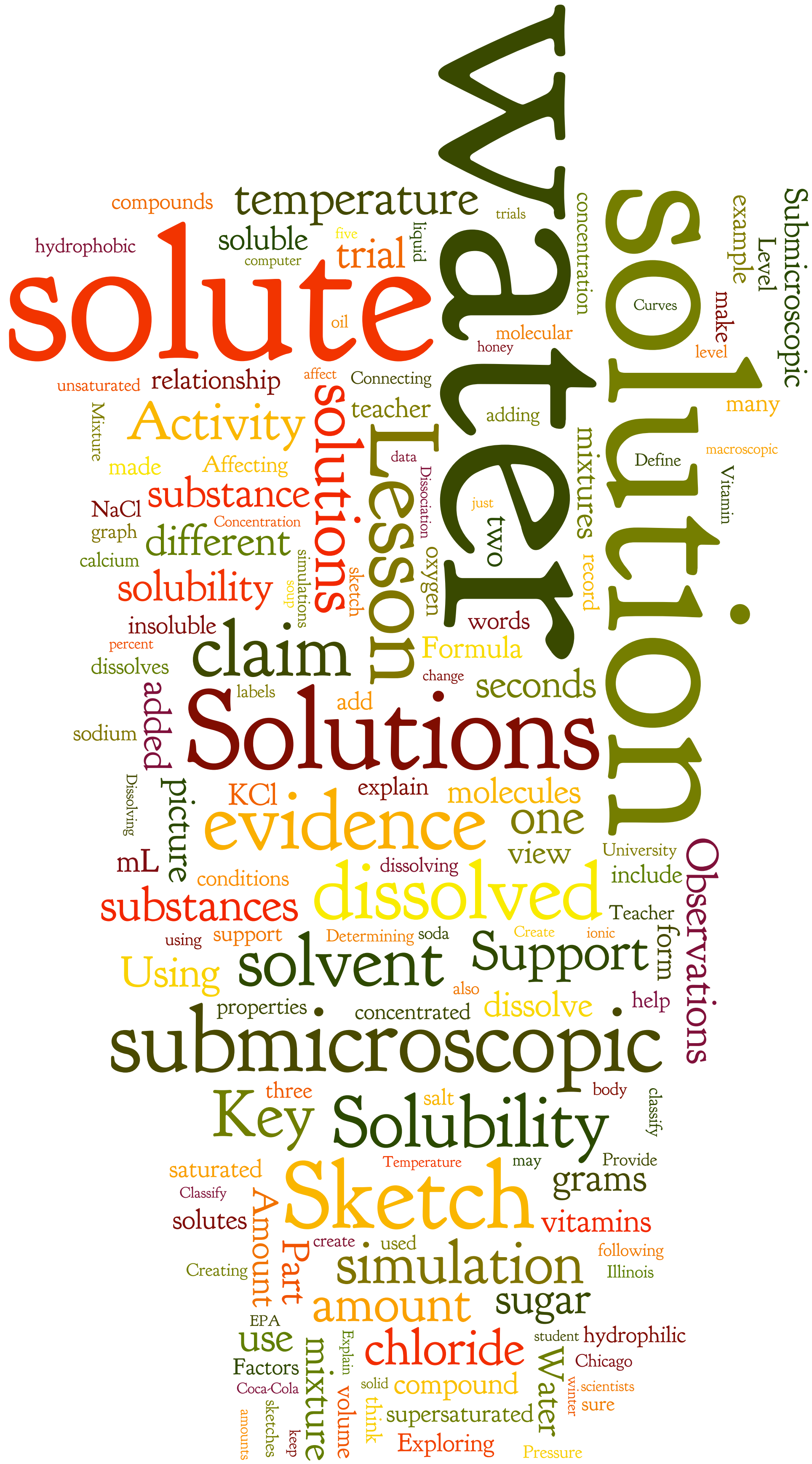
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Chicago
Coca-Cola
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amounts
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keep
volume
think
Pressure

The Connected Chemistry Curriculum

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U2S v4.0 1 January 2018

The Connected Chemistry Curriculum

Technology

System Requirements

The Connected Chemistry Curriculum has a software component (a set of *Simulations*) which is available at The Connected Chemistry Curriculum website, connchem.org. This software is necessary to use the curriculum, and is open-source and free of charge.

Besides the CCC software, you will need:

- **A personal computer of recent vintage, with an OpenGL-enabled graphics card.**
- **A 13" screen (or larger), with at least 1280 × 800 (WXGA) pixel resolution**
  For most computer monitors this is not a problem. Projectors, on the other hand, sometimes only manage VGA resolution (640 x 480), which will not allow sufficient room for our Simulations.
- **The latest Java runtime environment (JRE)**
  As of this writing, the latest JRE is Java 6, version 29. Java is free of charge: http://www.java.com/en/download/
- **Macintosh OS X 10.6 (Snow Leopard) or later, or Windows 7 or later**
  Earlier versions of the Macintosh OS or Windows may run, but may suffer performance issues. The software should also run on Linux. None of these options have been tested, however, so make sure you run all simulations before using them live in the classroom.

Troubleshooting

Please consult The Connected Chemistry Curriculum website (connchem.org) for up-to-date troubleshooting information, and to download software

The Connected Chemistry Curriculum

Welcome

Welcome to *The Connected Chemistry Curriculum*! The Connected Chemistry Curriculum, or CCC, is designed to help students learn about chemistry by directly exploring the submicroscopic level of matter and phenomena that form the basis of study in chemistry. Educators designed CCC using direct feedback from teachers, students and researchers. CCC uses computer-based simulations to provide a unique submicroscopic perspective of the chemical world for students.

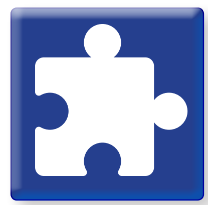
Activity Icons

These icons will be found throughout the teacher and student manuals.
The icons designate the purpose/theme of the activity or section.

Connecting

Hands-On Activity

Student Simulations

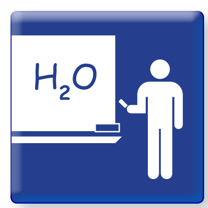


Putting It All Together

Questions

Lab Safety

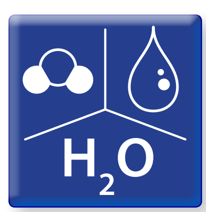
Sketching (without simulations)



Teacher Demonstration

Wet Lab

Teacher Facilitated Discussion



Chemistry Levels

Introductory Reading

Connected Chemistry
Solutions Unit
Contents

Connected Chemistry
Solutions Unit
Lesson 1: Exploring Solubility

Student's Lesson at a Glance

Lesson Summary

The importance of studying solubility is reinforced through an introduction regarding the role of solubility in the human body. Students explore solubility through the real-world application of hydrophobic and hydrophilic substances, a topic they may have some familiarity with from biology. Students continue to explore the differences between a solvent and solute on the macroscopic and submicroscopic levels. In the final activity of the unit, students will once again practice formula writing for the substances they will encounter throughout the unit.

SWBAT (Students Will Be Able To)

- Define solubility
- Explore the concepts of hydrophobic and hydrophilic
- Identify the components that make up a solution
- Define the difference between a solvent and a solute submicroscopically

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

Connected Chemistry Reminder

- Students and teachers from many different schools helped designed Connected Chemistry so that the lessons are more helpful and meaningful for all classroom participants.
- Many questions will ask you "what you think" or "to make predictions." The only answer that is wrong is the answer that is left blank.
- Prefixes and suffixes on words can help you discover the meaning of a word.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Symbolic keys can help you and others decode your sketches at a later time.
- Ions are charged particles that show up with a gray halo in the simulations. Ions makeup ionic compounds. Use the periodic table to determine the charge of an ion.

Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting

1. Why do you think water is called the "universal solvent"?

2. What chemical and physical properties do you think make water a good solvent?

3. What do you think it means to have a "phobia"?

4. What do you think the prefix "hydro" means?

Solubility is the ability of a solute to dissolve in a solvent. A **solute** is the substance that is dissolved into a solvent and the **solvent** is the liquid in which the solute dissolved. **Dissolving** is when a compound breaks apart into isolated particles. A common solvent is water, and a solution that has a substance dissolved in water is called an **aqueous solution.** Other liquids can be solvents too (e.g. hexane or acetone), but they do not form aqueous solutions because they are not composed of water. These solvents form non-aqueous solutions. Chemists are not the only scientists interested in studying how substances dissolve. Solubility is very important in the fields of nutrition, medicine, and environmental studies. Knowing what substances dissolve in water is important. For example, many substances that are helpful and harmful to people can dissolve in the water that people consume.

Nutritionists also need to differentiate which substances are soluble in water and which ones are insoluble in water. A substance is **soluble** in water if it dissolves when added to water. Likewise, a substance is **insoluble** in water if it does not dissolve in water. A nutritionist may suggest taking daily vitamins. Some vitamins are soluble in water, which we can drink to support the function of our body systems. Similarly, our digestive system breaks food into particles that can dissolve into our blood stream. Blood is an aqueous solution, which means it is a combination of water and other dissolved substances, such as vitamins and nutrients. Because blood is aqueous, it can transport many dissolved substances (e.g., vitamins and medicines) to the rest of the body.

Vitamins are necessary in very small amounts to help support many of the chemical reactions in your body. Unlike plants and bacteria that make their own vitamins, humans and other animals do not make all the vitamins they need to survive. Animals must get some vitamins from the food they eat, such as plants that produce edible fruits and vegetables. In fact, Vitamin D is the only vitamin that humans make, which is synthesized in the skin when it is exposed to sunlight. There are three essential vitamins (see table below) people must consume to stay healthy.

Understanding the chemical and physical properties of vitamins can help doctors, nutritionists, and patients make better choices about health. Knowledge of how vitamins work in the body allows you to get the maximum benefit from them. Some vitamins are *water soluble* and some vitamins are only soluble in fats. Vitamins B and C are water soluble and easily go into the bloodstream.

Water insoluble vitamins are also called *fat soluble* vitamins. Vitamins A, D, K, and E are insoluble in water, but soluble in fats. These vitamins mix with fats in foods and interact with *hydrophobic* and *hydrophilic* carriers in the body. These carriers can engulf the fat soluble vitamins and carry them into the bloodstream. Water soluble vitamins need to be replaced because they are flushed and excreted out easily; however, fat insoluble vitamins are stored in the liver. Taking too many fat soluble vitamins could cause a large build up in the liver and cause toxicity in the body.

Vitamin	Function
Vitamin B	Keeps the brain and nervous system healthy
Vitamin C	Keeps your immune system healthy
Vitamin K	Needed for blood and bones

5. Do you think that fats (such as oils) are soluble or insoluble in water? *Support your claim with evidence.*

6. Would vitamins A, D, K, and E be classified as *polar* or *nonpolar* based on how they behave in water? *Please explain.*

7. Would vitamins B and C be classified as polar or nonpolar substances based on how they behave in water? *Please explain.*

8. Since vitamins A, D, K, and E are insoluble in water, would they be classified as hydrophobic or hydrophilic? *Please explain.*

Activity 2: Introduction to Solutions and Solubility

Part 1: *Use Simulation 1, Set 1*

Many of the substances people use on a daily basis- such as hand soap, soup, orange juice, tap water, and soda – are not *pure substances*. Rather, these substances are **solutions**. Solutions are an example of **homogeneous mixtures**. Recall that a homogeneous mixture is one in which the solute molecules are evenly spread throughout the solvent molecules. Many, but not all, solutions include water as a solvent because one of water's physical properties is that it can dissolve many substances due to its *polarity*. Because of this, scientists often refer to water as the "universal solvent". Recall that a solution that has a solute dissolved in water as a solvent is called an aqueous solution. When a tablespoon of Kool-Aid © powder (solute) is added to a cup of water (solvent), the Kool-Aid © powder dissolves to form a Kool-Aid © drink (an aqueous solution) that contains sugar molecules, dye molecules, and water molecules.

9. Define solvent in your own words.

10. Define solute in your own words.

List four everyday substances which are solutions. Identify one solute and one solute in each solution.

Solution	**One solute in the solution**	**Solvent in the solution**
e.g., Kool Aid®	Sugar	Water

View your teacher's simulation of a aqueous solution of water and another common substance. Create a submicroscopic sketch of the solution. Sketch one molecule of the solvent and one formula unit of the solute. Remember, the gray halos in a simulation indicates that an ion has formed.

Sketch submicroscopic view of the solution	**Sketch one molecule of the solvent**	**Sketch one formula unit of the solute**
Key		

11. Using the computer simulation monitors, determine how many solute particles are in the simulation.

12. Using the computer simulation monitors, determine how many solvent particles are in the simulation.

Lesson Reflection Questions

13. Based on what you see in the simulation you just sketched, can you revise your definition of a solvent by adding more information? If so, what can you add to your definition?

14. Based on what you see in the simulation you just sketched, can you update your definition for a solute with more information? If so, what can you add to your definition?

15. Based on what you see in the simulation you just sketched, can you update your definition for a solution with more information? If so, what can you add to your definition?

16. Based on what you see in the simulation you just sketched, can you update your definition for an aqueous solution with more information? If so, what can you add to your definition?

Part 2

Although Kool-Aid® powder is soluble in water, other substances such as pure metals (e.g., gold, silver, titanium), wax, and olive oil are insoluble in water.

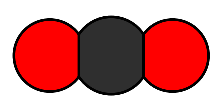
17. Would you classify solubility as a chemical or physical property? *Support your claim with evidence.*

18. If a substance is soluble in water, can you classify it as hydrophilic or hydrophobic? *Support your claim with evidence.*

19. If a substance is insoluble in water, can you classify it as hydrophilic or hydrophobic? *Support your claim with evidence.*

Activity 3: Putting It All Together – Decoding Scientific Observations Using a Key

Create a key for individual atoms. Decode the model of the compounds, using the key you created, into a chemical formula.

Name	Formula	Model
Carbon dioxide	CO_2	
Water		

Name	Formula	Model
Acetic acid (vinegar)		
Glycerol		
Sodium bicarbonate (baking soda)		
Pentane (oil)		
Ethanol		
Silicon dioxide (sand)		
Calcium chloride		

Name	Formula	Model
Sodium chloride		
Key		

20. Which substances from the table above are ionic compounds? *Support your claim with evidence.*

Connected Chemistry

Solutions Unit

Lesson 2: Dissolving and Dissociation

Student's Lesson at a Glance

Lesson Summary

In this two-day lesson, students observe the teacher's demonstration that not all homogeneous mixtures or solutions are the same. Students use computer simulations to simulate both soluble and insoluble substances in water. From this interaction, students classify these mixtures into different categories. By using the simulations, students can differentiate between a molecular and ionic compound. In the final activity, students use a model kit to simulate dissociation with water and sodium chloride.

SWBAT (Students Will Be Able To)

- Define dissolution and dissociation
- Distinguish between dissolving and dissociating
- Differentiate among solutions, suspensions, and colloids
- Explain that soluble ionic compounds dissociate into cations and anions when placed in water
- Explain that soluble molecular compounds dissolve into individual molecules when placed in water, but do not dissociate into ions

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

Connected Chemistry Reminder

- Many questions will ask you "what you think" or "to make predictions." The only answer that is wrong is the answer that is left blank.
- Prefixes and suffixes on words can help you discover the meaning of a word.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Symbolic keys can help you and others decode your sketches at a later time.

Notes

Homework

Upcoming Quizzes/ Tests

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Please turn to the next page.

Activity 1: Connecting

A **mixture** is a combination of two or more substances that are not chemically bonded and do not exist in fixed proportions to each other. Not all mixtures are the same. On the table, your teacher has three bottles of water and containers with equal amounts of sand and two unknown white crystallized substances (labeled #1 and #2). Your teacher is going to add the sand to one of the bottles of water, crystal substance #1 to a second bottle, and crystal substance #2 to the last bottle. After adding the sand and crystallized substances to the water, your teacher will shake them up.

1. Look at the glass of soda. What do you observe about the liquid in the bottle?

2. Look at the bottle of unshaken Italian salad dressing. What do you observe about the substance in the bottle?

3. Would you classify soda and Italian dressing as mixtures?

4. How are soda and Italian dressing different?

5. Describe what you see in the bottle with the sand and water.

6. Describe what you see in the bottle with the crystal substance #1 and water.

7. Describe what you see in the bottle with crystal substance #2 and water.

8. What makes the sand and water mixture different from the other two mixtures?

Recall, that the prefix *hetero* means “different.” A mixture that forms and separates into layers is called a **heterogeneous mixture**. A mixture that does not separate into layers, but evenly distributes the solute in the solvent is called a **homogeneous mixture**.

9. Crystal substance #1 and crystal substance #2 both formed homogeneous mixtures. Do you think the homogeneous mixtures formed in exactly the same way? *Support your claim with evidence.*

To create a solution, a solute is combined with a solvent, such as water. Solutions can be produced by one of two distinct processes. In the first process, a solute **dissolves**. Dissolving is when a compound breaks apart into isolated particles. The second process is when a substance **dissociates**. Dissociation is when an ionic compound dissolves and breaks apart into constituent ions.

10. Two of the mixtures above created a solution. Do you think the two solutions were created as a result of dissolution, dissociation, or a combination of the two? *Support your claim with evidence.*

Activity 2: Solubility Demonstration

Demonstration

Use Simulation 2, Set 6

- *Your teacher has a container with cooking oil and water in it.*
  Sketch a macroscopic view of the mixture.

Sketch a macroscopic view of oil and water	Describe your drawing

- *Your teacher will start a simulation of this mixture on the submicroscopic level.*
- *Your teacher will first add pentane, a type of substance that is similar to cooking oil, and then water. Sketch a submicroscopic view of the mixture and record your observations.*

Sketch Submicroscopic View of Mixture	Sketch One Molecule of Water	Sketch One Molecule of Pentane
Key		
Observations		

11. How would you classify a mixture of oil and water? Please explain.

12. Can a mixture of oil and water be considered a solution? *Support your claim with evidence.*

Activity 3: Solubility Simulation

Part 1

Use Simulation 2, Set 1-7

Your teacher has seven containers at the front of the classroom that contain the following mixtures:

- Water and sodium chloride
- Water and glycerol
- Water and sand
- Water and calcium chloride
- Water and acetic acid
- Water and pentane
- Water and sodium bicarbonate

Sketch what each of the mixtures look like on a macroscopic level.

Using the simulation, create each mixture and sketch a submicroscopic view of your observations. Include a key.

Mixture	Sketch a Macroscopic View of the Mixture	Sketch a Submicroscopic View of the Mixture	Observations of the Submicroscopic View
1. Water + Table Salt ($NaCl$)			
2. Water + Sand (Silicon Dioxide, SiO_2)			
Water + Glycerol ($C_3H_8O_3$)			
4. Water + Calcium chloride ($CaCl_2$)			

Mixture	Sketch a Macroscopic View of the Mixture	Sketch a Submicroscopic View of the Mixture	Observations of the Submicroscopic View
5. Water + Acetic Acid (CH_3COOH)			
6. Water + Pentane (C_5H_{12})			
7. Water + Baking Soda ($NaHCO_3$)			
Key			

13. Looking at the seven mixtures you made, which ones can you classify as solutions? *Provide evidence to support your claim.*

From this list, create two categories of mixtures. Classify the seven mixtures into the two categories you created.

NaCl and water

Sand and water

Pentane and water

Sodium bicarbonate and water

Acetic acid and water

$CaCl_2$ and water

Glycerol and water

Category	1____________________	2 ____________________
Mixtures		

14. Which of the seven mixtures were aqueous solutions? *Explain your answer.*

15. In the computer simulation, how does a solid compare to an aqueous solution?

16. Are the solids in the computer simulation (e.g., sand, sodium chloride) an accurate representation of how a solid would look in the real world? *Support your claim with evidence.*

Part 2

Use Simulation 2 Set 7

Re-examine the seven solutions at the front of the room.

17. Ignoring the labels and just looking at the containers on the macroscopic level, are you able to distinguish between the mixtures?

18. In both the sodium chloride and calcium chloride simulations, there were gray halos around the particles. What do the halos represent?

Recall that **compounds** contain atoms of multiple elements. There are two types of compounds: **molecular compounds** and **ionic compounds**. It is important to remember the differences between these types of compounds because ionic compounds and molecular compounds behave differently when they form solutions. Ionic compounds break apart by **dissociating** into charged particles call ions. Molecular compounds break apart by **dissolving** into individual molecules, but they do not break apart into charged particles or into individual atoms.Considering the three simulations again, classify the compounds based on the information you just read in the paragraph above.

19. Is sodium chloride an ionic compound or a molecular compound? *Support your claim with evidence.*

20. Is glycerol an ionic compound or a molecular compound? *Support your claim with evidence.*

21. Is calcium chloride an ionic or a molecular compound? *Support your claim with evidence.*

22. Is baking soda an ionic compound or a molecular compound? *Support your claim with evidence.*

23. What two differences can you identify when comparing calcium chloride and sodium chloride to baking soda?

Part 3

Look back at the sketches of the five solutions you completed in Part 1. Using this knowledge, classify the five solutions as dissociations or dissolutions.

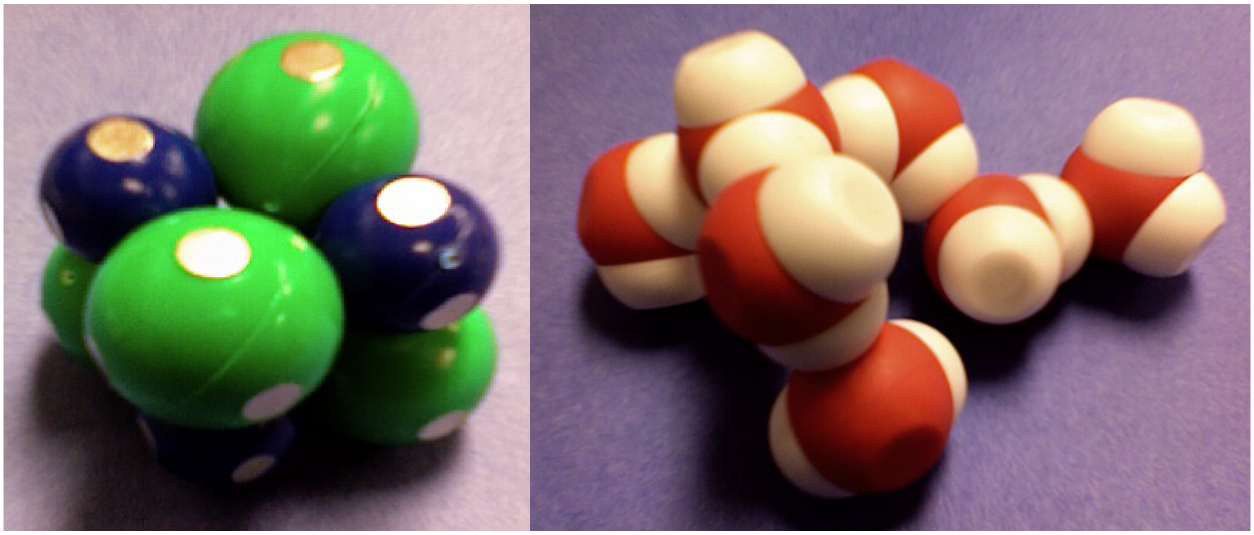
24. Is combining calcium chloride and water an example of a solution made through dissolution or dissociation? *Support your claim with evidence.*

25. Which of the five solutions include ionic compounds that dissociate? *Support your claim with evidence.*

26. Which of the five solutions include molecular compounds that dissolve? *Support your claim with evidence.*

Activity 4: Modeling Dissociation

The mixture of sodium chloride and water in the computer simulations can be represented with physical models. In your hand "mix" the NaCl (s) and H_2O (l) physical models.



Sketch the model after "mixing"	Observations
Key	

27. If there are attractions between the model atoms, describe which atoms are attracted to each other.

28. How does water, a polar substance, facilitate the dissociation of substances?

29. If you used a physical model of a pentane molecule, would you be able to create the same outcome as you did with the sodium chloride and water? *Support your claim with evidence.*

30. What does the physical model allow you to experience in the dissociation of sodium chloride in water that the computer simulations do not allow?

31. What is the limitation of using physical models to represent dissociation?

32. Instead of ions having halos as they do in the simulation, how is charge of the ion represented in the physical model?

Lesson Reflection Question

33. Create a Venn diagram that shows the similarities and differences between dissociation and dissolution.

Connected Chemistry

Solutions Unit

Lesson 3: Multiphase Solutions

Student's Lesson at a Glance

Lesson Summary

Students explore the concept that solutions can be made from more than just solid and liquid states of matter. Students investigate how polarity affects solubility. Students identify if real-world substances are solutions.

SWBAT (Students Will Be Able To)

- Identify what a multiphase solution is and how it is composed

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

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- Prefixes and suffixes on words can help you discover the meaning of a word.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Symbolic keys can help you and others decode your sketches at a later time.
- Dissolving and dissociating are different ways of forming a solution. Dissolving involves molecular compounds. Dissociating involves the breaking apart of ionic compounds into ions. Ions will have halos in solutions.

Notes

Homework

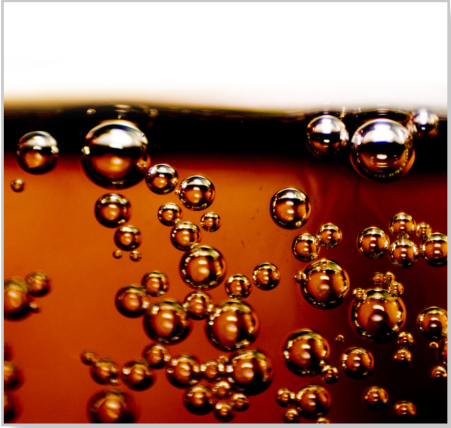
Upcoming Quizzes/ Tests

Activity 1: Connecting

1. What do you think are three factors that could affect solubility?

2. Consider the following statement about polarity: "Like dissolves like." How could you use this statement to select solvents and solutes when making solutions?

3. Do you think there is a relationship between the polarity of a molecule and how substances dissolve or dissociate at the submicroscopic level?



The most common way to create a solution is to use a liquid solvent and a solid solute. Water is used as a solvent to create aqueous solutions. However, this is not the only way to create solutions. Some liquids can be dissolved into other liquids. Mouthwash is an example of a solution of water and many other liquid ingredients, including mint flavoring and fluoride. The combination of these substances in mouthwash helps to create a flavor to mask the other strong ingredients used to protect your teeth. Similarly, gases can also be dissolved into other gases. For example, the air we breathe is actually a solution of oxygen, water, nitrogen, and other gases.

Gases can also be dissolved into liquids. Most "fizzy" drinks get their bubbles from carbon dioxide that has been dissolved in the liquid to form a solution. This is called a **multiphase solution** because the solution is created from a liquid and gas phase of matter. A solvent's ability to dissolve a solute can be affected by internal and external factors. Some solvents are better than others at dissolving solutes. For example, recall that the polarity of a solvent can affect how well solutes dissolve.

Activity 2: Teacher Facilitated Discussion

4. Consider the following statement. *"All solutions are mixtures, but not all mixtures are solutions."* Is the statement true or false? *Provide evidence for your claim. Use real-life examples as part of your evidence.*

Below is a table of some of ingredients in regular Coca Cola®. Please fill out the table. In order to complete the table. Use the Internet to research and gather the pieces that you do not know.

Substance	Chemical Formula	Phase of matter prior to adding to mixture	Ionic or Molecular Compound?
Water			
Carbon dioxide			
Fructose			
Sucrose			
Phosphoric acid			
Vanillin			
Caffeine			
Sodium chloride			

5. Is Coca-Cola® a solution or a mixture? *Support your claim with evidence.*

6. Is Coca-Cola® a multiphase solution? *Support your claim with evidence.*

7. What makes Coca-Cola® similar to Kool-Aid® on the submicroscopic level?

8. What makes Coca Cola® different than Kool Aid® at the submicroscopic level?

9. Consider the following statement, "Carbonated water is a solution." *Explain why this statement is true.*

10. Based on your table of Coca-Cola® ingredients, what combination of phases are used to make Coca-Cola®?

11. If you removed water from the Coca-Cola®, would you still have a solution? *Support your claim with evidence.*

12. A student who has not taken chemistry claims that water is the only solvent. *Explain whether that student is correct or incorrect and why.*

Lesson Reflection Questions

13. Why do you think water is a universal solvent? Be sure to discuss the physical properties of water in your response..

14. What substances will not dissolve in water and what in solvent would they dissolve?

Activity 3: Putting It All Together

Determine if the following scenarios are true or false. Support your answer with evidence from researching each of the given scenarios. If you decide that the statement is true, make sure to clearly identify the solvent and solute. In addition, identify the phases of the solvent and solute. Be prepared to discuss your answers and evidence in class.

15. Maple syrup is a solution. Circle **True** or **False**. *Explain with evidence.*

16. Vinegar is a solution. Circle **True** or **False**. Explain with e*vidence.*

17. Air is a solution. Circle **True** or **False.** *Explain with evidence.*

18. Brass, an alloy metal, is a solution. Circle **True** or **False**. Explain with e*vidence.*

Connected Chemistry

Solutions Unit

Lesson 4: Predicting Solubility

Student's Lesson at a Glance

Lesson Summary

Students complete a wet lab in which they explore the solubility of different solvents and solutes. Some substances may be soluble, insoluble, or partially insoluble. This lab is designed to help students begin to think about what factors influence solubility. These factors are explored in Lesson 5.

SWBAT (Students Will Be Able To)

- Use the experimental method to design their own lab to test a hypothesis about the solubility of different solutes in different solvents.
- Classify the solubility of three solutes (salt, sugar, and cornstarch) in three solvents (water, cooking oil, and rubbing alcohol).

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

Connected Chemistry Reminder

- Follow lab safety procedures at all times.
- Keep good notes when completing the lab. Include all labels. Good notes and data collection make lab write ups easier to complete.
- A good hypothesis is a proposed explanation about what outcomes will occur in an experiment based on limited information. Your hypotheses should be clearly written, testable, and observable.
- In science, it is OK if you gather data that shows your hypothesis is incorrect.
- Use scientific vocabulary appropriately from the previous Lesson at a Glance vocabulary sections to create your lab writeup.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.

Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Wet Lab - Testing Substance Solubility

You will explore the solubility of different solvents and solutes in the following lab. Some substances may be soluble, insoluble, or partially soluble. This lab will also help you think about what factors influence solubility.

Connected Chemistry
Solutions Unit
Lesson 5: Factors Affecting Solubility

Student's Lesson at a Glance

Lesson Summary

Students explore demonstrations and simulations on the factors that affect solubility, including agitation, amount of solute added, temperature and pressure. Students develop the ability to explain the relationships that exist between these variables on both the macroscopic and submicroscopic level.

SWBAT (Students Will Be Able To)

- Determine what factors do and do not affect the solubility of a substance (e.g., polarity, size of molecules, temperature, agitation, pressure, composition, and amount of substance already dissolved in solution)

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

Connected Chemistry Reminder

- Many questions will ask you "what you think" or "to make predictions." The only answer that is wrong is the answer that is left blank.
- The terms solute and solvent can be easily confused. The solute is the substance that is being dissolved. The solvent is the substance that dissolves the solute at a specific temperature.
- Use the vocabulary and note section to take organized notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Symbolic keys can help you and others decode your sketches at a later time.
- Ions will be seen in the simulation. Make sure the are included in the key in addition to regular atoms of the substance.
- Make sure you understand the difference between the independent and dependent variable in an experiment.

Notes

Homework

Upcoming Quizzes/ Tests

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Activity 1: Connecting

1. Define "agitation" of a mixture in your own words.

2. What do you think is the purpose of agitating a solution?

Your teacher will make a table salt and water solution. The solution needs to be very concentrated. While stirring quickly, your teacher will add table salt into the room temperature water. Stirring is one way to *agitate* a solution. Carefully observe what happens to the mixture during stirring and after stirring ends.

3. Other than adding more water into the solution, how could your teacher dissolve table salt faster?

Activity 2: Demonstration of Solubility Changes

Part 1: *Use Simulation 3, Set 1*

Using the CCC simulation, your teacher will show you the interaction between table salt and room temperature water at the submicroscopic level. Unlike simulation 2 when you were able to see the solid solute dissolve or dissociate by the solvent, all the sets in simulation 3 will be shown in aqueous solutions.

- *Create a submicroscopic sketch, record the temperature of the simulation and record observations.*

<table>
<tr><td rowspan="5">Solution of sodium chloride and water</td><td rowspan="5">Submicroscopic Sketch</td><td colspan="4">Record Data from Monitors</td></tr>
<tr><td>Temperature</td><td></td><td>Pressure</td><td></td></tr>
<tr><td>Amount of Solvent</td><td></td><td>Amount of Solute Added</td><td></td></tr>
<tr><td colspan="3">Amount of Solute Dissolved</td><td></td></tr>
<tr><td colspan="4">Record your Observations</td></tr>
<tr><td colspan="6">Key</td></tr>
</table>

4. If you adjust more than one variable at a time, will you be able to determine relationships between individual variables? *Explain your example.*

5. What are the possible relationships that can exist between an independent and dependent variable? *Explain your example.*

Part 2

The simulations calculate solution volume *additively*. This means that the solution volume in the simulation is equal to the volume of solute added to the volume of solvent. Examine the table below that was taken from actual experimental data and graph the data. *Be sure to label the axes. Additional graph paper can be found on pages 80-81 if needed.*

Amount of sodium chloride (mL) Added to 100 mL of water	Change in volume of solution (mL)
1.00	0.38
2.02	0.57
3.02	0.87
4.02	1.28
5.03	1.52
6.00	1.90
6.99	2.35
7.97	2.60
8.99	3.00
10.07	3.60

6. What relationship, if any, exists between the amount of solute added and the total volume of the solution?

7. How does this real-life data vary from the virtual data that was collected in the simulations?

8. Explain from the submicroscopic level why the amount of solute added changes the volume of the solution.

Activity 3: Simulation of Changes

Part 1: Varying Temperature: *Use Simulation 3, Sets 1, 3, and 6*

In this activity, you will manipulate one variable while keeping the other variables constant. The variable that you manipulate is called the **independent variable**. In the table below, the independent variable column has a bold border. You will directly manipulate the temperature of the system by changing the amount of heat added. The other variables are kept constant in this simulation. The variable that is changing as a result of the manipulation of the independent variable is called the **dependent variable**. The dependent variable (marked with an asterisk) is the amount of dissolved solute. Complete three different trials of one mixture. Pause each trial at 30 seconds and sketch as directed below for trials 1, 2, and 3. Make sure to include labels for all measurements.

Mixture	Trial	Temp (°C)	Pressure (atm)	Amount of solute added (g)	Volume of solvent (mL)	Volume of solution (mL)	* Amount of dissolved solute (g)
	1						
	2						
	3						

Sketch submicroscopic picture of trial 1 after 30 seconds	Sketch submicroscopic picture of trial 2 after 30 seconds	Sketch submicroscopic picture of trial 3 after 30 seconds
Observations	**Observations**	**Observations**
Key		

9. What kind of relationship exists between the amount of solute that dissolves and temperature?

10. What kind of relationship exists between the amount of solute dissolved and temperature: a direct or inverse relationship?

11. Some people like to brew sweet ice tea at very cold temperatures. Based on your observations, will tea brew faster or slower at cold temperatures? *Explain your answer at the submicroscopic level.*

12. Using your submicroscopic sketches, explain how increasing the temperature affects the ability of a solute to dissolve.

Part 2: Varying Pressure

Complete three different pressure trials for one mixture while keeping all other variables constant. Using the counters on the simulation, record the amount of solute dissolved in the column with an asterisk at each pressure that you select. Pause at 30 seconds and sketch as directed below for trials 1, 2 and 3. Make sure to include labels for all measurements.

Mixture	Trial	Temp (°C)	Pressure (atm)	Amount of solute added (g)	Volume of solvent (mL)	* Amount of dissolved solute (g)
	1					
	2					
	3					

Sketch submicroscopic picture of trial 1 after 30 seconds	Sketch submicroscopic picture of trial 2 after 30 seconds	Sketch submicroscopic picture of trial 3 after 30 seconds
Observations	**Observations**	**Observations**
Key		

13. Is there a relationship between the amount of solid solute dissolved in liquid solvent and pressure? If so, what is the relationship?

14. Using your submicroscopic sketches, explain how increasing the pressure affects the ability of a solid solute to dissolve in a liquid solvent.

15. Make a graph of the amount of solid solute dissolved in liquid solvent versus pressure. *Be sure to label the axes. Additional graph paper can be found on pages 80-81 if needed.*

Part 3: Varying the Amount of Solute

Complete five different trials of one mixture by adding different amounts of solute while keeping the other variables constant. You should include a wide range of amounts. Using the counters on the simulation, record the amount of solute dissolved for each different amount of solute that you added in the column with an asterisk. Pause at 30 seconds and sketch as directed below for trials 1, 2 and 3. Make sure to include labels for all measurements.

Mixture	Trial	Temp (°C)	Pressure (atm)	Amount of solute added (g)	Volume of solvent (mL)	* Amount of dissolved solute (g)
	1					
	2					
	3					

Sketch submicroscopic picture of trial 1 after 30 seconds	**Sketch submicroscopic picture of trial 2 after 30 seconds**	**Sketch submicroscopic picture of trial 3 after 30 seconds**
Observations	**Observations**	**Observations**
Key		

16. Is there a relationship between the amount of solid solute added and the amount of solute that dissolves? If so what is the relationship?

17. Is the relationship between amount solute added and the amount of solute dissolved a direct or inverse relationship?

18. Assuming that the water temperature and the amount of sugar used are kept constant, why would sugar dissolve more easily into bottled water than into tap water?

19. Using your submicroscopic sketches, explain how increasing the amount of solute affects the ability of a solute to dissolve.

20. Make a graph of the amount of solid solute added and the amount of solute that dissolves. *Be sure to label the axes. Additional graph paper can be found on pages 80-81 if needed.*

Activity 4: Teacher Facilitated Discussion

As a class, use the data from the small groups to complete the table below. Use only the substances that were soluble in water. Use the class data to complete the analysis questions.

			Part 1		Part 2		Part 3	
Group	**Mixture**	**Trial**	Temp (°C)		Pressure (atm)		Solute Added (g)	
A	**Sodium chloride + Water**	**1**						
		2						
		3						
B	**Calcium chloride + Water**	**1**						
		2						
		3						
C	**Sodium bicarbonate + Water**	**1**						
		2						
		3						

21. How does the solubility of calcium chloride differ from the solubility of sodium chloride?

22. Based on the data collected, what solid substance is the most soluble in 100 grams of water at approximately 60 °C? *Support your claim with evidence.*

23. Based on the data collected, what solid substance was the least soluble in 100 grams of water approximately 60 °C? *Support your claim with evidence.*

24. What independent variable has no relationship to the dependent variable of solubility for the five solutions that contain a solid solute and liquid solvent? Explain why this variable has no relationship to solubility.

25. Explain how each variable has an effect or does not have an effect on the solubility of a substance at the submicroscopic level.

Connected Chemistry
Solutions Unit
Lesson 6: Determining Concentration

Student's Lesson at a Glance

Lesson Summary

This lesson contains activities that help students understand what concentration is through the use of real-world examples and submicroscopic level observations of concentrated and dilute solutions. Students use simulations to gather data that allows them to learn how to calculate mass per volume and molarity. The authors of Connected Chemistry acknowledge that teachers may implement the Solutions Unit before or after the introduction of the mole. Teachers have the option to use either the mass per volume or the molarity activities depending on the pacing of their own curriculum.

SWBAT (Students Will Be Able To)

- Define concentration and how it can be represented on the submicroscopic level
- Define dilution and how it can be represented on the submicroscopic level
- Calculate mass per volume for solutions created AND/OR
- Calculate molarity for solutions created

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

Connected Chemistry Reminder

- Prefixes and suffixes on words can help you discover the meaning of a word.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Symbolic keys can help you and others decode your sketches at a later time.
- Sample calculations for mass per volume and molarity can be found in Appendix A (pages 76-77).

Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting

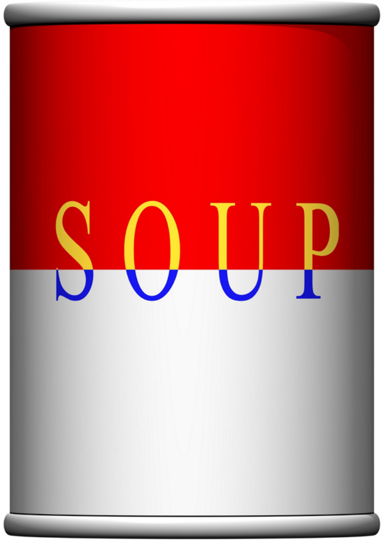
1. In art class, what is the purpose of adding water to concentrated paint?

The **concentration** of a solution is defined as the amount of solute dissolved in a given quantity of solvent. Solutions can be described as **concentrated** or **dilute**, but these designations only give a relative qualitative idea of concentration. The effects of concentration on the physical properties of a solution can be observed at home and in school. For example, watercolor paints in an art class are mostly made up of a mixture of pigments and water or another solvent, and paint can be diluted to affect color *saturation.*

Sketch red watercolor paint before adding water at the submicroscopic level	Sketch red watercolor paint after diluting with water at the submicroscopic level
Key	

2. Besides adding water, how else can you dilute concentrated paint?

A student comes home from school on a chilly day and decides that they want something to eat to warm up their body. The student finds a can of tomato soup and opens up the can. They pour the mixture in the pot and wait for it to warm up. Upon tasting one spoonful of the warm liquid, they immediately realize they did something wrong. They read the front label of the can and it says "condensed." On the side of the can, directions indicate to add one can of water to the soup before cooking.



3. In your own words, what does "condensed" mean?

____

____

4. Why would condensing some products be beneficial?

____

____

Soup, watercolor paint, and many other products you use at home are condensed or concentrated. Some juices, soaps, and flavor extracts come in a highly concentrated form. Recall that the solute in a solution does not necessarily have to be a solid. It can also be a liquid or a gas. Hydrogen peroxide that you buy in the store is actually a diluted solution with a liquid solute.

Sketch concentrated soup solution at the submicroscopic level	**Sketch diluted soup solution at the submicroscopic level**
Key	

Activity 2: Determining the Concentrations of Solutions

Simulation

Use Simulation 3, Sets 1, 3, and 6

Part 1: Mass per Volume

- *Run three trials adding different amounts of sodium chloride to water. You may use different solutes for each trial if you wish. Set the simulation to measure solute in grams.*
- *Using simulation outputs, record the amount of solute dissolved and the different amounts of solute that you selected. Make sure to include labels for all measurements.*
- *Once you have collected your data, use the values and the example calculation below to calculate the percent mass per volume. Fill in the columns with the asterisks using data from the simulation. Pause at 30 seconds and sketch as directed on the next page for trials 1, 2 and 3. For help in performing calculations, see "percent mass per volume" in Appendix A on page 76. The independent variable column is bolded in the table and the dependent variables are noted with an asterisk in the table. Do not forget to draw the solvent in your submicroscopic drawings.*

Trial	Temp. (°C)	Mixture (solute + water)	Amount of solute added (g)	Volume of Solvent (mL)	* Amount of solute dissolved (g)	* Volume of solution (mL)	Mass / volume percent
1							
2							
3							

Sketch submicroscopic view of trial 1 after 30 seconds	Sketch submicroscopic view of trial 2 after 30 seconds	Sketch submicroscopic view of trial 3 after 30 seconds
Key		
Observations	Observations	Observations

5. Classify your sketches in order from the most concentrated to the least concentrated.

6. Using your sketches, explain why the volume of the solution increases even though you did not add more of the solvent.

Part 2: Molarity

- *Using Simulation 3, Set 1 run three trials adding different amounts of sodium chloride to water.*
- *You should include a wide range of amounts. You may use different solutes for each trial if you*

wish. Set simulation to measure solute in moles by checking box above the measurements in the macroscopic section of the simulation.

- *Using the counters on the simulation, record the amount of solute dissolved at each different amount of solute that you selected. Make sure to include labels for all measurements. Pause at 30 seconds and sketch as directed below for trials 1, 2, and 3.*
- *Once you have collected all the data, calculate the molarity (M) using the data and the example calculations can be found the "calculating molarity" section of the calculation appendix.*

Trial	Temp. (°C)	Mixture: (solute + water)	Amount of solute added (moles)	* Volume of Water (mL)	* Amount of solute dissolved (moles)	* Volume of solution (ml)	Molarity (M)
1							
2							
3							

Sketch submicroscopic picture of trial 1 after 30 seconds	Sketch submicroscopic picture of trial 2 after 30 seconds	Sketch submicroscopic picture of trial 3 after 30 seconds
Observations	**Observations**	**Observations**
Key		

7. Classify your sketches in order from the most concentrated to the least concentrated.

Lesson Reflection Questions

8. Consider the following scenario: You are in the lab and you have 100 mL of a solution with a certain concentration in a beaker. You pour half of the solution out of the beaker. Is the concentration of the remaining solution in the beaker greater, lower, or the same as the original solution? *Explain your answer.*

9. Consider the following scenario: You are in the lab and you have 100 mL of a solution with a certain concentration in a beaker. Your lab mate accidentally pours 100 mL of water into the solution. Is the concentration of the solution in your beaker greater, lower, or the same as the original solution?*Explain your answer.*

10. It is possible to add more solute to a solution or to add more solvent to a given solution. Is it possible to take solute out of a solution or solvent out of a solution to make it more or less concentrated?

Connected Chemistry
Solutions Unit
Lesson 7: Saturation

Student's Lesson at a Glance

Lesson Summary

This two-day lesson includes a lab. Students are introduced to the concept of saturation through use of real-world applications and computer simulations. Students identify saturated and unsaturated solutions using both simulations and a solubility curve for a known ionic compound. Students will also discover the limitations of accurately identifying supersaturated solutions using computer simulations. Students begin to use a solubility curve to extrapolate information to solve solubility problems. Students perform a solubility lab in which they create solubility curves from the provided data.

SWBAT (Students Will Be Able To)

- Define unsaturated solutions as those solutions that are capable of dissolving additional solute
- Define saturated solutions as those solutions that cannot dissolve additional solute at a constant temperature
- Define supersaturated solutions as those solutions that have dissolved excess solute than normally possible, usually under specific conditions.
- Identify and explain how unsaturated, saturated and supersaturated solutions are formed at the submicroscopic level
- Generate solubility curves and identify how the solution looks at the different locations on the graph

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

Connected Chemistry Reminder

- Students and teachers from many different schools helped designed Connected Chemistry so that the lessons are more helpful and meaningful for all classroom participants.
- Many questions will ask you "what you think" or "to make predictions." The only answer that is wrong is the answer that is left blank.
- Prefixes and suffixes on words can help you discover the meaning of a word.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Symbolic keys can help you and others decode your sketches at a later time.

Notes

Homework

Upcoming Quizzes/ Tests

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Activity 1: Connecting

1. What do you think it means for a solution to become saturated? *Be sure to explain what you think it would look like on the macroscopic level and on the submicroscopic level. Support your claim with evidence.*

Recall that Kool-Aid® is a solution. When making Kool-Aid®, sugar is added according to the directions on the packet. However, some people may like it sweeter, so they might add more sugar and see it dissolve. More sugar can be added because the solution is **unsaturated**, which means the solvent is able to dissolve more solute. In the case of making Kool-Aid® with extra sugar, the solution can dissolve more sugar without it settling to the bottom.

If too much sugar is added to the solution, some of the sugar will eventually settle at the bottom of the pitcher and no more sugar will dissolve no matter how much the solution is stirred. The Kool-Aid® has now become **saturated**. A saturated solution is a solution that has reached a point where no more solute can be dissolved in the solvent. A saturated solution is as concentrated as possible at a given temperature.

Besides humans, many animals can create solutions. Bees create honey, which is a *solution* composed of fructose, glucose, water, oil, flower pollen, and special enzymes produced by bees. Honey not only supplies bees with food in the summer and winter months, it is also used by humans as a natural sweetener that is easy for the body to digest. When buying honey at the store, various labels might indicate their product is pure honey.

2. Do you think you can tell the difference between a saturated solution and an unsaturated solution at the macroscopic level? *Explain your answer.*

3. Do you think you can tell the difference between a saturated solution and an unsaturated solution at the submicroscopic level? *Explain your answer.*

Activity 2: Simulations of Saturation

Part 1: *Use Simulation 4, Set 1*

Sketch each of the three simulations that your teacher shows to you. Make sure you record the simulation temperature. The simulation is for a solution of KCl and water.

Submicroscopic sketch of Simulation 1 at 0 °C	Submicroscopic sketch of Simulation 2 at 25°C	Submicroscopic sketch of Simulation 3 at 99 °C
Observations	**Observations**	**Observations**
Key		

4. Classify Set #1 as saturated or unsaturated. *Support your claim with evidence.*

5. Classify Set #2 as saturated or unsaturated. *Support your claim with evidence.*

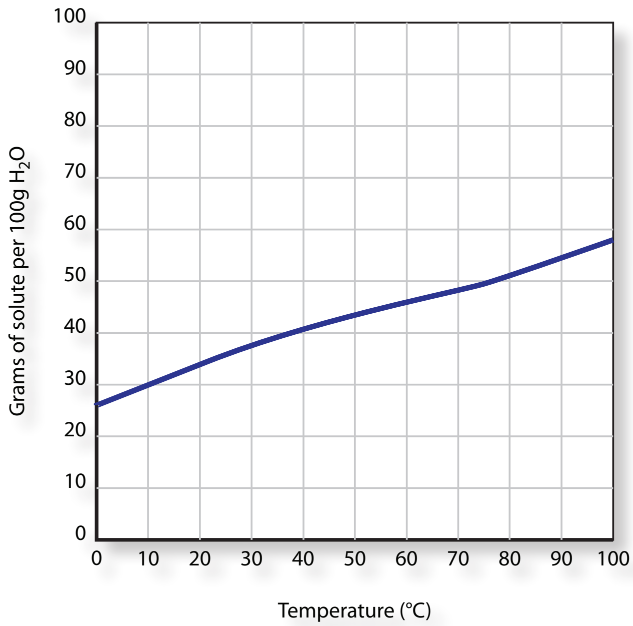
6. Classify Set #3 as saturated or unsaturated. *Support your claim with evidence.*

7. What is the limitation of just using the submicroscopic simulation to determine saturation?

Part 2

A student created a solubility graph for KCl. The teacher asked the student to label two points on the graph which represent a saturated and unsaturated solution for KCl. Recall the meaning of these two types of solutions.

Label the graph below with the letters to correctly identify the two types of solutions: A = Saturated, B = Unsaturated



Grams KCl Dissolved

8. Using the graph, locate a solution of 80 grams of dissolved KCl solute per 100 grams water at 90 °C. What type of solution is this? *Please explain.*

9. At 30 °C, how many grams of KCl is needed to saturate the solution?

10. What would happen to a saturated solution composed of 90 grams KCl dissolved in 100 grams water at 70 °C, if you added two more grams of KCl?

11. How much more KCl would you need to add to make a saturated solution if you already had added 10 g at 20 °C?

12. What would make a supersaturated solution of KCl begin to precipitate out?

13. When labels indicate "pure" honey, does this mean that honey is a pure substance in scientific terms? *Support your claim with evidence.*

Honey is a special type of solution because it is a naturally made **supersaturated solution**. A supersaturated solution is a case in which the solvent contains more solute than it can hold *theoretically* at a given temperature. Supersaturated solutions are formed by heating a solution to dissolve more solute, then cooling the solution down slowly. By cooling slowly, the honey is able to dissolve more sugar at a lower temperature than it can under normal circumstances.

14. What does the prefix *super-* mean?

15. In your own words, what do you think supersaturated means?

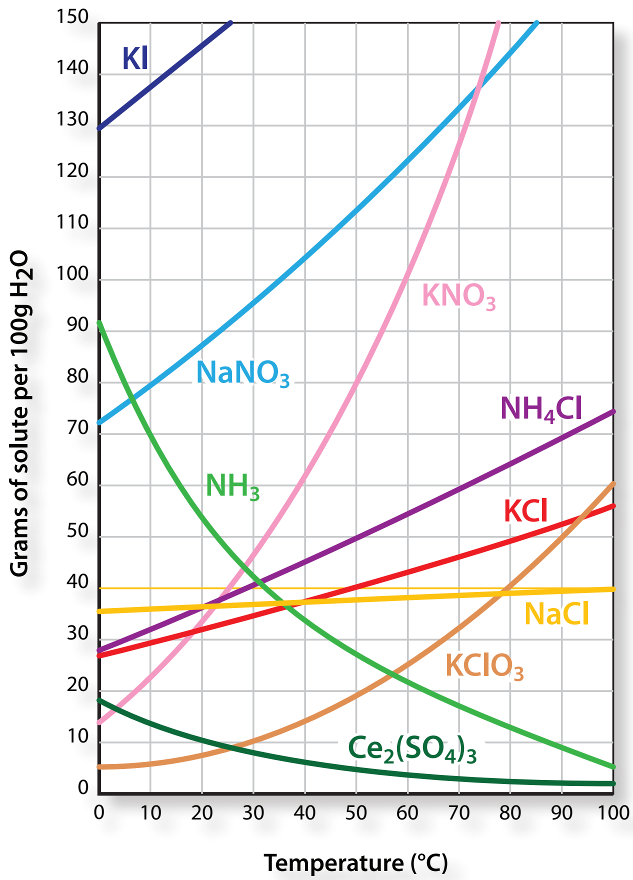
Honey **crystallizes**, meaning it forms a solid when sitting undisturbed for a long period of time. Supersaturated solutions are often unstable and easily crystalize. Honey and other supersaturated solutions are created by heating the solvent, which causes the solvent molecules to move farther apart from each other. This situation allows more solute particles to dissolve in between the solvent molecules than at lower temperatures. In nature, bees accomplish this by heating water (the solvent) and dissolving two different kinds of sugars, glucose and fructose (the solutes), to make a supersaturated solution. Where do the bees get the heat to create the supersaturated solution? Honey is made in the summer when the temperatures are warmer and flowers are in bloom. The summer heat causes the solvent to dissolve more sugar into the solution. Worker bees also help to regulate the temperature of the hive by vibrating their wings to generate heat. The bees then cool the solution down slowly so that the sugar still remains dissolved in the solvent. This temperature regulation ensures that honey remains a liquid in the cold winter months. Because honey is supersaturated, addition of any extra solid sugar crystals, agitation, cooling, or even small air bubbles could cause many of the sugar molecules to precipitate out of the solution. After precipitation occurs, the honey is no longer supersaturated.

16. What does the phrase "precipitate out" mean?

17. At the submicroscopic level, what happens to the molecules of a solvent that is being heated such that it allows more solute to be dissolved into the solution?

Activity 3: Putting It All Together: Independent Practice

Use the graph to answer the following questions:



18. How many grams of solute are required to saturate 100 g of water in each of the following solutions?

KCl at 80 ºC	
$KClO_3$ at 90 ºC	
$NaNO_3$ at 10 ºC	
NH_3 at 20 ºC	

19. What is each of the solutions below: saturated or unsaturated? All of the solutes are mixed with 100 g of water.

40 g of NaCl at 80ºC	
30 g of NH_3 at 30ºC	
34 g of KCl at 20ºC	
80 g of KNO_3 at 60ºC	

20. How many grams of KNO_3 per 100 g of water would be crystallized from a saturated solution as the temperature drops from each of the following temperatures?

70ºC to 20ºC	
60ºC to 40ºC	
50ºC to 30ºC	
50ºC to 0ºC	

21. How many additional grams of $NaNO_3$ are required to keep each of the following $NaNO_3$ solutions saturated during the temperature changes indicated?

100 g of water, 10ºC changing to 30ºC	
200 g of water, 10ºC changing to 30ºC	
100 g of water, 40ºC changing to 90ºC	
1000g of water, 40ºC changing to 90ºC	

22. Which solute is the least affected by changes in temperature? *Support your claim with evidence.*

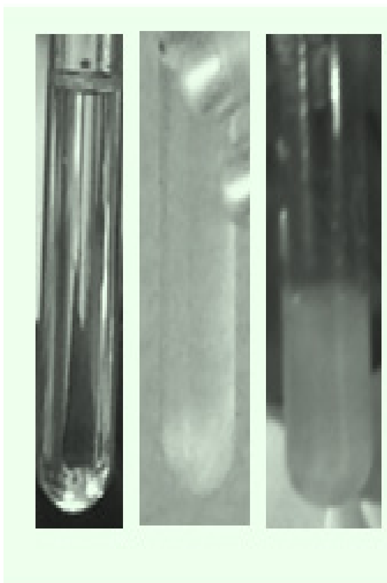
23. Which two solutes show a decrease in solubility with increasing temperature? *Support your claim with evidence.*

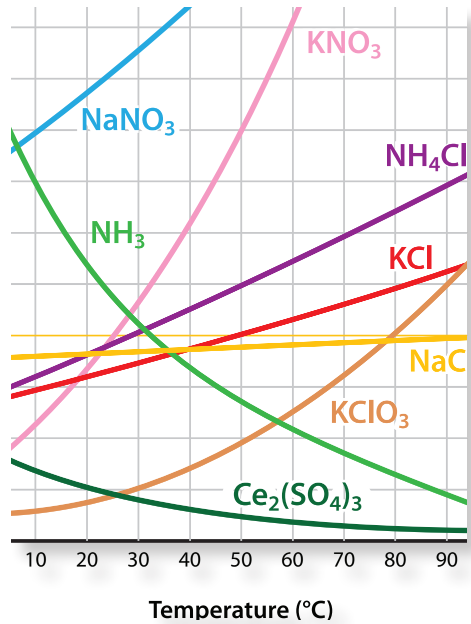
24. Can you use the graph to represent a supersaturated solution? *Support your claim with evidence.*

25. Which solute is more soluble: KCl or NaCl? *Provide evidence for your answer.*

Lesson Reflection Question

26. The image of the three test tubes shows a macroscopic image of various amount of KCl mixed with water. The solubility curve for KCl is shown next to the image. Do the macroscopic images show a saturated solution, unsaturated solution, or supersaturated solution? *Provide evidence for your answer.*





Activity 4: Solubility Lab: Creating a Solubility Curve

Part 1: Solubility Curve Lab

Part 2: Creating and Interpreting Solubility Curves

Student's Lesson at a Glance

Lesson Summary

The final lesson solidifies the importance of solubility as it relates to real-world issues. Students discover how solubility curves are used as a tool to prevent water pollution. Students analyze the effectiveness of ionic compounds as a means to prevent roads from icing. Finally, as a tie-in to solubility curves and multiphase solutions, students research and present on the environmental impact of dissolved oxygen levels.

SWBAT (Students Will Be Able To)

- Apply prior knowledge of solubility and solubility curves to real-world problems.

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

Connected Chemistry Reminder

- Use your notes and vocabulary from this unit to develop your presentation.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching or making graphs. Symbolic keys can help you and others decode your sketches at a later time. Keys on a regular graph will help clearly interpret data.
- Be careful when using the word “salt” in chemistry. Salt can be used to describe any number of ionic compounds including regular table salt (sodium chloride), calcium chloride, copper sulfate, potassium chloride, and other substances.

Notes

Homework

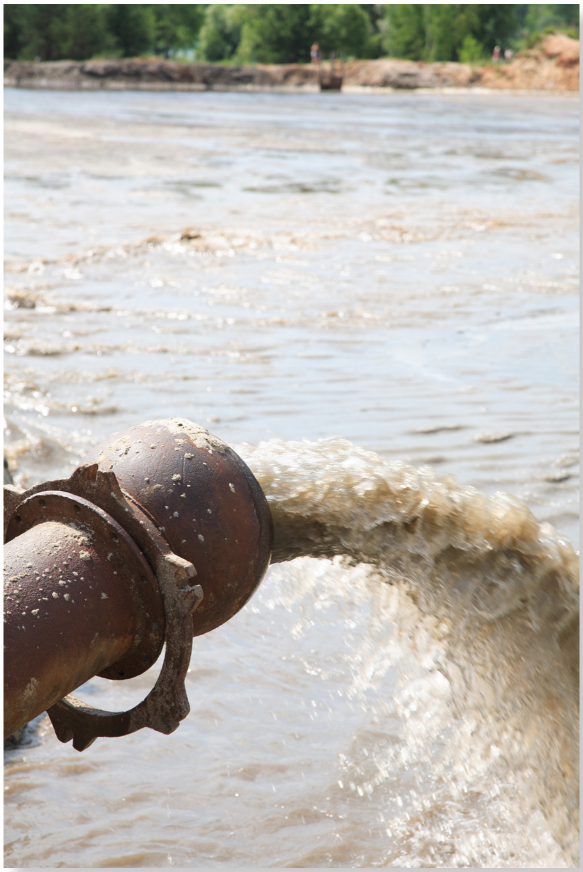
Upcoming Quizzes/ Tests

Activity 1: Connecting

1. What substances do you think you dump down the drain? Include anything you flush, rinse, dump, or pour down all the drains inside or outside in the gutter.

Water is considered to be a "universal solvent" and is of the most abundant natural resources on the planet. Clean, pollutant-free water is essential for maintaining life on Earth. *Water pollution* occurs when pollutants from agricultural field *runoff*, waste products from factories, sewage from storm drains and other sources end up in the water cycle. Because water is an a excellent solvent for many substances, harmful levels of toxins can build up in the water unintentionally as a result of human actions.

The Clean Water Act of 1977 and the Water Quality Act of 1987 are two laws passed by the United States government to regulate and eventually eliminate the practice of releasing toxic substances into rivers, lakes, and other sources of water. The Environmental Protection Agency (EPA) is the federal government agency entrusted with monitoring water and making sure it is safe for the environment. Despite strict penalties and fines, some companies continue to violate these laws. Below is an excerpt released by the EPA about violations by a major homebuilder that built many houses in 21 states. The homebuilder allowed dangerous substances to wash away into local storm drains around the building sites.



Cynthia Giles, an assistant administrator for EPA's Office of Enforcement and Compliance and Assurance states, "Contaminated storm water puts children and families at risk as it may carry pollutants, including sediment, debris, and pesticides that contribute to water quality problems. These pollutants affect our nation's rivers, lakes and sources of drinking water" (Kika, 2010).

So how does the EPA ensure that companies are abiding by the law? The EPA sends out scientists to gather water samples from all over the country. The scientists that work for the EPA need to have a very strong understanding of solubility. These researchers must know many things about the waste produced by different companies. For instance, scientists must determine the following information on different wastes:

- Whether substances are soluble or insoluble in water
- How temperature affects a substance's ability to dissolve in water
- What levels of dissolved solutes are safe for the environment
- Consequences for organisms exposed to concentrated levels of dissolved solutes

The EPA scientists use solubility curves for each substance they are studying to determine how much a given solute will dissolve at a specific temperature. These solubility graphs are reference tools that help guide the scientists in gathering evidence to prosecute companies that continue to harm the environment.

2. Try to recall any examples from the media or your own experience when you have heard about pollutants in the water. Describe one example and what happened in two or three sentences.

3. Consider what you already know about solubility. Why do you think gathering more water samples during the summer months is more important as compared to the winter months?

4. Think about all the substances you have at home. Name two to three substances you think would be toxic if enough of each were allowed to get into the water supply.

5. Do you think the amount of contaminated solutes that dissolve into a river changes its toxicity? *Support your claim with evidence.*

Activity 2: Teacher Facilitated Discussion

Part 1

Colligative properties are a set of properties for solutions that depend on the number of solute particles in a given volume of solvent. The number of solute particles in a solution can change the temperature at which a solution will boil or freeze. For instance, during the winter months, the conditions for traveling become hazardous due to ice formation on road surfaces. Many highway departments turn to the common chemical compound of salt to help travelers reach their destination safely. Salt dissolves in the water from melting ice and snow on the roads to create a solution called *brine*. Road crews use the colligative properties of the brine to keep the roads from forming ice. There are four deicing salts for creating brine: sodium chloride (rock salt), calcium chloride, potassium chloride, and magnesium chloride. Each salt has different physical characteristics and consequences on the environment that may make it more or less suitable to use.

In your small group, use the Internet to research each of the colligative properties of each salt solution as it is used for deicing. After researching, please answer the following questions.

- *Identify the relationship between the concentration of dissolved salt and solution freezing point*
- *Identify the temperature limitations of each of the salts*

6. Would colligative properties be classified as chemical or physical properties? *Support your claim with evidence.*

7. How does the number of molecules affect a solution's freezing point?

8. What happens if a road crew uses too little salt?

9. Can a road crew use "too much" salt? *Support your claim with evidence.*

10. Explain which salt you would use at home if you needed to deice your sidewalk. *Support your selection with at least three reasons from your research.*

Lesson Reflection Question

11. Salt and sugar can both be used to change the freezing point of water. *Explain why salt is the better choice based on what you know about solutions and colligative properties.*

Activity 3: Putting It All Together

Oxygen is a critical substance for the survival of nearly every living thing, including many aquatic organisms. Water contains dissolved oxygen; the oxygen comes from the atmosphere and aquatic plants. Atmospheric oxygen is mixed in as water moves in rivers, lakes, and oceans. Plants living in the water also produce oxygen as a byproduct of photosynthesis. The oxygen from the plants can be dissolved into water. The amount of oxygen that dissolves in water is limited by physical conditions, such as the temperature of the water.

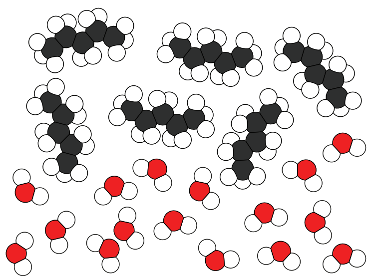
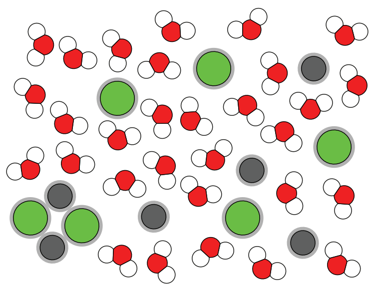
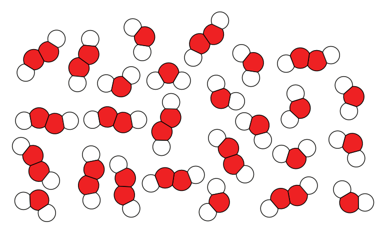
In this next activity, you will get a chance to use the Internet to research the impact of dissolved oxygen on organisms in lakes. Once the research is complete, answer the following questions.

1. Identify the conditions in the environment that affect the solubility of dissolved oxygen. Explain why the concentration of oxygen is affected by these conditions.
2. Create a graph that represents the relationship between temperature and dissolved oxygen. Explain how the graph differs from what you have learned about solid solutes in the previous lesson.
3. Create a visual representation of the dissolved oxygen zones or layers in a lake during the summer. Identify where the most living organisms would be found and why.
4. Explain how humans can impact dissolved oxygen levels.
5. Be prepared to teach a three to five minute lesson to another small group. The goal of the lesson is to define what dissolved oxygen is, how dissolved oxygen levels are affected by different environmental variables, and the impact of fluctuations of dissolved oxygen levels.

Activity 4: Capstone

Given the following submicroscopic images, determine the following for each picture. *Be sure to provide evidence for your answer to each part of the question.*

- Is this an example of dissociation?
- Is this an example of dissolution?
- Is the solute soluble in water?
- Is the solute insoluble in water?
- Is the solute a molecular compound?
- Is the solute an ionic compound?
- Label which substance is the solute.
- Label which substance is the solvent.
- Is this a solution?
- Would this be considered aqueous?
- Is this a homogeneous mixture?
- Is this a heterogeneous mixture?
- Is this a pure substance

A	B	C
		

A nurse gives a patient an intravenous (IV) solution that has 10 grams of calcium chloride in 100 mL of water. Draw a submicroscopic picture of what you think this would look like in the first box. There was a leak in the IV bag and half of the solution dripped out of the bag. In the second box, draw a picture of what you think it will look like after half has leaked out. To cover the mistake, the nurse added 50 mL of water back to the IV bag and sealed it. In the third box, draw what you think it looks like after 50 mL of water is added to what is left after the second box. Determine whether you think that this fixes the problem.

Box 1: 10 grams of calcium chloride in 100 mL of water	Box 2: Half is poured out	Box 3: 50 mL water is added to Box 2

Connected Chemistry

Solutions Unit

Student Appendix A: Calculations

When we express the concentration of a solute in percent mass per volume, we report the mass of a specific solute for every 100 mL of the total solution as a standard.

The formula for percent mass per volume is:

$$\frac{\textbf{Mass of solute (in grams)}}{\textbf{Volume of solution (in mL)}} \times 100\%$$

For example, a 4% solution of NaCl in water is made by dissolving 4 g NaCl in enough water to give a total final volume of 100 mL.

$$\frac{\text{4 g NaCl}}{\text{100 mL}} \times 100\% = 0.04 \times 100\% = 4\% \text{ NaCl solution}$$

The total final volume of solution is measured after completely mixing the solute and the solvent. If a solute is mixed with a solvent in different amounts, it will not always equal a 100 mL solution. Since it is impossible to predict the volume after mixing, enough solvent is added to first dissolve the solute. More solvent is later added to bring the solution to a final desired total volume. Thus, to make a 4% NaCl solution, we add enough water to 4 grams of NaCl to bring the final volume of the solution to 100 mL.

Ratios can be used to calculate solutions that are greater or less than 100 mL.

Example of calculating concentration of percent mass/volume

1. What is the concentration of a solution in percent mass per volume made by dissolving 5.7 g NaCl in enough water to have a total solution volume of 125 mL?

$$\frac{\text{5.7 g NaCl}}{\text{125 mL of solution}} = \frac{?}{\text{100 mL of solution}} \quad \textit{(cross multiply)}$$

$$\frac{\text{5.7 g NaCl x 100 mL solution}}{\text{125 mL of solution}}$$

4.56 grams per 100 mL solution or 4.56%

Example of Calculating Molarity

The **molarity (M)** of a substance in solution is defined as the number of moles of solute per liter of solution.

$$\frac{\textbf{moles of solute}}{\textbf{liters of solution}} = \textbf{molarity (M)}$$

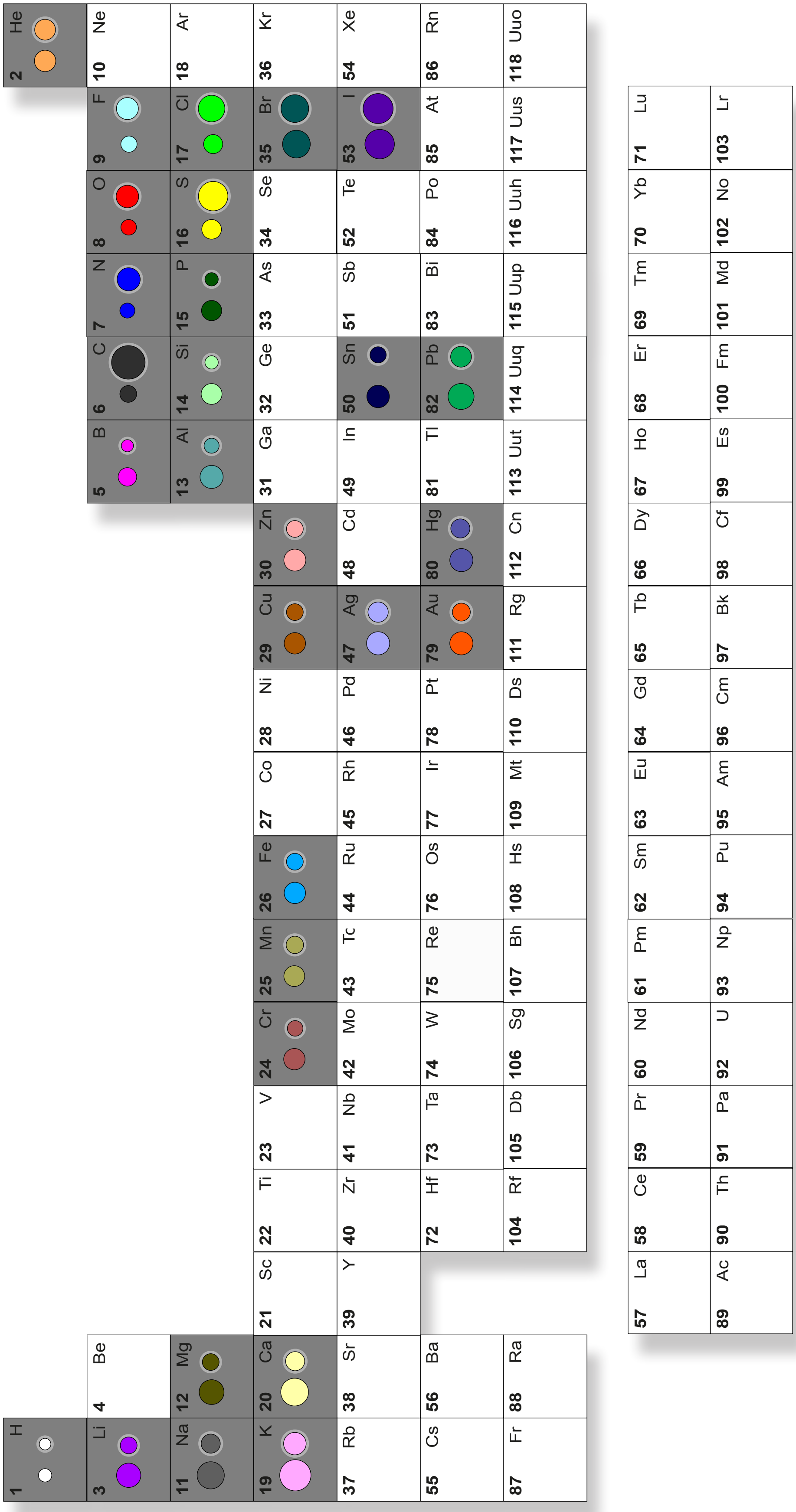
In the simulations, the solution is given in mL. You will need to convert milliliters to liters: 1 L = 1,000 mL.

$$\frac{\textbf{moles of solute}}{\textbf{liters of solution}} = \textbf{molarity (M)}$$

Example:

$$\frac{\text{3 moles of CaCl}}{\text{1.75 L of } H_2O} = \text{1.7 moles/L or M}$$

Elements Used in the Connected Chemistry Curriculum



Name	Symbol	Atomic Number	Atomic Weight
Hydrogen	H	1	1.00794
Helium	He	2	4.00260
Lithium	Li	3	6.941
Boron	B	5	10.811
Carbon	C	6	12.0107
Nitrogen	N	7	14.0067
Oxygen	O	8	15.9994
Fluorine	F	9	18.9984
Sodium	Na	11	22.9898
Magnesium	Mg	12	24.3050
Aluminum	Al	13	26.9815
Silicon	Si	14	28.0855
Phosphorus	P	15	30.9738
Sulfur	S	16	32.065
Chlorine	Cl	17	35.453
Potassium	K	19	39.0983
Calcium	Ca	20	40.078
Chromium	Cr	24	51.9961
Manganese	Mn	25	54.9380
Iron	Fe	26	55.845
Copper	Cu	29	63.54
Zinc	Zn	30	65.38
Bromine	Br	35	79.904
Silver	Ag	47	107.8682
Tin	Sn	50	118.710
Iodine	I	53	126.904
Gold	Au	79	196.967
Mercury	Hg	80	200.59
Lead	Pb	82	207.2