SeaGlide_TEAM	Solubility & Salinity Unit Plan	Lessons #5 - 6 (60 minutes each)

Description:
You will learn about the solubility of water by becoming an assistant chemist in a commercial lab. As chemists in the pharmaceutical industry, it is your job to synthesize chemicals to be used in medicine. However, you must first determine the different characteristics of water, which poses as a universal solvent, before continuing your lab work. You must also establish the standard for the water being used then present these results in a lab report to your principal investigator.

Students will be able to:

- Rank the relative strengths of intermolecular forces
- Describe how temperature alters solubility
- Understand how solubility affects salinity and O_2 concentrations
- Relate changes in salinity and O_2 to the ecosystem

Students will understand:
In commercial chemistry laboratories, chemists work with several solvents and synthesis methods to obtain the various chemicals used in medicine, food, and other products. One of the most important solvents they work with is water because of its polarity and strong intermolecular forces. Students will analyze water's intermolecular forces through its solubility, which also affects its salinity and pH.

Key Definitions & Concepts:

- **Intermolecular Forces**: are the forces which mediate interaction between molecules, including forces of attraction or repulsion which act between molecules and other types of neighboring particles.
- **Solubility**: the amount of a substance that dissolves in a unit volume of a liquid substance to form a saturated solution under specified condition of temperature and pressure.
- **Salinity**: the concentration of dissolved salt in a given volume of water.
- **Solvent**: the component of a solution that is present in the greatest amount.

Standards: **[Copied from: 1]**
CHEM 3.2.10.A1: Explain the unique properties of water (polarity, high boiling point, forms hydrogen bonds, high specific heat) that support life on Earth

- Because of water's strong intermolecular bonds, its molecules exhibit polarity. This lends water its unique properties which make it the universal solvent.

ESS2.C: The roles of Water in Earth's Surface Processes

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosity and melting point of rocks.

	Background Information	

Prior Knowledge:

- The differences between hydrophobic and hydrophilic molecules.
- Water has an area of positive charge and negative charge, which makes it polar.
- Nonpolar molecules are repelled by water and do not dissolve in water.
- The main properties of water:
    - Its attraction to polar molecules
    - High specific heat
    - High heat of vaporization
    - The lower density of solid state when compared to liquid state
    - High polarity

Science Practices: [Copied from: 2]	**Core Ideas: [Copied from: 3]**	**Cross Cutting Concepts: [Copied from: 4]**
● Asking questions and defining problems ● Planning and carrying out investigations ● Analyzing and interpreting data ● Constructing explanations and designing solutions ● Obtaining, evaluating, and communicating information	● Types of Interactions ● Structure and Properties of Matter ● Chemical Reactions ● The Roles of Water in Earth's Surface Processes	● Patterns ● Cause and effect ● Scale, proportion, and quantity ● Systems and system models ● Energy and matter ● Structure and function ● Stability and change

Possible Preconceptions/Misconceptions: Lesson #1: Solubility

Students will look at the final question on the *Is it Soluble?* worksheet and exhibit frustration because of the complex nature of the molecules. The instructor will need to emphasize that students do not need to predict anything beyond whether or not the combination of substances will result in a homogenous solution based on their knowledge of solubility. If students are continuing to struggle, it is recommended to have the students think about how polarity affects solubility. Beyond polarity, students do not need to know anything further about the molecules for completion of the *Is it Soluble?* worksheet.

Possible Preconceptions/Misconceptions: Lesson #2: Salinity

Students should be able to complete this lesson successfully but instructors should expect students to not necessarily make the connection that pH is an essential chemical factor that affects organisms in an aquatic ecosystem. Although the analysis questions are designed to be open ended and have students think beyond salinity, expect students to provide answers closely related to salinity. Since density is not covered until later, also expect students to not make a connection between the concentration of salinity to the concept of density.

Lesson Plan - 5E(+) Model

Engage: Lesson # 1: Solubility [5]

The instructor will begin the lesson by handing out a worksheet (*Water & Solubility*) correlating to a video containing various substances. Students will have 2 minutes to predict whether each substance will dissolve in water. The instructor will then show the students the Comparing Solubility Video which demonstrates different substances being dissolved in water. Students will write down observations based on the contents of the video and then compare the results to their hypotheses. This will introduce students to solubility and the different characteristics that a substance should have in order to be soluble in water. The instructor should allot 5-8 minutes for this exercise.

Engage: Lesson # 2: Salinity

Upon starting the class, the instructor will distribute a *Pre-Quiz: Solubility* that will assess prior knowledge from the solubility lesson and will act as a bridge between salinity and solubility. Students will turn in the completed pre-assessment for grading as the instructor will then move onto the new lesson on salinity. The instructor will begin the class with a question to launch a class discussion. The question should be along the lines of "how many people ever went to the beach and accidentally swallowed salt water?" The purpose of this question is for students to address how they felt about this experience, and they are encouraged to analyze and describe how the salty water felt in their mouth, such as: was there a bitterness to the taste, etc. Instructors should ask simple questions relating to the saltiness of the water to describe salinity but still show a linkage to solubility. The instructor should allot 5-8 minutes for the pre-quiz and discussion activity.

Explore: Lesson # 1: Solubility: [6]

Part I: Introduction

The instructor will ask the students what they believe affects solubility and how they can test for these conditions. Students will draw upon past experiences and understandings when discussing these questions. See the *Instructor's Guide for Solubility* in the attachment section for discussion points. This 5 minute intro discussion will serve to get the students thinking about the upcoming lab activity and why these specific variables were chosen.

Part II: *Benchmark Lesson:* Solubility

Students will run through an experiment and complete the worksheet *Hot Cocoa Experiment*, which is designed to help students see the correlation between solubility and different water conditions. Students will be working in small groups of 2 to 3 to complete this activity and engage in analysis of the experiment. The question that students should keep in mind when focusing on the worksheet is: What properties makes a substance soluble in water? Solubility is a key concept in chemistry, and this activity will introduce students to connections associated with the properties of water. The instructor should allow 20 minutes for students to complete this activity.

Part III: *Investigation Lesson:* Effects on Salinity, pH, and O_2

Once the students have completed the lab activity, they will have 10 minutes to answer the analysis questions located on the second page of the *Hot Cocoa Experiment* worksheet. These questions elicit higher-level, critical thinking from the students by asking about how the variables affected the solubility

of the hot cocoa mix and by having the students explain their reasoning. Students will be applying their understanding of polar bonding from the prior lesson to completing this lab activity and analysis.

Explore: Lesson # 2: Salinity [8]

Part I: Introduction

The instructor will propose a question along the lines of "Do all bodies of water contain the same amount of salt?". This will encourage students to think and discuss the different types of bodies of water and how salt concentration is different depending on the body of water. The goal of this section is to have students work together as a class to discuss and determine that salt concentration varies and that it can be measured. See the *Instructor's Guide for Salinity* in the attachment section for discussion points. The instructor should allot 5 minutes for this brief discussion.

Part II: *Benchmark Lesson:* Measuring Salinity

The instructor will distribute the worksheet, *Aquatic Biomes and Salinity*. Students will work together in small groups of 2 to 3 students to build background knowledge on what salinity is by applying key concepts from their previous discussions to investigate how ecosystems thrive in bodies of water with different levels of salinity. The purpose of this worksheet is to have students establish variance of salt concentrations in different bodies of water (e.g. fresh versus salty). After the completion of the first two analysis questions, the instructor will allot 5 minutes to lead an open discussion about why students matched a water sample with a particular organism group (i.e. utilize the 5 minutes to discuss why the students answered those two questions and to address any misconceptions as necessary). This allows for students to defend their decisions with evidences and allows for the instructor to address any misconceptions as necessary. The purpose of this exploration activity is to have students make a connection between salinity and ecosystems. This activity should take less than 20 minutes to complete.

Part III: *Investigation Lesson:* Relationship Between Chemical Factors and Ecosystems:

At the end of the *Aquatic Biomes and Salinity* worksheet, students will be asked to relate other chemical factors to ecosystem conditions and discuss it with one another. The purpose of this question is to have students extend what they have learned from salinity and apply their learning onto other chemical factors and their effects on an ecosystem. In addition, students will be given a bonus question which asks the students to relate salinity to density. Students should understand that there is a proportional correlation between salt concentration and density. The goal of this 10 minute discussion is to have students apply their prior knowledge to new concepts.

Explain:

Throughout the exploration of this lesson, students will engage in discussions and activities that test their understanding of the topics at-hand. Instructors should informally ask questions to promote open class discussions. This will aid in evaluating questions that some students may experience difficulty answering. Also, students are expected to formalize their answers from the exploration activities and write about them based on their observations from the experimental results. During discussions, students are verbalizing their understanding of the material, as well as any misconceptions they may have. This controlled classroom discourse allows for cognitive development and for peer support in all students. This is seen through the lab-based activity and engagement for Solubility, where students are answering questions and verbally discussing their ideas. This behavior is also in the group-based

activity and investigation for Salinity, where students are working together to solve a real-world problem through problem assessing and solution designing.

Elaborate: Lesson # 1: Solubility: [7]

Following the lab activity, the instructor will have students complete the PhET activity Molecule Polarity. The purpose of the PhET is for the students to analyze and predict relative solubility. In commercial chemistry labs, many substances must be dissolved in a liquid before being added in a solution. Chemists must use their understanding of solubility to determine if the solute-solvent combination will be possible. This worksheet introduces the students to completing that same process and learning those same goals as active chemists. This activity should take 15 minutes to complete.

Elaborate: Lesson # 2: Salinity

The elaboration of this lesson begins with the third analysis question of the *Aquatic Biomes and Salinity* worksheet. Since students would be supplied with the knowledge on salinity, this analysis question will challenge their thinking as they are prompted to analyze how certain chemical properties can affect an organism's chance of survival. They will view what makes certain organisms thrive in ecosystems with intense conditions, i.e. acidic environments, temperature, hydrothermal vents, high salt content etc. By asking students to investigate scenarios that would affect an organism's ability to survive in an ecosystem due to chemical conditions, this will allow them to bridge this lesson's goals to those relating to solubility.

Evaluate: Lesson # 1: Solubility:

This lesson is constructed to have both informal and formal evaluations throughout its entirety. The purpose of the informal evaluation is tied with the exploration section to encourage learning and student understanding. The open ended questions and experimental activity allows students to share their ideas and thoughts on solubility and the properties of water. Students will complete a 5 minute exit ticket at the end of the lesson. This activity should be completed individually, and it serves as a formal assessment designed to review the important learning goals of the lesson.

Evaluate: Lesson # 2: Salinity

This lesson is designed to have both informal and formal evaluations throughout its entirety. The informal evaluations occur during the engage and exploration sections where the instructor will facilitate a class discussion with leading questions as it involves salinity its linkage to solubility. This will flow into the exploration section where, from conducting an experiment, students will use their skills in making predictions and observations to later analyze their findings through the activities and worksheets. Instructors will distribute an activity sheet to complete along with an exit ticket to assess students' prior knowledge and their understanding of the current lesson. The formal evaluation of this lesson is the 5 minute exit ticket. This individual assessment will encourage students to use and reiterate what they have learned from the lesson, including how salinity is measured.

Enrich: Lesson # 1: Solubility:

This lesson could be differentiated by instructing students to complete an activity where they execute an experiment to determine whether a molecule is a carbohydrate, lipid, protein, or nucleic acid based on the solubility and molecular structure of the given molecule. Since the lesson focuses on chemical

solubility, this allows for the students to bridge the gap between chemical and biological applications to the topic.

Enrich: Lesson # 2: Salinity

This lesson could be differentiated by having students conduct an experiment that tests the outcome of a red blood cell placed in a saline solution. Students should have prior knowledge on how salinity affects an environment for organisms by completing this lesson. Hence, having students create connections between salinity, osmosis, and hypertonic effects enables them to engage in meaningful discovery and understanding that directly relate to biological applications.

All associated documents are attached below

Reference *Annotated Bibliography* on the very last page of this packet

Worksheets for the Solubility Lesson

Instructor's Guide for Solubility [6]

Background Information:

Solubility is a chemical property referring to the ability for a given substance, the solute, to dissolve in a solvent. It is measured in terms of the maximum amount of solute dissolved in a solvent at equilibrium. The resulting solution is called a saturated solution.

Certain substances are soluble in all proportions with a given solvent, such as ethanol in water. This property is known as miscibility. Under various conditions, the equilibrium solubility can be exceeded to give a so-called supersaturated solution, which is metastable.

The solvent is often a solid, which can be a pure substance or a mixture. The species that dissolves, the solute, can be a gas, another liquid, or a solid. Solubilities range widely, from infinitely soluble such as ethanol in water, to poorly soluble, such as silver chloride in water. The term insoluble is often applied to poorly soluble compounds, though strictly speaking there are very few cases where there is absolutely no material dissolved.

The process of dissolving, called dissolution, is relatively straightforward for covalent substances, such as ethanol. When ethanol dissolves in water, the ethanol molecules remain intact but form new hydrogen bonds with the water. However, when an ionic compound such as sodium chloride (NaCl) dissolves in water, the sodium chloride lattice dissociates into separate ions which are solvated (wrapped) with a coating of the water molecules.

Discussion Topics & Expectations:

In *Lesson #5 Solubility: Exploration: Introduction*, students will engage in a discussion about different variables that may affect the solubility of a substance. When guiding this discussion, the instructor should ask the following probing questions:

- When a substance dissolves in a liquid, the substance seems to "disappear." Does the substance actually disappear? Where does it go / what does "dissolve" mean in this context?
  - Expectation: No, the substance is dissolved. This means that the substance is broken down into its constituent ions and in the solution.
- When the substance is dissolved, what is happening to the molecules of the substance? Do intermolecular forces have anything to do with it?
  - The instructor may have to draw an example with the molecules interacting with one another. This is a key idea that students should understand.
  - Expectation: The substance is broken down into its individual molecules by the liquid. The molecules in the liquid pull the substance apart because of the intermolecular forces.
- What are some things that affect intermolecular forces?
  - Expectation: temperature, addition of another substance, polarity, etc.

The instructor will write down student responses on the board for future use and to reflect on later in the lesson during the exploration portion. The goal of this discussion is for students to discover that substances dissolve in solvent due to the intermolecular forces between them and that physical properties can affect those forces.

Name: _____ Date: _____

Water and Solubility

Directions: In the video, a scientist will test to see if the given solute (what is being dissolved) will dissolve in water (solvent). Before the video begins, write down your hypothesis for each solute. Record your observations while watching the video. After the video has ended, compare your hypothesis and observations. Was your hypothesis correct or incorrect? State why you think the solute was soluble or insoluble in water.

	Hypothesis	Observations	Conclusion
Salt			
Sugar			
Chalk			
Starch			
Baking Powder			

Name: _____ Date: _____

Hot Cocoa Experiment

Introduction: As demonstrated in the video, certain solutes can dissolve in water while others cannot. This is caused by the intermolecular forces between the solute molecules and the water molecules. When the bonds between the elements in a solute are weaker than the hydrogen bonds of water molecules, the solute is broken down by water and dissolved. However, several factors can affect how much solute is dissolved in the water. In the following experiment, you will be testing what some of these factors may be.

Materials:

- Hot Cocoa Mix
- 5x Paper cups
- 1x Waste Beaker
- 5x 150.0-mL Water
- 1x Digital Scale
- 1 tbsp Baking Soda
- 1 tbsp Vinegar

Directions:

1. Make hypotheses on the results of the experiment. Do you think the hot cocoa mix (solute) will dissolve in the water solution (solvent)? How much?
2. Record the weight of the hot cocoa mix, add it to the water solution, and stir until fully incorporated.
3. Pour the hot cocoa mix and water mixture into a waste beaker using a coffee filter. Do ***NOT*** discard the coffee filter.
4. Weigh the filter paper and record it. Did you notice a change? If so, how much?
5. Repeat Steps 2-4 using the other water solutions
6. After finishing the last hot cocoa and water mixture, discard the liquid in the waste beaker and clean your experiment station
7. Answer questions regarding the experiment

Data Table:

Hot Cocoa Mix (g)	Water (mL)	Temperature (°C)	Vinegar	Baking Soda	Coffee Filter (g)

Analysis Questions:

1. Using the weight of the coffee filters from the experiment, arrange the solutions in order of decreasing to increasing solubility.

2. Based on the data recorded and the graph above, which solution resulted in the most hot cocoa mix dissolved? How about least dissolved? Defend your answers.

3. Review your hypotheses. Were they correct or incorrect? Explain why.

4. Draw a diagram of hot cocoa mix dissolving in a water solution.

Name: _____ Date: _____

Molecule Polarity [7]

In this activity you will use a PhET simulation to explore molecule polarity.

Part I: What factors affect molecule polarity?

1. Explore the Molecule Polarity simulation for a few minutes with a partner. Before answering the questions associated with each of the three tabs, try to find all of the controls and figure out how they work.

Two Atoms

2. Describe all of the ways you can change the polarity of the two-atom molecule.

3. Explain how the representations below help you understand molecule polarity.

Three Atoms

4. Describe any <u>new</u> ways that can change the polarity of a three-atom molecule.

5. Explain the relationship between the bond dipoles and the molecular dipole.

6. Can a nonpolar molecule contain polar bonds? Explain your answer with an example.

Real Molecules

7. **Predict** the polarity of 6 real molecules. First, draw the molecules and any bond dipoles. Then draw any molecular dipoles. Explain your reasoning before you check your predictions with the simulation.

Name: _____ Date: _____

Exit Ticket

1. Which has a higher relative solubility and why: Boiling Water at (100°C) or Boiling Water at (100°C) saturated with sucrose? Defend your answer.

2. Draw and label a water molecule (H_2O).

3. Draw a model of water molecules dissolving molecules of table salt (NaCl).

Worksheets for the Salinity Lesson

Instructor's Guide for Salinity

Background Information:

Salinity is a measure of how much salt is presently dissolved in a solution. That being said, all ideas discussed in the Instructor's Guide for Solubility will be applicable to this lesson. However, because salt is an ionic compound made of polar bonds, it cannot dissolve in a solvent whose bonds do not exhibit polarity.

Discussion Topics & Expectations:

In *Lesson #6 Salinity: Exploration: Introduction*, students will engage in a discussion about how different bodies of water can have varying salinities. When guiding this discussion, the instructor should ask the following probing questions:

- Do all bodies of water contain the same concentrations of salt?
    - Expectation: No, the salt amount can vary per body of water.
- Does all water have some level of salt concentration (salinity)?
    - Expectation: Yes, all forms of water (except experimental deionized water) have some level of measurable salinity.

The goal for this discussion is for students to identify that salt concentration (salinity) can vary per body of water, whether it be an ocean/sea or a cup of tap water.

In *Lesson #6 Salinity: Exploration: Benchmark Lesson: Measuring Salinity*, students will engage in a discussion about why they placed a certain organism is a specific salinity environment. When guiding this discussion, the instructor should ask the following probing questions:

- Who put Organism Group A with the higher level of salinity? Who put it with the lower level salinity? What did you consider when doing that?
    - Expectation: Students should have put Organism Group A with the high level of salinity. The reason this was done is because those organisms thrive in a high salinity environment, meaning they have adapted to that level salinity. Putting them in a low salinity environment would be detrimental to their health. Apply parallel reasoning for putting Organism Group B in the lower level salinity solution.

The goal of this discussion is for students to correctly associate the need for regulated salt concentration (salinity) in an ecosystem for specific groups of organisms to thrive.

In *Lesson #6 Salinity: Exploration: Investigation Lesson: Relationship Between Chemical Factors and Environment*, students will engage in a discussion about what other factors can influence an environment. When guiding this discussion, the instructor should ask the following probing questions:

- Have any of you had a fish as a pet? If so, what did you have to do to the water?
    - Expectation: The water needed to be changed every once in a while. When new water was added, drops of chemicals were added.
        - If students don't know, these chemicals included: nitrates, oxygen, and saline
    - Based on what we know that a fish needs in its tank, do we think that other aquatic creatures need these as well? How about land animals? Why or why not?
        - Yes, all animals need these chemicals to do various bodily processes to survive.
    - Do we think all animals need the same amount of these chemicals or different amounts?
        - No, all animals need different amounts of these chemicals. Some animals will live in different environments that have more or less of these chemicals.

The goal of this discussion is for students to identify these different factors and think about how they can affect an organism.

Name: _____ Date: _____

Pre Quiz: Solubility

1. Define and describe solubility in your own words.

2. Sydney and Hannah have two tanks labeled A and B both containing 500 L of pure water. Assume they have 300 kg of salt and 250 L of oil. They are told to mix the salt into tank A and the oil into tank B.

    a. Which of the two solutes are most soluble in pure water and why?

    b. What do you expect the consistency to be for tank A?

    c. What do you expect the consisty to be for tank B?

    d. Can you think of a solute that would dissolve the oil better than pure water?

Name: _____ Date: _____

Aquatic Biomes and Salinity[8]

Introduction: Salinity can be measured using a refractometer, which measures the change of direction of light as it passes from air to water. Light moves slower in water than it does in air, and even slower in water that contains salt. You are a Marine Biochemist, and you have been assigned a project where you have to assess a group of organisms and decide which aquatic biome is best suitable for the organisms based on the salinity of the environment. Different organisms thrive in variable environments based on the conditions of the water and the available plants within the environment. Your job is to measure the level of salinity of the a given water sample and decide which environment is the best fit for the given organisms based on the descriptions given below. Report your results and conclusions to your Marine Branch manager.

Materials:

- Refractometer / Salinity meter
- 2 water samples varying in concentration of salt to represent different bodies of water (freshwater and saltwater)
- 2 50 ml beakers

Directions: For each water sample, measure the level of salinity using the refractometer, record your findings in the data table below. Determine which sample of water is best suitable for the group organisms based on their description provided below and your data. Finally, explain why the water sample is the best match for the organism group.

Organism Group A:

- Organisms: Stingray, whale, seahorses, and sea anemones.
- Desired Environment: these organisms thrive in an ocean-like ecosystem containing plants such as turtle grass, seaweed, and kelp. These ocean plants absorb carbon dioxide and help provide much of the Earth's oxygen.

Organism Group B:

- Organisms: trout, snails, clams, and shrimp.
- Desired Environment: these organisms thrive in ecosystems such as ponds, lakes, rivers, or streams. Plant life is diverse and often float on the surface of the water including water lilies, algae, moss, and duckweed.

Results: Data Table

	Level of salinity (ppt)	Recommended Organism Group
Water Sample 1		
Water Sample 2		

Analysis Questions:

1. Defend why you chose the recommended organism group for water sample 1.

2. Defend why you chose the recommended organism group for water sample 2.

3. Other than salinity, what chemical factors affect the type of organisms living in a given ecosystem? (Think about the effects of acids, varying temperatures etc.). Provide a detailed explanation.

4. **Bonus:** Why does the ocean contain higher concentrations of saltwater as opposed to freshwater environments?

Name: _____ Date: _____

Exit Ticket

1. Explain the role played by salinity when classifying a body of water as fresh water versus salt water. Discuss the types of organisms (i.e. animals, plants, etc.) capable of living in each of the salinity states (fresh versus salt water).

2. True or False: The salt that is in your salt shaker is the same salt that is in our oceans. Defend your answer.

Answer Keys for Solubility Lesson

Name: _____Answer Key_____ Date: _____

Water and Solubility

Directions: In the video, a scientist will test to see if the given solute (what is being dissolved) will dissolve in water (solvent). Before the video begins, write down your hypothesis for each solute. Record your observations while watching the video. After the video has ended, compare your hypothesis and observations. Was your hypothesis correct or incorrect? State why you think the solute was soluble or insoluble in water.

	Hypothesis	Observations	Conclusion
Salt	Expect: ● Will dissolve ● Will partially dissolve ● Will not dissolve	Expect: ● Dissolved (clear) ● Did not dissolve (cloudy)	Dissolved because it was crystals
Sugar	*Hypotheses will vary per student*	*Observations will vary per student*	Dissolved because it was crystals
Chalk	*Hypotheses will vary per student*	*Observations will vary per student*	Did not dissolve because it was powdery
Starch	*Hypotheses will vary per student*	*Observations will vary per student*	Did not dissolve because it was powdery
Baking Powder	*Hypotheses will vary per student*	*Observations will vary per student*	Did not dissolve because it was powdery

Name: _____Answer Key_____ Date: _____

Hot Cocoa Experiment

Introduction: As demonstrated in the video, certain solutes can dissolve in water while others cannot. This is caused by the intermolecular forces between the solute molecules and the water molecules. When the bonds between the elements in a solute are weaker than the hydrogen bonds of water molecules, the solute is broken down by water and dissolved. However, several factors can affect how much solute is dissolved in the water. In the following experiment, you will be testing what some of these factors may be.

Materials:

- Hot Cocoa Mix
- 5x Paper cups
- 1x Waste Beaker
- 5x 150.0-mL Water
- 1x Digital Scale
- 1 tbsp Baking Soda
- 1 tbsp Vinegar

Directions:

1. Make hypotheses on the results of the experiment. Do you think the hot cocoa mix (solute) will dissolve in the water solution (solvent)? How much?
2. Record the weight of the hot cocoa mix, add it to the water solution, and stir until fully incorporated.
3. Pour the hot cocoa mix and water mixture into a waste beaker using a coffee filter. Do ***NOT*** discard the coffee filter.
4. Weigh the filter paper and record it. Did you notice a change? If so, how much?
5. Repeat Steps 2-4 using the other water solutions
6. After finishing the last hot cocoa and water mixture, discard the liquid in the waste beaker and clean your experiment station
7. Answer questions regarding the experiment

Data Table:

Hot Cocoa Mix (g)	Water (mL)	Temperature (°C)	Vinegar	Baking Soda	Coffee Filter (g)
	150	25°C	0 tbsp	0 tbsp	
	150	60°C	0 tbsp	0 tbsp	
	150	10°C	0 tbsp	0 tbsp	
	150	25°C	1 tbsp	0 tbsp	
	150	25°C	0 tbsp	1 tbsp	

amounts/measurements may vary depending on student

expect lighter coffee filters when the temperature is higher

Analysis Questions:

1. Using the weight of the coffee filters from the experiment, arrange the solutions in order of decreasing to increasing solubility.

   Answers may vary based on student data. Expect the scale to be...

   $$\text{Solution}_{\text{lower temperature}} <...< \text{Solution}_{\text{higher temperature}}$$

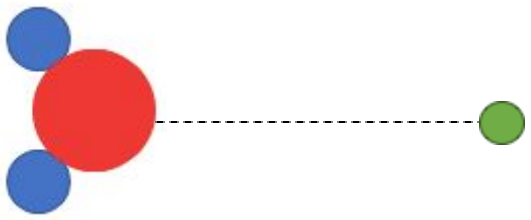
2. Based on the data recorded and the graph above, which solution resulted in the most hot cocoa mix dissolved? How about least dissolved? Defend your answers.

   The solution with a higher temperature results in more hot cocoa mix dissolved because the bonds between the cocoa mix molecules are weakened by the heat. This allows the water molecules to attract the separated molecules. The solution with a lower temperature results in less hot cocoa mix dissolved because the cocoa mix molecules are not weakened, and therefore not broken, easily.

3. Review your hypotheses. Were they correct or incorrect? Explain why.

   Answers will vary based on student data. Expect students to include possible sources of experimental error in their responses.

4. Draw a diagram of hot cocoa mix dissolving in a water solution.
   Below is a water molecule (left) attracting a hot cocoa mix molecule (right)



Name: _____Answer Key_____ Date: _____

Molecule Polarity [7]

In this activity you will use a PhET simulation to explore molecule polarity.

Part I: What factors affect molecule polarity?

1. Explore the Molecule Polarity simulation for a few minutes with a partner. Before answering the questions associated with each of the three tabs, try to find all of the controls and figure out how they work.

Two Atoms

2. Describe all of the ways you can change the polarity of the two-atom molecule.

The electronegativity of both atoms can be adjusted.

3. Explain how the representations below help you understand molecule polarity.

Bond Dipole, Partial Charges, and Bond Character help you visualize polarity.

Electrostatic potential and electron density also help to see polarity.

Three Atoms

4. Describe any new ways that can change the polarity of a three-atom molecule.

   Molecule dipole and electric field can now be used to change polarity.

5. Explain the relationship between the bond dipoles and the molecular dipole.

   The molecular dipole is the bond dipoles summed together.

6. Can a nonpolar molecule contain polar bonds? Explain your answer with an example.

   Yes, a nonpolar molecule can contain polar bonds. The individual bonds can be polar, but the overall molecular dipole can be zero and therefore nonpolar.

Real Molecules

7. **Predict** the polarity of 6 real molecules. First, draw the molecules and any bond dipoles. Then draw any molecular dipoles. Explain your reasoning before you check your predictions with the simulation.

Answers are dependent on student choice and responses. Students are expected to provide reasoning such as: bond dipole, molecular dipole, presence or absence of polar bonds, atom electronegativity, and the number of molecules.

Name: _____Answer Key_____ Date: _____

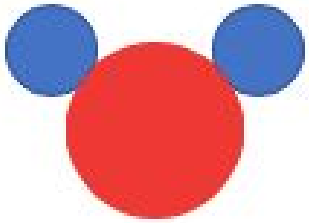
Exit Ticket

1. Which has a higher relative solubility and why: Boiling Water at (100°C) or Boiling Water at (100°C) saturated with sucrose? Defend your answer.

   Boiling Water at (100°C) has a higher relative solubility because there are more water molecules available to bond with the solute than there are in the Boiling Water at (100°C) saturated with sucrose.

2. Draw and label a water molecule (H_2O).

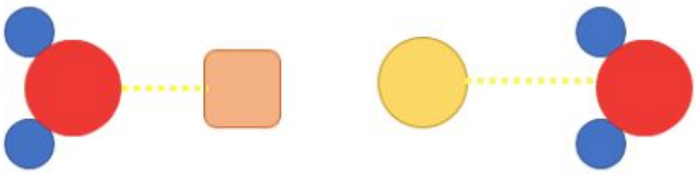
   Hydrogen atoms (partial positive charge)



   Oxygen atom (partial negative charge)

3. Draw a model of water molecules dissolving molecules of table salt (NaCl).

   Sodium (square) and Chlorine (circle)



Answer Keys for Salinity Lesson

Name: _____Answer Key_____ Date: _____

Pre Quiz: Solubility

1. Define and describe solubility in your own words.

   Solubility is a measure of how much solute can dissolve in a solvent

2. Sydney and Hannah has two tanks labeled A and B both containing 500 L of pure water. Assume they have 300 kg of salt and 250 L of oil. They are told to mix the salt into tank A and the oil into tank B.

   a. Which of the two solutes are most soluble in pure water and why?

      Salt because it is a polar compound and can dissociate into its ions. Oil is nonpolar and cannot dissolve.

   b. What do you expect the consistency to be for tank A?

      Very similar to water/no change.

   c. What do you expect the consisty to be for tank B?

      Very thick/not like water.

   d. Can you think of a solute that would dissolve the oil better than pure water?

      Answers may vary; expect the following or something similar:

      - Oil, Fats, or Anything nonpolar

Name: _____Answer Key_____ Date: _____

Aquatic Biomes and Salinity [8]

Introduction: Salinity can be measured using a refractometer, which measures the change of direction of light as it passes from air to water. Light moves slower in water than it does in air, and even slower in water that contains salt. You are a Marine Biochemist, and you have been assigned a project where you have to assess a group of organisms and decide which aquatic biome is best suitable for the organisms based on the salinity of the environment. Different organisms thrive in variable environments based on the conditions of the water and the available plants within the environment. Your job is to measure the level of salinity of the a given water sample and decide which environment is the best fit for the given organisms based on the descriptions given below. Report your results and conclusions to your Marine Branch manager.

Materials:

- Refractometer / Salinity meter
- 2 water samples varying in concentration of salt to represent different bodies of water (freshwater and saltwater)
- 2 50 ml beakers

Directions: For each water sample, measure the level of salinity using the refractometer, record your findings in the data table below. Determine which sample of water is best suitable for the group organisms based on their description provided below and your data. Finally, explain why the water sample is the best match for the organism group.

Organism Group A:

- Organisms: Stingray, whale, seahorses, and sea anemones.
- Desired Environment: these organisms thrive in an ocean-like ecosystem containing plants such as turtle grass, seaweed, and kelp. These ocean plants absorb carbon dioxide and help provide much of the Earth's oxygen.

Organism Group B:

- Organisms: trout, snails, clams, and shrimp.
- Desired Environment: these organisms thrive in ecosystems such as ponds, lakes, rivers, or streams. Plant life is diverse and often float on the surface of the water including water lilies, algae, moss, and duckweed.

Results: Data Table

	Level of salinity (ppt)	Recommended Organism Group
Water Sample 1		
Water Sample 2		

***Answers will vary; students should assign Group A with the higher salinity water sample**

Analysis Questions:

1. Defend why you chose the recommended organism group for water sample 1.

   Answers will vary, expect the following:
   If water sample has a higher salinity, then organism group A should be chosen because those organisms live in oceans, which contain high salt concentrations. If water sample has a lower salinity, then organism group B should be chosen because those organisms live in low salinity (freshwater) environments.

2. Defend why you chose the recommended organism group for water sample 2.

   Answers will vary... (see above explanation)

3. Other than salinity, what chemical factors affect the type of organisms living in a given ecosystem? (Think about the effects of acids, varying temperatures etc.). Provide a detailed explanation.

   Answers will vary, but expect something similar to the following:
   Temperature because an organism must be able to produce/sustain heat. pH because acidity/basicity can interact with beneficial molecules in the ecosystem, limiting the available nutrients and resources for the organisms present.

4. **Bonus:** Why does the ocean contain higher concentrations of saltwater as opposed to freshwater environments?

   Ocean water is contains more chlorine ions than river and other freshwater sources. This makes ocean and sea waters more saline. This happens because acid rain dissolves rocks on land that contain minerals like sodium chloride etc. These then seep down into ocean water, and years of deposition of such minerals makes ocean water saline.

Name: _____Answer Key_____ Date: _____

Exit Ticket

1. Explain the role played by salinity when classifying a body of water as fresh water versus salt water. Discuss the types of organisms (i.e. animals, plants, etc.) capable of living in each of the salinity states (fresh versus salt water).

   Expect the following:

   - Freshwater contains much lower salt concentrations than salt water considering quantity
   - Freshwater organisms include: amoeba, fish, crawfish, salamanders, and turtles
   - Salt water organisms include: starfish, crabs, sharks, and plankton

2. True or False: The salt that is in your salt shaker is the same salt that is in our oceans. Defend your answer.

   True because table salt is simply NaCl. This same compound is found in the ocean, which is why we also have sea salt as a condiment.

Annotated Bibliography

[1] Nsta. (n.d.). Access the Next Generation Science Standards by Topic. Retrieved January 18, 2019, from https://ngss.nsta.org/AccessStandardsByTopic.aspx

This website was used in each lesson in the Water Chemistry & Biology module to select proper national set standards for science subjects that each lesson is centered around.

[2] Nsta. (n.d.). Science and Engineering Practices. Retrieved January 18, 2019, from https://ngss.nsta.org/PracticesFull.aspx

This website used in every lesson in the Water Chemistry & Biology module to find Standards for Science and Engineering Practices that are applicable in each lesson.

[3] Nsta. (n.d.). Disciplinary Core Ideas. Retrieved from https://ngss.nsta.org/DisciplinaryCoreIdeasTop.aspx

This website was used in each lesson in the Water Chemistry & Biology module to select appropriate disciplinary core ideas set forth by the NSTA that are at the center of each lesson.

[4] Nsta. (n.d.). Crosscutting Concepts. Retrieved from https://ngss.nsta.org/CrosscuttingConceptsFull.aspx

This website was used in each lesson in the Water Chemistry & Biology module to selecting appropriate crosscutting concepts set forth by the NSTA that apply to each science lesson.

[5] KClassScienceChannel. (2013, June 19). Compare solubility of salt, sugar and chalk | Solutions | Chemistry. Retrieved February, 2019, from https://www.youtube.com/watch?v=9FBpdaokLto

This reference was used for educational purposes. The video was used as part of an engagement activity with an associated worksheet. The video is shown; however, questions were neither adapted nor excerpted from the reference.

[6] ScienceDaily. (n.d.). Solubility. Retrieved March, 2019, from https://www.sciencedaily.com/terms/solubility.htm

This reference was used for excerption purposes. The information from this reference was directly excerpted from the reference to develop the instructor's guide in the lesson. This reference was useful in providing instructor's the necessary scientific information needed to teach the material.

[7] PhET Interactive Simulations. (2019, April 04). Molecule Polarity. Retrieved February, 2019, from https://phet.colorado.edu/en/simulation/molecule-polarity

This reference was used as an educational tool within the unit plan. The reference was used as part of the elaboration for lesson #1. The PhET has associated questions in the unit plan; however, these were neither adapted nor excerpted from the reference.

[8] US Department of Commerce, & National Oceanic and Atmospheric Administration. (2008, November 14). Why is the ocean salty? Retrieved from https://oceanservice.noaa.gov/facts/whysalty.html

This website was used for adaptation within the Chloride and Salinity lesson. The reference aided in the completion of the Engage. The students were asked why ocean water is saline while river water is not. The answer to that was found in this website, and it was adapted for the students.