



Junior High 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:

- ü Water-tight tray
- ü 2 empty small containers or beakers
- ü 2 test tubes or use U-FIZZ sleeve, or a clear container
- ü Water
- ü Salt
- ü Spoon
- ü 5 cups Vinegar (White vinegar)
- ü 7-8 Tbsp Baking Soda
- ü pH 7 indicator or a pH meter.
- ü 2 clean empty 2L soda-pop bottles
- ü Funnels
- ü Up to 2L juice
- ü U-FIZZ carbonator kit
- ü Paper Towel
- ü 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
- 1.4 Quantities of reactants and products

2.0 Henry's Law

- 2.1 The simple equation explained

3.0 Measurements

- 3.1 Mass
- 3.2 Volume
- 3.3 Density (must be known to convert concentrations)
- 3.4 Concentration
 - 3.4.1 Molar
 - 3.4.2 By volume
- 3.5 pH
- 3.6 Temperature

4.0 Solutions

- 4.1 Diffusion and solution rates.
- 4.2 Different solutions have different characteristics
 - 4.2.1 CO₂ Gas is different from Air

5.0 Pressure

- 5.1 Force per unit area
- 5.2 Compressibility of gasses, incompressibility of liquid
- 5.3 Vacuum

6.0 Exploring Fluids

- 6.1 Liquids can hold gas
- 6.2 Viscosity

7.0 Temperature

- 7.1 Warmer solvents dissolve more solid solutes
- 7.2 Warmer liquids dissolve LESS gaseous solutes

8.0 Conservation of mass

- 8.1 In closed system, reactants and products weigh same before and after reaction

9.0 Periodic Table

10.0 Hypothesis

- 10.1 What will happen?

Legend:

- Questions
- ∅ Formulas
- Definitions
- ü List

The U-FIZZ Lesson:

Introduction

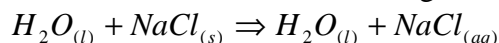
Take the water-tight tray, and place in it 1 empty small container or beaker. (3.1) Weigh and record the mass of the container or beaker. (3.2) Measure 125mL warm water into the container or beaker. (3.1) Weigh and record the mass of the water. (3.6) Measure the temperature of the water. (3.2/3.1) Measure and weigh about 2mL or 1/4 tsp of salt. Take the salt and hold it above the warm water.

- (1.3/4.0/10.0) What will happen when I add this salt to the water?

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

- (1.3/4.0/10.0) 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”. Present the following dissolution formula.



- Solution: *a homogeneous, molecular mixture of two or more substances.*
- (1.2/4.0) 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: that you can recover the solvent. {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 place the other empty small container or beaker in the tray. (3.2) Measure 125mL Vinegar into the container or beaker. (3.2/3.1) Measure and weigh about 4mL or 1/2 tsp of salt.

- (1.0/1.3/10.0/10.1) 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.

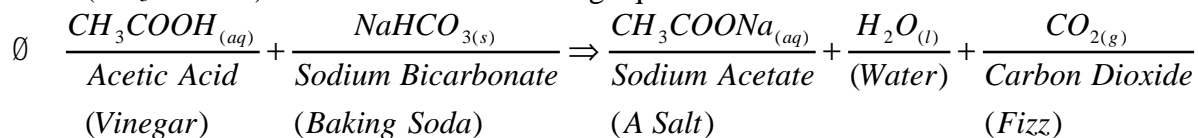
- (1.3) What was different from when I put the salt into the water?
- (1.0/1.1) Where did the baking soda go?
- (1.0/1.1) Where did the vinegar go?

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" (CO₂). The chemical name for Vinegar is Acetic Acid (CH₃COOH). The chemical name for Baking Soda is Sodium Bicarbonate (NaHCO₃). The special salt that is created is not normal salt like in the kitchen. It is called "Sodium Acetate" (CH₃COONa). Now write the following equation on the board:



(3.4.2) Explain that the Vinegar is not pure Acetic Acid. It is 5% acetic acid and 95% water by volume. That means to make 100 mL of Vinegar, you take 95 mL of water, and then add 5 mL of acetic acid.

Write down a list of the atoms present in the chemical reaction. (9.0) Show each one of them on the periodic table. Then count how many are on the left side of the arrow, and how many are on the right side.

Atom	Left Side	Right Side
C	3	3
H	5	5
O	5	5
Na	1	1

Explain that all of the atoms just rearrange themselves, but they are all still there.

(3.5) Use a pH indicator that changes color at a pH near 7.0 (unless you have an instrument to measure pH, then use that instead). Add some indicator to a test tube with some Vinegar in it. Take note of the color. In a fresh empty test tube, dissolve some baking soda in some water. Add some indicator to it. Take note of the color. Explain how the pH indicator will indicate by its color whether the mixture is acidic or basic. Vinegar is an acid, and Baking soda is a base. Now add some indicator into the container or beaker with the mixture.

- (3.5) Is the mixture acidic or basic? Is there more vinegar or more baking soda?
- (10.0/10.1) What can we add more of to balance the mixture?

If the pH indicator shows that the mixture is acidic, add more baking soda. If the pH indicator shows that the mixture is basic, add more vinegar. (1.4/3.5) Keep adding reactant until the pH indicator just changes color. Explain that the mixture is balanced

now. The vinegar and the baking soda cancel each other. All there is left in the mixture is the salt and the water.

Explain that most of the CO₂ gas left the mixture and floated away into the air. The bubbles you can see are CO₂ gas as well. Explain that there is also some CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ mostly escaped into the air. Remind them that some of the CO₂ that did not escape was dissolved in the water made the water fizzy. Explain that there is a formula for knowing how much CO₂ dissolves into the water. (2.0/2.1) It is called Henry's Law of dissolved gasses. Write the following formula on the board:

$$c = kp$$

Explain that 'k' is just a number 0.034 for CO₂. (3.4.1) The pressure of the CO₂ measured in atm multiplied by the number 0.034 will tell you the concentration of CO₂ in mol/L. If there is more pressure, there is more gas.

- (3.2/3.2.1/10.0/10.1) What if you could catch all of the CO₂ that was escaping from the reaction and dissolve it into some juice? Remember that dissolved CO₂ 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.

- (1.0/10.0/10.1) 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. (4.2.1) Air dissolved in liquid is NOT fizzy. Only CO_2 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.

- (5.0/5.2/5.3) Why isn't the juice coming down the hose?

Draw the following picture on the board:



- (5.0/5.1/5.2) What happens inside this cylinder when you push down on the plunger?

Explain that the compressing the air increases the pressure. Now explain that when the juice starts going down the hose, the liquid acts like a piston, and forces the air in the hose down. This increases the pressure under the liquid. The tiny increase in pressure is enough to push back up on the liquid and keep it in place.

Now, with the U-FIZZ all connected, (3.1) find the mass of the entire system. This includes the mass of both bottles and everything all connected. Record the mass. (This will be used later to explain the conservation of mass 8.0.)

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

- (1.0/5.0) 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) What are these bubbles?

Explain that the bubbles are CO₂ coming from the reaction. We have trapped the escaping CO₂ from the reaction using the hose. All of the CO₂ 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. (5.0/5.2) This builds up the pressure inside the bottles. In short, all the CO₂ 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. (5.0/5.1/5.2) Explain that the pressure inside the bottle is somewhere around 40 psi. Explain that this means for every square inch on the bottle, the compressed gas is pushing on the wall of the bottle with 40 pounds of force! {You may wish to use a permanent marker to draw the outline of a square inch on the bottle, and write in the number 40.}

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

- (2.0/4.0/4.1/6.1) Do you think the drink is fizzy now?

Explain that the fizz comes from CO₂ 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.

- (4.1) 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}(7.0/7.1) Explain that for solids dissolving in liquids, the warmer the water, the more that can dissolve, and the faster it will dissolve. (7.0/7.2) 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.

- (4.1/4.0/6.1) 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 CO₂ 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.

Explain that we want to dissolve in all of the CO₂ faster so it will be fizzy sooner.

- (4.1/6.1) How can we speed up how fast the CO₂ dissolves?
- (4.1/6.1) How can we stir the juice while it's still in the bottle?
- (4.1/6.1) How can we break up the CO₂ 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 CO₂ into tiny bubbles just like crunching a hard candy 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.

- (10.0/10.1) Do you think the juice is fizzy now?

Explain that we have just shaken a soda-pop. It may foam up when we open it. (6.2) Explain that the thicker the liquid or juice, the more foaming there will be.

Before opening any bottle, find the mass of the entire system again. Record the number next to the value you obtained prior to the reaction.

- (8.0/8.1) Why is the mass the same, even though we have made all of this CO₂ gas?

Explain that there are still just as many molecules, they just rearranged themselves. They don't change their mass just because they have reorganized themselves.

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. CO₂ 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 CO₂ gas back out of the liquid.

- (1.2/10.0/10.1) How can we get the CO₂ back?

Explain that when the soda-pop goes into your stomach, it is warmed up. The CO₂ does not dissolve as well in warm liquid. Explain that as the soda-pop warms up, the CO₂ is released and recovered from the solution. The CO₂ comes back out of the liquid, and fills up your stomach. Until you burp! You are burping up CO₂! That's how you get the CO₂ 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 CO₂.