liquid is the solvent and the solid substance is the solute. It is possible to have more than one solute in a solution. For example, in a sodium chloride/sucrose/water solution, water is the solvent and sodium chloride (table salt) and sucrose (sugar) are the solutes.

There are also gas/gas, gas/liquid, liquid/liquid, and solid/solid solutions. Do you think that a solid/solid solution sounds strange? One example of a solid/solid solution is sterling silver, which is made by combining the elements of copper

Name It!

solution
Two or more substances (either a compound or an element) mixed very well together so that all the different atoms and molecules are evenly distributed.

solvent
The substance present in a solution in the greatest amount.

Name It!

solute
The substance present in a solution in a lesser amount.

dilute solution
A solution in which just a small amount of a solute is dissolved.

saturated solution
A solution of the greatest amount of solute that can be dissolved into a solvent at a given temperature.

and silver. Silver is the solvent since it is present in the greatest amount and copper is the solute. An example of a gas/liquid solution is carbonated water. Water is the solvent and carbon dioxide gas is the solute. What kind of solution do you think soft drinks are? If you think it is a solid/gas/liquid solution, you are right.

There is another way to characterize solutions and that is by telling how much of the solute is present — in general terms. A **dilute solution** means that just a small amount of a solute is dissolved. Some amount of solute is added to a solvent and stirred a little, and it is dissolved. A **saturated solution** contains the greatest amount of solute that can be dissolved into a solvent at a given temperature.

Review It

1. A ________________ means that two or more substances are mixed very well together so that all the different atoms and molecules are evenly distributed.
2. There are two types of ingredients in a solution, the ________________ and the ________________.
3. The solvent of the solution is the substance present in the solution in the ________________ amount.
4. The solute (or solutes) is the substance present in a ________________ amount.

5. Soft drinks are an example of a

_________________/_________________/

_________________ solution.

Additional Notes

Hands-On:

Preparing a Saturated Solution

Sugar solutions are important in the kitchen, in the laboratory, and in medicine. In the kitchen, there are a variety of syrups and other sugar-containing liquids. The laboratory relies on known concentrations of sugar solutions for experiments. If you have ever been in a hospital or watched a television program about hospitals, you've probably seen patients with an intravenous (IV) tube going into a vein in their arm. The tube comes from a bottle that is usually hanging on a pole beside the patient's bed. A variety of medicines can be in the bottle, but many times the clear liquid going into the patient is a sugar solution. The sugar can be glucose and is given to replace fluids and give the patient strength to get well. The amount of glucose varies (5%, 10%, or 20% glucose solution), but they are all made by dissolving the glucose (solute) into water (solvent). This means that a certain percentage of the solution in the bottle is glucose.

For this Hands-On, we will make a saturated sugar solution using sucrose (table sugar) and water.

Additional Notes

Equipment Needed

- 1 cup (250 milliliters) of sucrose (table sugar)
- 100 milliliters of water
- glass measuring cup
- measuring tablespoon

Activity

1. Pour 100 milliliters of water into the measuring cup.

2. Add sugar, 1 tablespoon at a time, to the water. Stir each spoonful until completely dissolved.

3. After each tablespoon is added and stirred, observe the solution. If all the sugar crystals dissolve and the solution is clear, then the solution is not yet saturated. (Note: It may take quite a few tablespoons to get a saturated sucrose solution. The amount of sugar required may vary due to water hardness or temperature variation.)

4. When the crystals no longer dissolve — even after several minutes of stirring — the saturation point has been exceeded.

Think about It

1. How many tablespoons of sugar did it take to get to saturation?

____

____

Additional Notes

2. What do you think will happen if you let the liquid evaporate? You could pour some into a pie pan or jar and see. This may take several days — be patient. Describe what remains in the cups.

____

____

Hands-On (Easier Alternative)

Which Is Which?

When salt (NaCl) is dissolved in water, the original shape of the salt grains is no longer visible. The same is true when sugar is dissolved in water. This would make it difficult to determine which was which based on appearance.

Equipment Needed

- four paper cups that are exactly alike
- table salt
- sugar

Activity

1. Fill each cup with 4 ounces of warm tap water.

2. In two of the cups, place 1 teaspoon of sugar.

3. In the other two cups, place 1 teaspoon of salt.

4. Stir all four cups until the salt and sugar are dissolved.

Scripture
May the glory of the Lord endure forever; may the Lord rejoice in his works. (Psalm 104:31)

Discovery Zone
The ocean is really a giant solution. Water is the solvent and many salts are the solutes.

5. Mix up the cups so you don't know which has sugar and which has salt.

6. Examine each cup and try to determine which ones contain dissolved sugar and which contain the dissolved salt.

7. After trying to guess by looking, try smelling the solutions.

8. After smelling, try tasting the solutions. (Take a very small taste; you might want to spit it out.)

Think about It

1. Discuss the process of trying to figure out which was which. How did you do in guessing? This demonstrates that appearance isn't always a good way to determine what a substance is.

____

____

Unit Four Wrap-Up

Show What You Know!

1. Molecules in solids, liquids, or gases are always in ____________________.
   a. motion
   b. trouble
   c. atomic chaos

2. Any kind of matter that has a definite shape and definite volume is a ____________________.
   a. gas
   b. solid
   c. puzzle

3. In liquids, the ____________________ move much faster because they have more energy.
   a. molecules
   b. protons
   c. bugs

4. Liquids have an indefinite ____________________ and a definite ____________________.
   a. volume, shape
   b. problem, solution
   c. shape, volume

Study Notes

Study Notes

5. Molecules move more when they have more ____________________.
   a. space
   b. money
   c. energy

6. The molecules in a gas have a lot of ____________________.
   a. volume
   b. energy
   c. fun

7. ____________________ tend to spread out and don't stay in one place very long.
   a. Gases
   b. Cats
   c. Solids

8. Gas laws and other laws in chemistry are an example of the order that God has ____________________ in the physical world of matter.
   a. created
   b. learned
   c. forgotten

9. ____________________ is a word that is used to mean the amount of force that you apply to a specific area.
   a. Pressure
   b. Stress
   c. Punch

10. Boyle's law says if the pressure is ____________________, the volume will decrease.
    a. decreased
    b. increased
    c. released

Study Notes

11. Charles's law says if the temperature is ____________________, the volume will increase.
    a. decreased
    b. increased
    c. cold

12. Gas molecules really do obey the ____________________.
    a. speed limit
    b. gas laws
    c. ten commandments

13. The difference between solids, liquids, and gases is really the difference in the amount of ____________________ the molecules have.
    a. money
    b. power
    c. energy

14. Heat is ____________________ that can be put into matter.
    a. temperature
    b. energy
    c. wasted

15. The temperature at which a solid melts is called the ____________________ point.
    a. final
    b. important
    c. melting

16. The temperature at which a liquid freezes is called the ____________________ point.
    a. freezing
    b. extreme
    c. good

Study Notes

17. The temperature at which a liquid becomes a gas is called the ____________________ point.
    a. gaseous
    b. boiling
    c. your

18. A ____________________ means that two or more substances are mixed very well together so that all the different atoms and molecules are evenly distributed.
    a. solution
    b. mess
    c. compound

19. There are two types of ingredients in a solution: the ____________________ and the ____________________.
    a. important, unimportant
    b. solvent, solute
    c. liquid, solid

20. Soft drinks are a ____________________ / ____________________ / ____________________ solution.
    a. solid, gas, liquid
    b. gas, gas, gas
    c. liquid, liquid, gas

appendix B

RESOURCE LIST

by Rebecca Delvaux

The majority of books in this appendix are likely to be stocked in most public libraries or available through interlibrary loan. Many are also available for purchase from major bookstores or homeschool book retailers. Please use your discretion as you investigate these resources. Many address topics such as evolution, include illustrations that you may deem inappropriate, and may interject thoughts contrary to biblical thought. We have included such resources because there is a glaring lack of explicitly Christian resources on the chemistry topics covered in this book.

Please note the list of chemistry reference books. These may be utilized with every lesson in addition to the other library books, but they are especially helpful for the lessons that have no library books listed. These reference books have illustrations, charts, and explanations that complement *Christian Kids Explore Chemistry* and may be particularly appreciated by younger learners and visual learners of all ages. Note that they are *not* from an explicitly Christian perspective.

I have noted if a resource is appropriate for a particular age group. Unless noted otherwise, books with 32 pages or less are

Additional Notes

lower grammar (LG) books and those with 64 or more pages are upper grammar books (UG). I have also noted if the resource provides adult-level, in-depth topic coverage. Of course, resources of any length may be useful for both lower and upper grammar level children.

Many helpful videos and DVDs are also available to enhance your study of chemistry. A comprehensive list of supplemental videos is available online at www.brightideaspress.com — complete with links to online retailers to simplify your research and shopping. There you will also find lists of games, websites, and magazines to supplement your study of chemistry.

It is my heartfelt prayer that you and your children will be richly blessed by this curriculum and the supplemental resources.

Chemistry Reference Books

A Guide to the Elements by Alvert Stwertka (Oxford University Press; ISBN: 0195150279; 2002; 248pp) FYI: Written for 9 – 12 year olds

Chemistry (Eyewitness Science) by Ann Newmark (Dorling Kindersley; ISBN: 0789448815; 1999; 64pp)

Matter (Eyewitness Science) by Christopher Cooper (Dorling Kindersley; ISBN: 0789448866; 1999; 64pp)

Ultimate Visual Dictionary of Science (Usborne Books; ISBN: 0789435128; 1998; 448pp)

Usborne Illustrated Dictionary of Chemistry (Usborne Books; ISBN: 0746037945; 2000; 128pp)

Usborne Illustrated Dictionary of Science (Usborne Books; ISBN: 0794500641; 2001; 382pp)

Usborne Book of Science (Usborne Books; ISBN: 0746008309; 144pp) Covers chemistry, physics, and biology.

Online chemistry encyclopedia at Science Daily (online magazine); brief listings with illustrations at: www.sciencedaily.com/encyclopedia/chemistry/

Additional Notes

Unit One: The Basics of Chemistry

Lesson 1: Introduction to Chemistry?
chemistry reference books

Lesson 2: Chemistry Tools
chemistry reference books

Test Tubes and Beakers: Chemistry for Young Experimenters by E.H. Coulson, A.E.J. Trinder, and Aaron Klein (Doubleday; 1971; 134pp)

Lesson 3: Matter
chemistry reference books

Matter Really Matters (Let's Wonder about Science series) by J.M. Patten (Rourke, ISBN: 1559161248; 1995; 24pp)

Matter (Eyewitness Science) by Chris Cooper (Dorling Kindersley; ISBN: 1879431882; 1992; 64pp)

Lesson 4: Elements
chemistry reference books

The Periodic Kingdom: A Journey into the Land of the Chemical Elements (Science Masters series) by P.W. Atkins (Basic Books; ISBN: 0465072666; 1997; 176pp) Adult

Additional Notes

Elements, Compounds, and Mixtures (Let's Wonder about Science series) by J.M. Patten (Rourke; ISBN: 1559161272; 1995; 24pp)

What Is the World Made Of? All About Solids, Liquids, and Gases (Let's-Read-and-Find-Out Science Book) by Kathleen Weidner Zoehfeld (HarperCollins; ISBN: 0060271442; 1998; 32pp)

A Guide to the Elements by Albert Stwertka (Oxford University Press; ISBN: 0195150279; 2002; 248pp) FYI: Written for 9–12 year olds

Sparks of Life series by Jean F. Blashfield (Raintree Steck-Vaughn; 2002; 64pp)

- *Magnesium* (ISBN: 0739843605)
- *Iron and the Trace Elements* (ISBN: 0739843591)
- *Chlorine* (ISBN: 0739843583)
- *Sulfur* (ISBN: 0739834525)
- *Potassium* (ISBN: 0739834517)
- *Phosphorus* (ISBN: 0739834509)
- *Sodium* (ISBN: 0817250425)
- *Oxygen* (ISBN: 0817250379) [+Unit 7]
- *Nitrogen* (ISBN: 0817250395)
- *Hydrogen* (ISBN: 0817250387)
- *Carbon* (ISBN: 0817250417) [+Unit 5]
- *Calcium* (ISBN: 0817250409)

The Elements series by Jens Thomas (Benchmark Books; 2002; 32pp)

- *Silicon* (ISBN: 0761412743)
- *Carbon* (ISBN: 0761408789) [+Unit 5]
- *Noble Gases* (ISBN: 0761414622) [+Unit 4]

Additional Notes

Chemicals in Action series by Chris Oxlade (Heinemann Library; 2002; 48pp)

- *Metals* (ISBN: 1403425000)
- *Elements and Compounds* (ISBN: 1588101967)
- *Atoms* (ISBN: 1588101959)
- *Materials, Changes and Reactions* (ISBN: 1588101975) [+Unit 3]
- *States of Matter* (ISBN: 1588101991) [+Unit 4]

First Books — Chemical Elements series by Karen Fitzgerald (Franklin Watts; 1997; 64pp)

- *The Chemical Elements* (ISBN: 0531194558)
- *The Story of Oxygen* (ISBN: 0531202259)
- *The Story of Nitrogen* (ISBN: 0531202488)
- *The Story of Iron* (ISBN: 0531202704)

Lesson 5: Mixtures and Compounds

chemistry reference books

Unit Two: Atoms and Molecules

Lesson 6: the Atoms

chemistry reference books

Atoms and Molecules (Usborne Understanding Science) by P. Roxbee-Cox and M. Parsonage. (Usborne; ISBN: 1881105899; 32pp) UG+

Lesson 7: Atomic Number

chemistry reference books

Atoms and Molecules (Usborne Understanding Science) by P.

appendix C

FOR FURTHER BIOGRAPHICAL STUDY

Biographies

Antoine Lavoisier: Founder of Modern Chemistry (Great Minds of Science) by Lisa Yount (Enslow; ISBN: 0894907859; 1997; 128pp)

Louis Pasteur: Disease Fighter by Linda Wasmer Smith (Enslow; ISBN: 0894907905; 1997;128pp)

Marie Curie: Discoverer of Radium by Margaret Poynter (Enslow; ISBN: 0894904779; 1994; 128pp)

Marie Curie (History Maker Bios) by Laura Hamilton Waxman (Lerner Publications; 2004; 48pp)

The Mystery of the Periodic Table (Living History Library) by Benjamin Wiker and Jeanne Bendick (Bethlehem Books; ISBN: 188393771X; 2003; 170pp)

Additional Notes

Oxford Portraits in Science series, various authors (Oxford University Press) UG

Linus Pauling: And the Chemistry of Life by Tom Hager (ISBN: 0195139720; 2000; 144pp)

Louis Pasteur and the Hidden World of Microbes by Louise Robbins (ISBN: 0195122275, 2001; 128pp)

Francis Crick and James Watson: And the Building Blocks of Life by Edward Edelson (ISBN: 0195114515; 1998; 110pp)

The Story of Science series by Joy Hakim (author of A History of U.S. series). (Smithsonian Institution Press; 2004; 256pp). These books read like adventure stories, and they are filled with chronological narratives about many scientists and their discoveries.

- *The Story of Science, Book One: Aristotle Leads the Way* (ISBN: 1588341607)
- *The Story of Science, Book Two: Newton at the Center* (ISBN: 1588341615)
- *The Story of Science, Book Three: Einstein Adds a New Dimension.* (ISBN: 1588341623)

Youngfolk's Book of Invention by T.C. Bridges (Little, Brown & Company; 1925)

- Read chapter 4, "Iron, Tin, and Steel," for a story about "Dud" Dudley, Andrew Yarranton, and Richard Reynolds. The chapter is available online: http://www.usgennet.org/usa/topic/preservation/science/inventions/cover.htm

- Read chapter 17, "Electric Light and the Phonograph," for a story about Mr. Edison and how carbon became a key to one of his inventions. The chapter is

Additional Notes

available online: http://www.usgennet.org/usa/topic/preservation/science/inventions/cover.htm

- Read chapter 19, "Balloons and Airships," for a story about gases, Bartolome Lorenzo di Guzmao, Francis Lana, Henry Cavendish, Stephen and Joseph Montgolfier, M. Pilâtre de Rozier, and James Sadler. This chapter is available online at: http://www.usgennet.org/usa/topic/preservation/science/inventions/cover.htm

- Read chapter 22, "From Gunpowder to High Explosives," for a story about Alfred Nobel's work with acids leading to explosives and establishing the annual Nobel Prize. This chapter is available online at: http://www.usgennet.org/usa/topic/preservation/science/inventions/cover.htm

- Read chapter 26, "Radium and the X-Ray," for a story about Marie Curie. The chapter is available online: http://www.usgennet.org/usa/topic/preservation/science/inventions/cover.htm

- Read chapter 27, "The Electric Furnace," for a story about Henri Moissan and his work with carbon. The chapter is available online: http://www.usgennet.org/usa/topic/preservation/science/inventions/cover.htm

Notable Chemists to Research

- Alchemists (precursors to chemists; ca 400-1400)
- Ampere, Andre Marie
- Armstrong, Henry
- Arrhenius, Svante

Answer Key
Unit Four Wrap-Up

Directions to Teachers
Correct answer is bold.

1. Molecules in solids, liquids, or gases are always in ____________________.
   a. motion
   b. trouble
   c. atomic chaos

2. Any kind of matter that has a definite shape and definite volume is a ____________________.
   a. gas
   b. solid
   c. puzzle

3. In liquids, the ____________________ move much faster because they have more energy.
   a. molecules
   b. protons
   c. bugs

4. Liquids have an indefinite ____________________ and a definite ____________________.
   a. volume, shape
   b. problem, solution
   c. shape, volume

5. Molecules move more when they have more
______________________.
   a. space
   b. money
   c. energy

6. The molecules in a gas have a lot of
______________________.
   a. volume
   b. energy
   c. fun

7. ______________________ tend to spread out and don't stay in one place very long.
   a. Gases
   b. Cats
   c. Solids

8. Gas laws and other laws in chemistry are an example of the order that God has ______________________ in the physical world of matter.
   a. created
   b. learned
   c. forgotten

9. ______________________ is a word that is used to mean the amount of force that you apply to a specific area.
   a. Pressure
   b. Stress
   c. Punch

10. Boyle's law says if the pressure is ______________________, the volume will decrease.
   a. decreased
   b. increased
   c. released

11. Charles's law says if the temperature is ____________________, the volume will increase.
    a. decreased
    b. increased
    c. cold

12. Gas molecules really do obey the ____________________.
    a. speed limit
    b. gas laws
    c. ten commandments

13. The difference between solids, liquids, and gases is really the difference in the amount of ____________________ the molecules have.
    a. money
    b. power
    c. energy

14. Heat is ____________________ that can be put into matter.
    a. temperature
    b. energy
    c. wasted

15. The temperature at which a solid melts is called the ____________________ point.
    a. final
    b. important
    c. melting

16. The temperature at which a liquid freezes is called the ____________________ point.
    a. freezing
    b. extreme
    c. good

17. The temperature at which a liquid becomes a gas is called the ____________________ point.
    a. gaseous
    b. boiling
    c. your

18. A ____________________ means that two or more substances are mixed very well together so that all the different atoms and molecules are evenly distributed.
    a. solution
    b. mess
    c. compound

19. There are two types of ingredients in a solution: the ____________________ and the ____________________.
    a. important, unimportant
    b. solvent, solute
    c. liquid, solid

20. Soft drinks are a ____________________ / ____________________ / ____________________ solution.
    a. solid, gas, liquid
    b. gas, gas, gas
    c. liquid, liquid, gas

Answer Key

Review It Exercises

UNIT ONE

Lesson 1

1. matter
2. chemist
3. created
4. carbon
5. biochemistry

Lesson 2

1. test tube
2. Erlenmeyer flask
3. beaker
4. glass tubing
5. funnel

Lesson 3

1. weight, space
2. matter, energy
3. solid, liquid, gas
4. properties
5. Physical

Lesson 4

1. element
2. compound
3. 92
4. matter
5. God

Lesson 5

1. compound, mixture
2. mixture
3. compound
4. chlorine, sodium
5. solid, gas, liquid

UNIT TWO

Lesson 6

1. atom
2. nucleus, extranuclear region
3. neutron, proton
4. positive, negative
5. equal

Lesson 7

1. atomic number
2. protons
3. unique
4. carbon
5. ions

Lesson 8

1. weight
2. protons, neutrons
3. atomic mass number
4. scientific instruments
5. periodic table of the elements

Lesson 9

1. atomic number
2. number, weight, symbol
3. periodic law
4. noble
5. metals

Lesson 10

1. Molecule
2. substance
3. small
4. water
5. element, elements

UNIT THREE

Lesson 11

1. chemical bond
2. ionic
3. five
4. protons
5. ionic

Lesson 12

1. covalent
2. shared
3. two
4. molecule
5. eight

Lesson 13

1. chemical formula
2. symbols
3. two, one
4. front
5. $C_{12}H_{22}O_{11}$

Lesson 14

1. sodium chloride
2. God
3. Chemists
4. binary
5. chemistry

Lesson 15

1. chemical reaction
2. bond
3. reactants
4. products
5. characteristics

Lesson 16

1. acids, bases
2. proton
3. metals
4. bases
5. ion

Lesson 17

1. bitter
2. slippery
3. grease
4. acids
5. accept

Lesson 18

1. salt
2. Tin fluoride
3. Living things
4. acid, base
5. calcium carbonate

UNIT FOUR

Lesson 19

1. motion
2. solid
3. molecules
4. shape, volume
5. energy

Lesson 20

1. energy
2. Gases
3. shape or volume
4. oxygen, nitrogen, carbon dioxide
5. light

Lesson 21

1. created
2. Pressure
3. increased
4. increased
5. gas laws

Lesson 22

1. energy
2. faster, energy
3. melting
4. freezing
5. boiling

Lesson 23

1. solution
2. solvent, solute
3. greatest
4. lesser
5. solid, gas, liquid

UNIT FIVE

Lesson 24

1. Hydrocarbons
2. organic chemistry
3. methane
4. kerosene, asphalt
5. four

Lesson 25

1. alkane
2. carbon, hydrogen
3. ethane
4. -ane
5. butane

Lesson 26

1. double
2. ethene
3. stronger
4. C_3H_6
5. four

Lesson 27

1. carbon, hydrogen
2. covalent bond
3. alkyne
4. -yne
5. three

Lesson 28

1. derivatives
2. alcohol
3. hydrogen
4. Methanol
5. C_2H_5OH

Lesson 29

1. derivative
2. acids, alcohols
3. esters
4. plants
5. ester group

Lesson 30

1. information
2. amino acids
3. carbohydrate
4. glucose, fructose
5. energy