Solutions

By: Matt Huber, Michael Wild, Jasmine Gilbert and Dr. Faith Yarberry

Following completion of this module, the student will:

- Be able to use the terms solute, solvent, and solution correctly.
- Understand the concept “Like Dissolves Like.”
- Obtain an understanding of the solution process for compounds in water.
- Be able to identify a solute as a strong electrolyte or weak electrolyte.
- Be able to identify the amount of solute present in a solution given the concentration for that solution.
- Realize how concentration differences influence osmosis.
- Understand how soap allows hydrogen bonding water to link with oil that contains London Forces to remove grease from dirty dishes.
Lesson #1 – Terminology and “Like Dissolves Like”

A solution is a homogenous mixture that contains a solute and a solvent. The solute is the dissolved substance in a solution. It is the minor component of a solution. The solvent is the major component of a solution. When the solute is combined with the solvent, a homogenous mixture will form. A homogenous mixture is a substance with a uniform composition throughout. In order for a homogenous solution to exist that means that the solute must fully dissolve in the solvent. When will a solution form?

The effect of intermolecular forces on the properties of a single substance was described in the Water vs Hydrocarbon module. Intermolecular forces are also the driving force behind solution formation. The best solvent for a given solute will be the solvent with the exact same intermolecular force as the solute. This is referred to as the “Like Dissolves Like” principle.

Demonstration Materials:

Water  
Styrofoam (2 types – starch based and styrofoam based)  
Acetone  
Four beakers

Demonstration:

- Fill 2 beakers with water and 2 beakers with acetone.  
- Add a starch packing peanut to one beaker of each type of solvent and observe.  
- Add a piece of Styrofoam to the other beaker of each type of solvent and observe.  
- Explain by drawing the three materials.
It is necessary to understand the solution process to comprehend why it is important that the solute and solvent have similar intermolecular forces. The following diagram illustrates the solution process that occurs between water and sodium chloride. Before discussing the solution process, it is necessary to refresh students on the structure of water and of sodium chloride. As mentioned in the Water vs Hydrocarbon module, water is a polar molecule due to its shape and connectivity. This polarity provides water with a partially positive pole and a partially negative pole within the molecule. The partially negative pole is found on the oxygen and the partially positive pole on the hydrogen. Sodium chloride is an ionic compound that consists of the
positive cation sodium and the negative anion chloride. In other words, both of these compounds contain a positive end and a negative end and just like magnets the positive end of one molecule will be attracted to the negative end of another molecule.

In the diagram you will note that the partially negative end of water orients itself towards the sodium cation. Multiple water molecules will surround the sodium ion and dissolve the ion into solution. The same type of thing occurs with the chloride anion. The partially positive end of water will orient itself toward the chloride anion. Several water molecules will surround the chloride anion, carrying it away into solution. To show a video of this process, go to http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/molvie1.swf. 
Lesson #2 – Electrolytes

Lesson 1 discussed the solution process. Lesson 2 will build on this concept. The solution process is the same for all materials, but the degree to which a solute dissociates differs from one substance to the next. The degree of dissociation is described by the equilibrium constant, $K$, for a reaction. A $K > 1$ indicates that a significant amount of the solute dissociates into ions during the solution process (reaction is essentially all product). A $K < 1$ indicates that very little of the reactant solute underwent dissociation (reaction is essentially all reactant).

\[
\text{NaCl (s) + H}_2\text{O (l)} \rightarrow \text{Na}^+ \text{(aq) + Cl}^- \text{(aq)} \quad K = 36
\]
\[
\text{AgCl (s) + H}_2\text{O (l)} \rightarrow \text{Ag}^+ \text{(aq) + Cl}^- \text{(aq)} \quad K = 1.8 \times 10^{-10}
\]

According to these equations and $K$ values, 1 mole of sodium chloride will dissociate entirely to form sodium ions and chloride ions by the end of the reaction, whereas, 1 mole of silver chloride in water dissociates very little and in the end the solution will contain essentially no silver ion or chloride ion.

A solution will conduct electricity when ions are allowed to move around freely in solution. This type of solution is referred to as an electrolyte. The greater the number of ions in solution, the better the solution will be at conducting electricity and is referred to as a strong electrolyte. Hence, solutes with large $K$ values will be good conductors of electricity and are deemed strong electrolytes. Strong electrolytes include highly soluble ionic compounds, strong acids and strong bases. Solutes with very small $K$ values, hence very few ions in solution, will conduct electricity but poorly. These are referred to as weak electrolytes. Weak electrolytes include ionic compounds that dissociate very little, weak acids, and weak bases. Some solutes will not dissociate at all in a given solvent and therefore will not conduct electricity. These compounds are non-electrolytes.

Demonstration Materials:
- 4 250-mL beakers
- 1 M hydrochloric acid
- Vinegar
- Sodium chloride (table salt)
- Calcium carbonate
- Electrodes

Demonstration
1. Add hydrochloric acid to a 250-mL beaker
2. Add vinegar to a second 250-mL beaker
3. Add table salt to a third 250-mL beaker
4. Add calcium carbonate to a fourth 250-mL beaker
5. Place the electrodes into each solution separately
6. Have the student make observations identifying the strong acid, weak acid, soluble ionic compound and slightly soluble ionic compound.
7. Have the student explain their observations with respect to dissociation of solute.
Lesson 3 – Concentrations

Demonstration Materials for entire lesson:
2 packets of drink mix
2 quart pitchers
2 drinking glasses of different sizes
Labeled reagent bottles of differing molarities and concentration units sitting on desks
Table salt
Balance
Beakers of different sizes
Stuffed cloth moles

Demonstration:
1. Following student directions, prepare a pitcher of drink mix. Use terms of solute, solvent, solution, and homogenous mixture during the process.
2. Ask the students to tell you the concentration in the pitcher (1 pack / pitcher)
3. Pour some of the prepared drink into the two drinking glasses.
4. Ask the students to tell you the concentration of solute (drink mix) in each glass. They should understand that the concentration is the same. While the amount of drink mix in the glass is less than that in the pitcher, the volume is equally reduced.
5. Ask how to make a 0.5 pack / pitcher solution. Again follow the student’s directions. Students should realize that the packet must be opened and the amount desired weighed out on a balance.
6. Point out the reagent bottles and explain that the terms molarity and % are expressions of concentration.
The term concentration indicates the amount of solute present in a solution. There are many units that can be used to represent the concentration of a solution.

<table>
<thead>
<tr>
<th>Concentration Term</th>
<th>Formula</th>
<th>Unit</th>
<th>Where Commonly Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Percentage</td>
<td>( \left( \frac{\text{grams solute}}{\text{grams solution}} \right) \times 100 )</td>
<td>w/w %</td>
<td>Water Pollution Chemistry</td>
</tr>
<tr>
<td>Mass-volume Percentage</td>
<td>( \left( \frac{\text{grams solute}}{\text{milliliters solution}} \right) \times 100 )</td>
<td>w/v %</td>
<td>Mixture of Liquids or Mixtures of Gases</td>
</tr>
<tr>
<td>Volume-Volume Percentage</td>
<td>( \left( \frac{\text{milliliters solute}}{\text{milliliters solution}} \right) \times 100 )</td>
<td>v/v %</td>
<td>Mixture of Liquids or Mixtures of Gases</td>
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<tr>
<td>Parts per Million</td>
<td>( \left( \frac{1 \text{ g solute}}{1,000,000 \text{ g solution}} \right) )</td>
<td>ppm</td>
<td>Air, Water, Soil Pollution</td>
</tr>
<tr>
<td>Parts per Billion</td>
<td>( \left( \frac{1 \text{ g solute}}{1,000,000,000 \text{ g solution}} \right) )</td>
<td>ppb</td>
<td>Air, Water, Soil Pollution</td>
</tr>
<tr>
<td>Molarity</td>
<td>( \left( \frac{\text{moles solute}}{\text{liters solution}} \right) )</td>
<td>M</td>
<td>Chemistry Laboratory</td>
</tr>
</tbody>
</table>

Examples:

<table>
<thead>
<tr>
<th>Solution</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>70% isopropyl alcohol</td>
<td>70 milliters of isopropyl alcohol is present in 100 mL of solution</td>
</tr>
<tr>
<td>3% hydrogen peroxide</td>
<td>3 mL of hydrogen peroxide present in 100 mL of solution</td>
</tr>
<tr>
<td>0.9 ppm methane</td>
<td>0.9 g of methane in every 1,000,000 g of air</td>
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The most common unit used in a chemical laboratory is that of Molarity. **Molarity is moles of solute per liter of solution.** Let’s look at some examples.

**Demonstration:**

1. Stuff a mole in a 1 L beaker and ask the students to tell you the concentration. Answer - 1 M (Write the results on the board.)
2. Stuff a second mole into the same beaker and ask the students to tell you the concentration. Answer - 2 M (Write the results on the board)

3. Maintain beaker for illustration later.

Reemphasize at this point that the concentration depends on the amount of solute in a specific volume of solution. In the demonstration above we were dealing with 1 L of solution (1 L beaker). What if we change up the volume?

**Demonstration:**

1. In a 400-mL beaker add 1 mole. Have the students calculate the concentration of this solution. Answer - 2.5 M. (Write the results on the board)

2. Add a second mole to the beaker and have the students determine the concentration. Answer – 5M. (Write the results on the board)

3. Place the 1 L beaker from earlier side by side with the 400 mL beaker. Ask the students to identify why the concentrations are different.

Emphasize that we are placing the same quantity of moles in each beaker, but the quantity is spreading out over less volume in the 400 mL beaker, hence the solutions are stronger than in the 1 L beaker.

**Demonstration: Preparation of sodium chloride solution**

Tell the students that you would like to prepare 500 mL of 0.1 M solution of Sodium Chloride.

**Questions**

(1) What does the concentration unit mean?

(2) How many moles of sodium chloride will be needed for 1 L of solution?

(3) How many moles of sodium chloride will be needed for 500 mL which is ½ the volume of a liter?

(4) What mass of sodium chloride will be dissolved in water to make the solution? Molar Mass of sodium chloride is 58.45 g/mol.

Now prepare the solution.

1. Mass the amount of sodium chloride determined in question 4.

2. Add that amount to a 600 mL beaker.

3. Fill the beaker with 400 mL of water.

4. Stir to dissolve the sodium chloride.

5. Top the solution off at 500 mL.

**Lab #1** gives them practice with making hydrochloric acid solutions.
Thus far solutions of strong electrolytes have been prepared. Strong electrolytes dissociate readily into ions in the formation of a solution. At some point the solvent will not be able to dissolve additional solute. This is the point in which a saturated solution arises. The solubility of a solute can be altered, however, through heat. For most molecular and ionic compounds, an increase in temperature will result in an increase in the solubility of the solute. In other words, more solute can be added to a solvent that is hot than a solute that is at room temperature or below. The solution that forms when the concentration of the solute is greater than that in a saturated solution is referred to as a supersaturated solution. Labs 2-5 allow for the formation of a supersaturated solution.
Lesson 4 – Osmosis

All living things are made up of cells. Cells are separated by a semi-permeable membrane. A semi-permeable membrane is one that allows small molecules such as water, oxygen, and carbon dioxide pass in and out of the cell.

Demonstration Materials:
Dry beans
Salt
Colander
Container with lid
Large bowl

Demonstration:
1. Combine ½ cup dry beans and ½ cup salt into the container with the lid.
2. Secure the lid and shake back and forth several times until the contents are mixed.
3. Hold the colander over a bowl and pour the mixture into the colander.
4. Gently shake the colander up and down several times over the bowl.
5. Observe the contents of the colander and bowl

When solutions of differing concentrations are separated by a semi-permeable membrane, solvent molecules (water) will pass through the membrane in a process called Osmosis. Although passage of the solvent through the membrane is bi-directional, a greater number of solvent molecules will pass from the side that is lower in solute concentration to the side of greater solute concentration until an equilibrium attained. Lab 6 allows them to observe the concept of osmosis.
Lesson 5 – Combining Water with Hydrocarbons

If like dissolves like, oil and water should not mix because oil contains London forces and water contains hydrogen bonding which are very different intermolecular forces. So, the question: how can grease be removed from plates via dishwashing? The answer is found in the structure of the soap that is added. Soap contains a **hydrophobic tail, water fearing**, which will interact with the oil and a **hydrophilic head, water loving**, that will interact with the water to bring the two compounds together and allow the grease to be removed from the plates.

The process involves the hydrophobic tails encompassing the oil molecule while the hydrophilic heads orient themselves towards the water solvent forming a micelle around the oil molecule. The micelle allows for the oil to be rinsed away from the plate.
Overheads
Lesson #1 – Definitions

Solution – Homogenous mixture of a solute and a solvent

Homogenous mixture – a mixture with a uniform composition throughout

Solute – Substance dissolved. Minor component the solution

Solvent – Major component of the solution
Lesson #2 – Definitions

Electrolyte – A solution that conducts electricity because ions are allowed to move around freely

Strong Electrolyte – A solution that conducts electricity well due to the large number of ions in solution

Weak Electrolyte – A solution that weakly conducts electricity due to the presence of a few ions

Non-Electrolyte – A solution that does not conduct electricity
Lesson 3 – Definitions

Concentration – a value that indicates the amount of solute present in a solution

Molarity – moles of solute present in one liter of solution

Saturated solution – a solution containing the maximum amount of solute that the solvent can dissolve

Supersaturated solution – a solution that contains more solute than the solvent can typically dissolve.
Lesson 4 – Definitions

Semi-permeable membrane – a membrane that allows only small molecules to pass through

Osmosis – passage of water through the membrane
Definitions – Lesson #5

Hydrophobic – water fearing

Hydrophilic – water loving
Lesson 1

Solutions form when these three kinds of forces are similar.
Lesson 2

\[ \text{NaCl (s) + H}_2\text{O (l)} \rightarrow \text{Na}^+ (\text{aq}) + \text{Cl}^- (\text{aq}) \quad K = 36 \]

\[ \text{AgCl (s) + H}_2\text{O (l)} \rightarrow \text{Ag}^+ (\text{aq}) + \text{Cl}^- (\text{aq}) \quad K = 1.8 \times 10^{-10} \]
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Lesson 5
Laboratories
Laboratory #1

Materials Needed Per Group

2 mL of 6 M HCl
Stirring Rod
1 10-mL graduated cylinder
3 100-mL graduated cylinders
pH meter
Background:

Solution preparation from a solid was discussed in class, but, solutions can be prepared by diluting stronger solutions to the desired concentration. The question is: how much of the stronger solution do I need to use to make my solution? The simplest way to determine the quantity of stronger solution needed is by using the equation for dilutions which is:

\[ M_i V_i = M_f V_f \]

\( M_i \) represents the concentration of the stronger solution, \( M_f \) represents the concentration of the desired solution, and \( V_f \) represents the desired volume of the new solution. Using this equation you can solve for \( V_i \) which will tell you the quantity of the higher concentration material that you need to dilute.

Example:

I need 100 mL of a 0.05 M hydrochloric acid solution for a laboratory that is being performed today. All that I have available in the stock room is concentrated hydrochloric acid which is 12 M. How do I prepare the desired solution from what I have on hand?

\[ (12 \text{ M HCl}) \times V_i = (0.05 \text{ M HCl}) \times (100 \text{ mL}) \]

\[ V_i = 2.4 \text{ mL} \]

To prepare the solution:

Begin by adding 50 mL of water to a 100 mL graduated cylinder. Slowly add 2.4 mL of 12 M HCl to the graduated cylinder while stirring. (Always add acid to water)

Top the solution off to the 100 mL mark with water.

Stir to thoroughly mix.

The result is 100 mL of a 0.05 M HCl solution

Today you will be preparing three solutions by dilution.
**Procedure:**

1. Calculate the volume of 6 M HCl needed to prepare 100 mL of a 0.1 M HCl solution and verify your answer with the teacher.

   ________________________________
   Teacher’s initials ______

2. Add 50 mL of water to a 100 mL graduated cylinder.

3. Slowly add the quantity of 6 M HCl determined in step 1 to the graduated cylinder while stirring. (**Always add acid to water**)

4. Top the solution off to the 100 mL mark with water.

5. Stir to thoroughly mix.

6. Use a pH meter to determine the pH of your solution

   ________________________________
   Teacher’s initials ______

7. Calculate the volume of the 0.1 M HCl prepared in step 5 needed to prepare 100 mL of a 0.01 M HCl solution and verify your answer with the teacher.

   ________________________________
   Teacher’s initials ______

8. Add 50 mL of water to a 100 mL graduated cylinder.

9. Slowly add the quantity of 0.1 M HCl determined in step 7 to the graduated cylinder while stirring. (**Always add acid to water**)

10. Top the solution off to the 100 mL mark with water.

11. Stir to thoroughly mix.

12. Use a pH meter to determine the pH of your solution

   ________________________________
   Teacher’s initials ______

13. Calculate the volume of 0.01 M HCl prepared in step 11 needed to prepare 100 mL of a 0.001 M HCl solution and verify your answer with the teacher.

   ________________________________
   Teacher’s initials ______

14. Add 50 mL of water to a 100 mL graduated cylinder.

15. Slowly add the quantity of 0.01 M HCl determined in step 13 to the graduated cylinder while stirring. (**Always add acid to water**)

16. Top the solution off to the 100 mL mark with water.

17. Stir to thoroughly mix.

18. Use a pH meter to determine the pH of your solution

   ________________________________
   Teacher’s initials ______
Laboratory #2

Materials Needed Per Group
100-mL beaker
100-mL graduated cylinder
90 g sodium acetate
Hot plate
Stirring rod
Refrigerator
Foil

Procedure:
1. Mass out 90 g of sodium acetate and record your mass
2. Add 25 mL of water to a beaker.
3. Slowly add sodium acetate until it no longer will dissolve.
4. Mass the remaining sodium acetate and record your mass
5. Record the approximate volume of your solution
6. Place the beaker on a hot plate and bring the water to a gentle boil
7. Slowly add the remaining sodium acetate while stirring
8. After all solid has dissolved place a piece of foil over the top.
9. Place the beaker in a refrigerator to cool overnight
10. Next day gently remove the foil and add 1 crystal of sodium acetate
Data:

Initial mass of sodium acetate from step 1 __________________

Mass of sodium acetate remaining in step 4 __________________

Mass of sodium acetate required to make a saturated solution ________________

Volume of solution from step 5 ___________________

Post-Laboratory Questions:

What is the concentration of a saturated solution of sodium acetate?

Mass of sodium acetate in g __________________

Moles of sodium acetate in mol __________________

Volume of solution in mL (step 5) __________________

Volume of solution in L __________________

Molarity of saturated solution __________________

What is the difference between a saturated solution and a supersaturated solution?

What happened when a crystal of sodium acetate was added to the supersaturated solution in step 10?
Laboratory #3

Materials Needed Per Person
A wooden skewer (you can also use a clean wooden chopstick)
A clothespin
1 cup of water
2-3 cups of sugar
A tall narrow glass or jar
Food coloring (optional)
Flavoring (optional)
Pan

Procedure:
1. Clip the wooden skewer with a clothespin so that it hangs down inside the glass and is about 1 inch (2.5 cm) from the bottom of the glass.
2. Remove the skewer and clothespin and put them aside for now.
3. Add 1 cup of water into a pan.
4. Add flavoring and food coloring at this point if desired.
5. Slowly add sugar to the pan while stirring. Continue adding sugar until no more dissolves. (approximately 1 cup)
6. Record how much is required for saturation
7. Heat the pan to a gentle boil.
8. Slowly add sugar into the boiling water, stir until it dissolves.
9. Keep adding more and more sugar, each time stirring it until it dissolves, until no more will dissolve in the hot water. This will take time and patience and it will take longer for the sugar to dissolve each time. Be sure you don't give up too soon. Once no more sugar will dissolve, remove it from heat and allow it to cool for 10 minutes.
10. While it is cooling, dip half of the skewer in the sugar solution and then roll it in some sugar to help jump start the crystal growth. Be sure to let the skewer cool completely so that sugar crystals do not fall off when you place it back in the glass.
11. Pour the hot sugar solution into the jar almost to the top.
12. Submerge the skewer back into the glass making sure that it is hanging straight down the middle without touching the sides.
13. Allow the jar to cool and put it someplace where it will not be disturbed.
14. Now just wait. The sugar crystals will grow over the next 3-7 days.

Post-Laboratory Question

Amount of sugar required for saturation? ____________________

What is the difference between a saturated solution and a supersaturated solution?
Laboratory #4

Materials Needed Per Person
½ of a pipe cleaner
Fishing line
Pencil
½ - ¾ cup Borax
Water
A tall narrow glass or jar
Pan

Procedure:
1. Fold the pipe cleaner into any shape.
2. Attach a piece of fishing line to the pipe cleaner.
3. Attach the other end of the fishing line to a pencil so that the bottom of the pipe cleaner hangs down inside the glass and is about 1 inch (2.5 cm) from the bottom of the glass.
4. Remove the pencil and pipe cleaner and put them aside for now.
5. Add 2 cup of water into a pan.
6. Slowly add borax to the pan while stirring. Continue adding borax until no more dissolves. (approx. ¼ cup)
7. Record the amount of borax required.
8. Heat the pan to a gentle boil.
9. Slowly add an additional ¼ cup of borax into the boiling water, stir until it dissolves.
10. Remove it from heat and allow it to cool for 10 minutes.
11. Pour the hot borax solution into the jar almost to the top.
12. Submerge the pipe cleaner into the glass making sure that it is hanging straight down the middle without touching the sides.
13. Allow the jar to cool and put it someplace where it will not be disturbed.
14. Now just wait. The borax crystals will grow overnight.

Post-Laboratory Question

Amount of borax required for saturation? _______________________

What is the difference between a saturated solution and a supersaturated solution?
Laboratory #5

Materials Needed Per Person
Piece of string
Pencil
Table salt
Water
A tall narrow glass or jar
Pan

Procedure:
1. Attach the string to a pencil so that the bottom of the string hangs down inside the glass and is about 1 inch (2.5 cm) from the bottom of the glass.
2. Set the jar and string aside for now.
3. Add 2 cup of water into a pan.
4. Slowly add salt to the pan while stirring. Continue adding salt until no more dissolves. (approx. ½ cup)
5. Record the amount of salt required.
6. Heat the pan to a gentle boil.
7. Slowly add an additional 1 tablespoons of salt into the boiling water, stir until it dissolves.
8. Remove it from heat and allow it to cool for 10 minutes.
9. Pour the hot salt solution into the jar almost to the top.
10. Allow the jar to cool and put it someplace where it will not be disturbed.
11. Now just wait. The salt crystals will grow overnight.

Post-Laboratory Question

Amount of salt required for saturation? ________________________

What is the difference between a saturated solution and a supersaturated solution?
Laboratory #6

Materials Needed Per Three Groups: (Have 3 groups work together and share data.)
3 eggs
3 250-mL beakers or big clear cups
Vinegar
Karo Syrup
Salt Water
Distilled Water
3 - 12” pieces of string
3 rulers
Balance
Plastic wrap

Procedure – Day 1
1. Gently place an egg into a 250-mL beaker
2. Cover the egg with vinegar
3. Record your observations
4. Cover the beaker with plastic wrap
5. Place in refrigerator for 24 hours

Procedure – Day 2
1. Gently rinse the egg.
2. Record your observations about the egg. (How does it feel, what does it look like?)
3. Mass the egg. Record your data.
4. Measure the circumference of the egg by wrapping a string gently around the middle of the egg and then placing that length of string against a ruler. Record your data
5. Wash out the 250-mL beaker and dry the beaker.
6. Fill the beaker with Karo syrup, salt water, or distilled water according to your teacher’s instruction
7. Record the properties of the Karo syrup, salt water, or distilled water – what does it feel like and pour like?
8. Gently slide the egg into the Karo syrup, salt water, or distilled water
9. Cover the beaker with plastic wrap
10. Set aside for 48 hours.

Procedure – Day 4
1. Remove the egg.
2. Record the properties of the Karo syrup, salt water, or distilled water – what does it feel like and pour like?
3. Rinse the egg.
4. Record your observations about the egg. (How does it feel, what does it look like?)
5. Mass the egg. Record your data.
6. Measure the circumference of the egg by wrapping a string gently around the middle of the egg and then placing that length of string against a ruler. Record your data
7. Wash out the 250-mL beaker and dry the beaker.
Data:

What did you notice about the egg when you placed it in vinegar?

What did the egg look and feel like after sitting in vinegar overnight?

Mass of the egg from step 3 of day 2. __________________________

Circumference of the egg from step 4 of day 2. __________________________

Describe the:
  Karo syrup

  Salt water

  Distilled water.

What did the egg look and feel like after sitting in:
  Karo syrup for 48 hours?

  Salt water for 48 hours?

  Distilled water for 48 hours?
Describe the:
Karo syrup after removing the egg.

Salt water after removing the egg.

Distilled water after removing the egg.

Mass of the egg from step 5 of day 4. _______________________

Circumference of the egg from step 6 of day 4. _______________________
Combine Data of the Three Groups

<table>
<thead>
<tr>
<th>Egg in</th>
<th>Karo Syrup</th>
<th>Salt Water</th>
<th>Distilled Water</th>
</tr>
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<tbody>
<tr>
<td>Initial Mass of Egg</td>
<td></td>
<td></td>
<td></td>
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<td>Mass of Egg after 48 hours</td>
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<td>Difference in the Mass</td>
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<td>Initial Circumference of Egg</td>
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<td>Circumference of Egg after 48 hours</td>
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<td>Difference in the Circumference</td>
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Conclusions and Post-Laboratory Questions:

Define semi-permeable membrane.

Define osmosis.

Why was the shell of the egg removed first?

How did the egg change after addition to:
   Karo Syrup?

   Salt Water?

   Distilled Water?
Explain (using the terms osmosis, semi-permeable membrane, high solute concentration, low solute concentration) what happened between the:

Egg and Karo Syrup.

Egg and Salt Water.

Egg and Distilled water.

Write a generalized statement regarding the direction that water will flow through a semi-permeable membrane.
Saponification

Making Soap

Soap is the result of saponification. Saponification is a reaction that converts an ester, a lipid or fat, into glycerol and the salt of the fatty acid. The reaction below illustrates this process.

\[
\text{CH}_2\text{O} - \text{C(CH}_2\text{)}_{14}\text{CH}_3 + 3\text{NaOH} \\
\text{(or KOH, potassium hydroxide)} \\
\text{saponification} \\
\text{CH}_2\text{OH} + 3\text{CH}_3\text{(CH}_2\text{)}_{14}\text{CC}_2\text{Na} \\
\text{a fat} \\
\text{glycerol} \\
\text{a crude soap}
\]
Materials:

Sodium hydroxide
70% isopropyl alcohol
Crisco
Table salt
Calcium chloride
100-mL beaker
10-mL graduated cylinder
2 400-mL beaker
250-mL beaker
Wooden stick
Hot plate
Jar
Rubber band
Cheese cloth
Ice

Procedure:

1. In a 100 mL beaker, dissolve 2.4 g of sodium hydroxide (lye from a hardware store) in 10 mL of distilled water.
2. To that solution add 10 mL of 70% isopropyl alcohol.
3. Set this solution aside.
4. Heat water in a 400 mL beaker.
5. While the water is heating place 20 g of Crisco in a 250 mL beaker.
6. Melt the Crisco completely by placing the 250 mL beaker in the 400 mL beaker of hot water.
7. Pour the sodium hydroxide/alcohol solution into fat while stirring with a wooden stick.
8. Continue heating and stirring until a small sample can be completely dissolved.
9. While stirring the solution, another student should weigh 90 g of salt into a 400 mL beaker.
10. Dissolve the salt in 300 mL of water.
11. Pour the soap solution directly into the salt water. The soap will separate and float.
12. Use a rubber band to place a piece of cheesecloth over a jar. The cheesecloth should sag significantly. Pour the salt solution and soap through the cheesecloth. Allow solution to drain.
13. While the solution is draining, prepare 4 oz. of ice water.
14. Pour the 4 oz. of ice water on the soap to remove excess salt.
15. Gently squeeze excess water from the soap and cloth.
16. Add a piece of soap the size of a pea to 5 mL of distilled water in a test tube and with your thumb seal the top of the test tube and shake vigorously.
17. Place 4 mL of tap water and 1 mL of calcium salt solution in a test tube. Add a small piece of your soap to the test tube. Seal the top of the test tube and shake vigorously.
Questions and Conclusions:

Compare the results of your soap in distilled water and water containing calcium.

The water containing calcium would be considered hard water. What effect does hard water have on the sudsy ability of soap?
Affect of Soap on Food Color Distribution in Milk

Materials:

Pie plate
Milk
4 food colorings
2 Q-tips
Dishwashing soap

Procedure:

1. Pour some milk into a pie plate.
2. Add drop of 4 different food colorings near the center of the milk. Note your observation related to the food coloring.
3. Use a Q-tip and touch the surface of the milk in between the spots of color.
4. Place a drop of soap onto a new Q-tip.
5. Touch the surface of the milk with the soap laden Q-tip between the spots of color.
   Record your observations.

Questions and Conclusions:

What happened when you touched the clean Q-tip to the surface of the milk?

What happened when you touched the soap laden Q-tip to the surface of the milk?

Milk is 87.7% water, 4.9% lactose (carbohydrate), 3.4% fat, 3.3% protein, and 0.7% minerals. Given milks composition, why do you think that it behaved as it did when the Q-tip laden with soap touched the surface?