 **NSF Sustainable Energy Grant RET Lesson** 

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| **Lesson Title:** Wet Lab Classroom Lab Experiment | **Grade Level/Subject:**  9th-12th grade Chemistry |
| **Maximum # of Students:** Students in Class | **Total Time Required:** 90 minutes |
| Students should have a general understanding of the states of matter (solid, liquid, gas) and their properties.  Familiarity with the concept of solubility and factors that affect it, such as polarity and molecular structure. Students should be aware of basic safety measures when working with laboratory equipment and chemicals. Basic skills related to scientific inquiry. Some familiarity with chemical formulas and their representations of elements and compounds | |

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| **Materials and Preparation:**   |  |  | | --- | --- | | A. Solutions of Liquids in Water:   * Test tubes * Deionized water * Ethyl alcohol (C2H5OH) * Cyclohexane (C6H12) * Stirring rod * Hood (for safety) * Red organic waste container (for disposal)   B. Solutions of Gases in Water:   * Hot water bath * Ice water bath * Soda beverage * Test tubes * Cold water * Hot water * Hot tap water (from teacher) * Ice (for ice water bath) * Hot water source   C. Solutions of Solids in Water:   * Test tubes * Deionized water * Compounds: * Copper (II) sulfate * Copper (II) carbonate * Calcium carbonate * Calcium chloride * Calcium nitrate * Pencil (for labeling test tubes) * Reagent bench * Demonstrations: * Sugar (sucrose, C12H22O11) * Iodine (I2) * Sodium acetate * Ammonium nitrate * Sodium hydroxide * Erlenmeyer flasks * Deionized water * Thermometer * Balance (for measuring substances) * Hot plate (for heating water) * Ice (for cooling water) * Heatproof gloves (for safety) * Stirring rod * Hood (for safety) | * Propellers * Tubing * Solar panels (2V 400mA) * Multi-meters * Assorted LEDs * Solar motors * Pairs of clamp wires * Wire strippers * Protractors | |

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| **Performance Objectives/Learning Targets:**  The objective of this experiment is to provide a guided inquiry experience into the chemistry of solutions. Students will explore properties of solutions and determine which types of substances are soluble and insoluble in different types of solvents. They will predict outcomes of simple chemical reactions, explore the outcomes of changing reagent concentrations, and apply mathematical principles to support the claim that mass is conserved in chemical reactions. The experiment is designed for chemistry students, but parts of it can be used with physical sciences classes. | |
| **Standards:** | |
| **Lesson Procedure** | |
| **Before:** | Before conducting the activities described in sections A, B, and C, it's important to provide clear instructions to the students regarding safety precautions, experimental procedures, and proper disposal of materials. Here are the instructions and materials that need to be prepared beforehand for each activity:  A. Solutions of Liquids in Water:  Instructions:   * Ensure students understand the importance of wearing safety goggles and following all safety guidelines. * Demonstrate how to handle test tubes safely and use the hood when working with volatile substances. * Emphasize the proper disposal of waste materials into the designated red organic waste container. * Materials to be Prepared: * Test tubes * Deionized water * Ethyl alcohol (C2H5OH) * Cyclohexane (C6H12) * Stirring rod * Hood (for safety) * Red organic waste container (for disposal)   B. Solutions of Gases in Water:  Instructions:   * Set up the hot water bath and ice water bath. * Instruct students on how to handle test tubes safely and record observations accurately. * Explain the concept of solubility and ask students to predict which test tube will show more dissolution of carbon dioxide. * Materials to be Prepared: * Hot water bath * Ice water bath * Soda beverage * Test tubes * Cold water * Hot water * Ice * Hot water source   C. Solutions of Solids in Water:  Instructions:   * Demonstrate proper labeling of test tubes and handling of compounds. * Instruct students to add a small amount of each compound to the appropriate test tube and stir gently. * Discuss solubility and ask students to observe and record whether each compound dissolves or remains insoluble. * Materials to be Prepared: * Test tubes * Deionized water * Compounds (Copper (II) sulfate, Copper (II) carbonate, Calcium carbonate, Calcium chloride, Calcium nitrate) * Pencil (for labeling test tubes) * Reagent bench * Additionally, for all activities, ensure that safety equipment such as safety goggles and heatproof gloves are available for students to use as needed. |
| **During:** | **A. Solutions of liquids in water**  Take 2 test tubes with approximately 2 mL of deionized water to the hood. To one of the test tubes add about 2 mL of ethyl alcohol and stir with your stirring rod. To the other test tube of water add about 2 mL of cyclohexane and stir. Don’t forget to clean your stirring rod.   |  |  |  |  | | --- | --- | --- | --- | |  | Soluble in Water? | Polar or Nonpolar? | Ionic or Molecular? | | Water |  |  |  | | Ethanol (C2H5OH) |  |  |  | | Cyclohexane (C6H12) |  |  |  |   Disposal: Empty both test tubes into the red organic waste container.  **Food coloring in hot and cold water** To about 250 mL of hot tap water in a beaker add 1 drop of food coloring. Then add 1 drop of food coloring to about 250 mL of cold tap water in another beaker. Observations:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Give a brief explanation of the difference in the way food coloring disperses in hot water versus cold water. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **B. Solutions of gasses in water**  Set up a hot water bath (obtain hot water from the teacher) and an ice water bath. Add about 3 mL of the soda beverage to two different test tubes. Place one test tube in the cold water bath and one test tube in the hot water bath, and record your observations.  Observations:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Soda is dissolved carbon dioxide CO2 in water (with sugar and other flavorings) Is the carbon dioxide more soluble in hot water or in cold water?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Explain\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **C.** **Solutions of solids in water**  Take 6 test tubes with about 3 mL of deionized water to the reagent bench. With a pencil label the test tubes with the formulas of the following compounds. Add a small amount (about the size of a pea) of the compounds to the appropriate test tube. Stir.  **Ionic compounds in water**   | **Substance** | **Formula** | **Ionic or Molecular?** | **Soluble or Insoluble?** | | --- | --- | --- | --- | | Copper (II) sulfate in water |  |  |  | | Copper (II) carbonate in water |  |  |  | | Calcium carbonate in water |  |  |  | | Calcium chloride in water |  |  |  | | Calcium nitrate in water |  |  |  |   Are all ionic compounds soluble in water?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **Demonstration: sugar in hot water and in cold water**  Your instructor will put 50 g of sugar (sucrose, C12H22O11) in 100 ml of cold water in one beaker and stir and 100 g of sucrose in 100 g of hot water (just below boiling) and stir Observations:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Explain the difference between the hot solution and the cold solution. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  How does temperature affect the solubility of a solid in water? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **Demonstration : Iodine in water and in cyclohexane (C6H12) versus NaCl in water and in cyclohexane**  Your instructor will pour about 3 ml of cyclohexane into two test tubes in the hood and deionized water into the other two test tubes. Your instructor will then place about a pea sized amount of NaCl into each of the solvents and the same amount of iodine crystals in the remaining test tubes.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Solute** | **Solvent** | **Soluble or Insoluble?** | **Ionic, Polar or Nonpolar Solute?** | **Polar or Nonpolar Solvent?** | | Sodium chloride (NaCl) | Water |  |  |  | | Sodium chloride | Cyclohexane |  |  |  | | Iodine (I2) | Water |  |  |  | | Iodine | Cyclohexane |  |  |  |   Be sure to separate halogenated organics from other wastes.  What conclusion can you make from the above table about the type of solute that best dissolves in a certain type of solvent ? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **Demonstration: Super Saturation**  Your instructor will show you saturated, unsaturated and supersaturated solutions of sodium acetate Look at each solution and record your observations below? solution Initial observation saturated unsaturated supersaturated   |  |  | | --- | --- | | **Solution** | **Initial observation** | | saturated |  | | unsaturated |  | | supersaturated |  |   Your instructor will now add a small crystal of sodium acetate to each of the solutions.  Record what happens.   |  |  | | --- | --- | | **Solution** | **Final observation** | | saturated |  | | unsaturated |  | | supersaturated |  |   **Demonstration: Heat of Solution** Your instructor will put approximately 25 ml of deionized water into 2 different Erlenmeyer flasks. The initial temperature is to be recorded before a substance is added. In one flask about 5 g of ammonium nitrate will be added. To the other flask about 5 g of sodium hydroxide will be added. Record the initial and final temperatures in the table below.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Substance name** | **Formula** | **Initial temperature** | **Final temperature** | **Endothermic or exothermic?** | | Sodium hydroxide |  |  |  |  | | Ammonium nitrate |  |  |  |  |   Which ionic substances dissolve in water? (There were a total of 9 ionic compounds in this experiment.)  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Which ionic substances do not dissolve in water? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Which molecular substances dissolve in water? (There were a total of 5 molecular compounds in this experiment.)  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Why? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Which molecular substances do not dissolve in water? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Why? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  How can many solids be made more soluble in water? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  How can gasses be made more soluble in water? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What are the factors that influence how a substance dissolves in water? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What was the most important concept you learned today about solutions? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| **After:** | * Have students answer the following problems individuals, then discuss as a class:   **Problems**  1. What is the percent mole-to-mole concentration of an aqueous solution of sodium nitrate in which there are 24.34 grams of solute in 138.87 grams of solvent? Answer\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  2. How many grams of copper (II) sulfate are dissolved in 247 mL of solution if the concentration is 48.6% CuSO4 (m/v)? Answer\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  3. How many mL of alcohol are needed to make 4.50 L of a 25.0 % aqueous solution? (Assume the volumes are additive.) Answer\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  4. If vinegar is a 5.0% (m/v) solution of acetic acid in water, how many grams of acetic acid are dissolved in a 1.0L bottle of vinegar? Answer\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  5. What is the percent concentration (mole-to-mole) of a sodium fluoride solution made by dissolving 65.4 grams of sodium fluoride in 125.1 grams of water? Answer\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  6. Saline solution is often used in hospitals and by optometrists. It is a 0.92% (mass/volume) aqueous solution of sodium chloride. How many grams of NaCl would be found in 1.59 liters of saline solution Answer\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| **5E Model:** *Engage, Explore, Explain, Evaluate, Elaborate*  **Engage:** Begin with a discussion about solutions. Ask what students know about liquids, gases, and solids in water.  **Explore:** Students conduct experiments with liquids in water, observing and recording their findings on solubility.  **Explain:** Discuss observations and findings, explaining differences in solubility based on polarity and molecular structure.  **Elaborate:** Students explore solubility of solids in water, conducting experiments and discussing factors influencing solubility.  **Evaluate:** Formative assessment: ask questions and provide problems to assess understanding of solubility concepts and application. | |