Beginner Chemistry Lessons

Information for the Teacher:

The U-FIZZ Carbonator provides many lessons for the budding chemist. This document outlines many lesson segments while preparing carbonated juice.

It is not necessary to present all of the lesson segments as given in the outline, and you may wish to customize some elements. Use your discretion and consider time, student background and education level, curriculum elements, etc.

It will be most effective to present an introduction to the lesson beginning where the students' interests lie or what they have recently been learning and use the U-FIZZ to re-introduce what they already know or are interested in. Then move them logically through new attention-grabbing principles that can be shown.

Depending on the time constraints, size of class, or disposition of students, you can decide how much hands-on participation of the students will be appropriate. If possible, use as much hand-on involvement as you can, because this will effectively help in developing the students learning and interest in science

Within the lessons, before each question there will be a number presented in parenthesis. This will inform you of which lesson topic is being covered by the question. After you ask each question, give enough time for discussion from the students.

What you will need:

- Water-tight tray
- 2 empty small containers
- 1 cup warm water
- 1/4 tsp salt
- Spoon
- 3 ½ cupsVinegar (White vinegar)
- 5 Tbsp Baking Soda
- 2 clean empty 2L soda-pop bottles
- Funnels
- Up to 2L juice
- U-FIZZ carbonator kit
- Paper Towel
- Drinking cups

Lesson Topics Covered:

1.0 Chemical Reactions
  1.1 Cannot recover reactants
  1.2 Can recover solution
  1.3 Difference between reaction and solution
2.0 Pressure
3.0 Solutions
  3.1 Diffusion and solution rates.
  3.2 Different solutions have different characteristics
    3.2.1 CO_2 Gas is different from Air
4.0 Exploring Liquids
  4.1 water can hold gas
  4.2 Liquids do not travel down the tube
5.0 Temperature
  5.1 Colder liquids hold more carbonation
6.0 Hypothesis
  -What will happen?

Legend:

- Questions
- Ø Formulas
- o Definitions
- ü List

The U-FIZZ Lesson:

Introduction

Take the water-tight tray, and place in it 1 empty small container. Fill the container with 1 cup warm water. Now take a ¼ tsp of salt.

- (1.3/3.0/6.0) What will happen when I drop this salt into the water?

Drop the salt into the water. Compare what did happen with the Hypothesis of the students. Stir the salt until it dissolves

- (1.3/3.0/6.0) Where did the salt go?

Explain that the salt dissolved into the water. All of the salt broke up into its molecules and those molecules are floating around in the water. They are invisible, but they are there. The salt is still salt, and the water is still water. Define that this is called a "solution".{You may present the following dissolution formula. It is likely more advanced than the students understand, but it may help students feel the connection between every-day observances and chemical formulae.}

- Ø $H_2O_{(l)} + NaCl_{(s)} \Rightarrow H_2O_{(l)} + NaCl_{(aq)}$
- o Solution: *a homogeneous, molecular mixture of two or more substances.*

- (1.2/3.0) Can we get the salt back?

Explain that you can recover the salt if you wait for the water to evaporate, or if you boil the water until it is gone. This is one aspect of a solution.{You may wish to show some salt water that has been sitting for days, or has been partly boiled. There will be a white residue on the walls of the container. This is salt}

Now remove the container of solution from the tray, and place the other empty small container. Fill this container with 1 cup White Vinegar. Now take 1 Tbsp of Baking soda.

- (1.0/1.3/6.0) What will happen when I drop this baking soda into the vinegar?

Drop the baking soda into the vinegar. Compare what did happen with the Hypothesis of the students. The reaction will likely spill the mixture over the walls of the container into the water-tight tray.

- (1.3) What was different from when I put the salt into the water?
- (1.0/1.1) Where did the baking soda go?
- (1.0/1.1) Where did the vinegar go?

Explain that the baking soda and vinegar combined in a chemical reaction. That's why there was so much more activity. It may look like some vinegar is left, and the baking soda dissolved into the liquid, but the liquid the students see is actually now water, and invisible floating in the water are molecules of a special kind of salt called "sodium acetate". Vinegar and baking soda went in. Water and salt came out. Compare the two containers. Explain that both of them are water and salt.

- (1.0/1.3/3.2/4.1) What can you see that is different between the two containers?

Explain that one of the solutions is bubbly. In fact, it is fizzy. If you drank the bubbly one, it would be fizzy just like a soda-pop. But since it is salt water, it would taste very gross. It is fizzy because the baking soda and vinegar didn't only make water and salt. It also made "Carbon Dioxide" (CO_2). The chemical name for Vinegar is Acetic Acid (CH_3COOH). The chemical name for Baking Soda is Sodium Bicarbonate ($NaHCO_3$). The special salt that is created is not normal salt like in the kitchen. It is called "Sodium Acetate" (CH_3COONa)

Ø $$\frac{CH_3COOH_{(aq)}}{(Vinegar)} + \frac{NaHCO_{3(s)}}{(Baking\ Soda)} \Rightarrow \frac{CH_3COONa_{(aq)}}{(A\ Salt)} + \frac{H_2O_{(l)}}{(Water)} + \frac{CO_{2(g)}}{(Fizz)}$$

Explain that most of the CO_2 gas left the mixture and floated away into the air. The bubbles you can see are CO_2 gas as well. Explain that there is also some CO_2 gas dissolved in the water too. Just like the salt was mixed in with the water and became invisible, the gas is mixed in with the water and can't be seen. This isn't talking about the bubbles. This is talking about molecules floating in the water. {You may wish to explain that CO_2 gas is not the only gas that dissolves in water. In fact, air and oxygen can also dissolve in water. The fish can breathe using their gills by taking oxygen right from the water.}

- (1.1/1.2/1.3/3.2/4.1) Since this mixture is now water, a salt, and some CO_2 gas, what will happen if we leave this mixture out for long enough or boil the water away? What will be left over?

Explain that the CO_2 gas would eventually all escape into the air. The special salt would be left behind. Again show the two containers. If the first was left to evaporate, salt would be left. If the second was left to evaporate, salt would be left. In the first one, we put salt into the water, and we would get salt back. In the second one, we put baking soda into vinegar, and we would get salt back – NOT vinegar and baking soda back. This is the difference between a solution and a chemical reaction. The solution keeps everything that you started with (salt and water). A chemical reaction means that you end up with different substances coming out (salt and water) than what you put in (vinegar and baking soda).

Now remind the students that when the vinegar and the baking soda reacted, the CO_2 mostly escaped into the air. Remind them that some of the CO_2 that did not escape was dissolved in the water made the water fizzy.

- (3.2/3.2.1/6.0) What if you could catch all of the CO_2 that was escaping from the reaction and dissolve it into some juice? Remember that dissolved CO_2 makes liquid fizzy!

Take a clean empty 2L soda-pop bottle. Fill it with a COLD juice, leaving at least 2 ½ inches of air space at the top. Take another clean empty 2L soda-pop bottle. Put 2 ½ cups vinegar into it. From the U-FIZZ kit, put the soda cylinder (the one with the holes) into the sleeve (the one without holes). Fill the cylinder to the very top with baking soda. Remove the soda cylinder from the sleeve and put the sleeve to one side.

- (1.0/6.0) What will happen when I put this tube full of baking soda into the Vinegar?

Slowly slide the soda cylinder into the bottle with the vinegar and gently let it drop in. Demonstrate how there is a reaction but that the holes in the soda cylinder control the reaction so it doesn't happen as fast. Attach the hose from the U-FIZZ kit to the vinegar bottle. Explain that the reaction has produced enough CO_2 to fill up the vinegar bottle, and push out the air. Air dissolved in liquid is NOT fizzy. Only $_{CO2}$ dissolved in liquid is fizzy. Explain that you have some air left in the bottle of juice. Now explain as you squeeze the bottle of juice that you are letting out all of the air out of that bottle. While the bottle of juice is still being squeezed, attach the other end of the hose to the bottle of juice. You can now release the bottle. Make sure both bottles have their corresponding end of the hose firmly attached so that no leaks will develop.

Hold the juice bottle upside-down.

- (2.0/4.0/4.2) Why isn't the juice coming down the hose?

Explain that the airspace in the tube acts like a vacuum. As soon as a little juice enters the hose, the pressure drops in that airspace. Atmospheric pressure is greater than the pressure in the airspace, and so there is a vacuum and the liquid is kept sucked back from coming all the way down.

Keep holding the juice bottle upside-down with one hand, and swirl the bottle with the vinegar with the other.

- (1.0/2.0) What is happening? (The juice bottle that should likely still be a little deformed should be expanding and filling with gas. You will see bubbles rapidly passing through the juice.)
- (1.0/2.0) What are these bubbles?

Explain that the bubbles are CO_2 coming from the reaction. We have trapped the escaping CO_2 from the reaction using the hose. All of the CO_2 has nowhere to go, and is trapped in the bottles. As the reaction continues to make more gas, more and more gas has to fit into the same space. As it gets crowded for all of the gas molecules, they start bumping into each other more as it gets more crowded. This builds up the pressure inside the bottles. In short, all the CO_2 tries to fit in the same space, this makes pressure, and the pressure makes the bottles hard. Let students feel how hard the bottles have become. See if any of the students think that they can squeeze the bottles now that they are under pressure. You will be finished swirling the vinegar bottle when essentially all of the baking soda is washed out of the soda cylinder.

Now you can show the two bottles. Explain that the reaction is finished

- (3.0/3.1/4.1) Do you think the drink is fizzy now?

Explain that the fizz comes from CO_2 being dissolved in the water. Remind the students that when you dropped salt into some water that you could still see it. It wasn't until you stirred it that it finally dissolved. Explain that dissolving takes time. Through a process called "diffusion" the dissolving will happen all by itself, but it will take a long time. Explain (or have students come up with) that the following are techniques that will help speed up dissolving:

- ü Agitation (stirring)
- ü Increased surface area (breaking up)
- ü Temperature

Explain that agitation is stirring or shaking. It adds physical energy to the solution, allowing solvents and solutes to pass by and through each other. This physically breaks down the solvent and also moves solvent from areas of solute that have become temporarily saturated.

- o Solute: Substance that dissolves (eg. Salt)
- o Solvent: Substance into which the solute dissolves (eg. Water)

Introduce the idea of a hard candy. When you put it in your mouth, you can only suck on the outside of the candy. The inside of the candy can't be sucked on until you suck away all of candy around it.

- (3.1) What happens when you bite or chew the candy? Is it gone faster?

Explain that when you bite the candy, it broke into pieces. Now you can suck on the outside of the candy and the inside of the candy. As you chew up the candy, you can suck on all the parts of the candy at the same time, and so the candy is gone much faster. When you break a solute into tiny bits, it dissolves faster.

Explain that the temperature also affects how quickly a solute will dissolve, and how much will dissolve. Explain that putting a teaspoon of salt in boiling water will dissolve much faster than if it was put into cold water. {You may wish to experiment on the length of time and quantities of salt that can be dissolved in different temperatures of water} Explain that for solids dissolving in liquids, the warmer the water, the more that can dissolve, and the faster it will dissolve. Explain that this is just the opposite if you are dissolving gas into a liquid. The colder the liquid, the more gas it will hold. Hot water will hardly hold any gas in it.

- (3.1/4.0/4.1) Ask the students if they like Cold soda-pop or hot soda-pop that has been sitting in the car.

Explain that a hot soda-pop will not be as fizzy, but will be much more under pressure because much of the CO_2 that was dissolved in the soda-pop escaped when it heated up.

Explain that with the juice that you are carbonating you have used a cold juice. We want to dissolve in all of the CO_2 that we just made from mixing Vinegar and Baking Soda.

- (3.1/4.1) How can we speed up how fast the CO_2 dissolves?
- (3.1/4.1) How can we stir the juice while it's still in the bottle?
- (3.1/4.1) How can we break up the CO_2 into tiny bubbles so it will dissolve faster?

Explain that we will shake the juice and that will do two things. It will stir the juice to speed up the dissolving, and it will break up the CO_2 into tiny bubbles so it will dissolve faster. Now begin shaking the juice vigorously enough to give it a good stir, and to make as tiny of bubbles as is possible. This should continue for about 2 minutes. Allow students each to have a turn shaking the juice.

- (6.0) Do you think the juice is fizzy now?

Slowly loosen the cap on the vinegar bottle to control the release of pressure. You will probably observe foaming of the juice. The foam will likely pass through the hose and harmlessly drop into the vinegar mixture, but if it is very foamy, the escaping gas may carry with it some of the foam. You may want to hold a paper towel around the cap if this happens. When all of the pressure is released, open the cap on the juice bottle.

- (Fun!) Who wants some soda-pop?!

Explain that the soda-pop is a solution. CO_2 gas has dissolved into the liquid. Remind the students that solutions can recover the solute. Just as we can get the salt back by evaporating the water, we can also do something to get the CO_2 gas back out of the liquid.

- (1.2/6.0) How can we get the CO_2 back?

Explain that when the soda-pop goes into your stomach, it is warmed up. The CO_2 does not dissolve as well in warm liquid. Explain that as the soda-pop warms up, the CO_2 is released and recovered from the solution. The CO_2 comes back out of the liquid, and fills up your stomach. Until you burp! You are burping up CO_2! That's how you get the CO_2 out of the liquid. You will notice that if the burps are through your nose, it will tingle. That is more evidence that it is CO_2.