Chemical Reactions that Produce Ethanol

Unit 2 Lesson 2

Precepts

F. Continuous Improvement
- F5. Acquire new knowledge.

J. Mental Growth
- J4. Solve problems.

National Standards

NL-ENG.K-12.8. Developing Research Skills.

Student Learning Objectives

As a result of this lesson, the student will …
1. Define and identify the fermentation process.
2. Recognize the reactions that occur in the fermentation process.

Time

Instruction time for this lesson: 90 minutes.

Resources

http://www.ethanolrfa.org

Tools, Equipment, Supplies

Writing surface
Projector
AS.A – one per student
TM.A
Assess.A – one per student
Tape/other means to affix paper to writing surface
Scissors
Safety glasses
Variety of fermented foods (see interest approach)
8 or more packages of yeast
Ice
Measuring spoons
Flour
Salt
Sugar
Vinegar

Stirrers
Heating element
4 clear glasses

Key Terms

The following terms are presented in this lesson and appear in ***bold italics***:
Ethanol
Fermentation

INTEREST APPROACH

*The interest approach helps students begin thinking about the term **fermentation** and the changes that take place in the **fermentation** process. Use a variety of examples of food that are fermented: bring in examples, show pictures, or talk about the examples. Examples include: cheese, cider, bread, yogurt, salami, soy sauce and sauerkraut.*


Take a look at the foods I have placed here. What do you see? *Elicit student responses.*

Some of these foods you may like and others you may not. Let's think about some commonalities of these foods. Think about what is similar between each of these foods. Jot down your answers on a scrap piece of paper and be prepared to share.

Allow students time to consider answers; instructor may need to assist students in determining similarities.


We did a great job considering the similarities of these items. Now let's share what we came up with. Who will share some of the similarities you wrote down?

These are all great responses. One of the similarities between these types of foods is that they went through a ***fermentation*** process to get to the final product. The reason the ***fermentation*** process is used is to help preserve certain foods, and provide aromas and flavors in others. ***Fermentation*** is used for a different reason in non-food sources like fuel, and that is what we are going to discover today. Remember, even though we ferment different substances for different reasons, the process is basically the same. Today we will take a look at that process.

In addition to the above scenario, the instructor may have the students taste each food and consider how it benefitted from the fermentation process (i.e.: cheese, flavor and preservation; sauerkraut, flavor, etc.)

OBJECTIVE 1. Define and identify the fermentation process.

*The purpose of this objective is to help students understand what **fermentation** is and the process the elements go through in order to obtain energy. The Go-Get-It Moment can be used to assemble the definition for **fermentation** and the Einstein Moment can be used to conceptualize the **fermentation** process. Prior to the lesson, the instructor should copy TM.A and cut each word into a separate piece. The pieces should be placed around the classroom so that students can find them when directed. The activity is written for an entire class; however, it can be modified to be conducted in smaller groups. Multiple sets of TM.A can be made if the instructor desires to have small groups complete the activity. Set the context for the activity by asking the following questions:*


We've just been introduced to the word ***fermentation*** and learned it is used to make products like bread, cider and even yogurt. Besides uses for food, the ***fermentation*** process can be used to change sugars into alcohol to create fuel. This is our topic today, to look at the chemical reactions that produce ***ethanol***. Let's come up with a definition for ***fermentation***. When you hear the word, "ferment", get out of your seat and look around the room for a card that has a word on it. These words will be used to put together our definition. There are 17 word cards total, so we need to be sure we have all of them. Let's take about 1 minute to find the cards. When you find a card, return to your seat.

Call on a student to repeat the directions back to the class.


Who can tell us what to do when we hear the word "ferment"?
Awesome. What questions are there? Okay, "ferment!"

Guide the students through the process of assembling the cards into a definition. Have them spread the cards out along the tables/desks. Once they have ordered the words correctly (see objective 1) have them affix the words in order to the writing surface and record the definition in their notes.


Now let's work together to put the cards in a sequence that makes sense for a definition of the word ***fermentation***. Let's work together as a class to do this. Go ahead and lay the cards out on the tables/desks.

Let's consider how these words might go together to create a definition for ***fermentation***. Work together as a class to put these words in and order that makes sense.

Allow 5-8 minutes for students to order the terms. The instructor can help students by pulling words out that are not in order or by asking students questions to consider whether the word is in the best place.


Great job! We have put these terms in the correct order! Next we need to do a couple of things. When I say, "Go" tape the word cards to the writing surface, keeping them in order, then return to your seat and take out a writing utensil and a piece of paper. What questions are there?
"Go!"

Now that we have created a definition for the word ***fermentation***, let's take a moment to record it in our notes. Go ahead and write this definition in your notes.

A. ***Ethanol*** is a product of ***fermentation***. ***Fermentation*** is a sequence of reactions which release energy from organic molecules in the absence of oxygen.

1. In this application of ***fermentation***, energy is obtained when sugar is changed to ***ethanol*** and carbon dioxide.

Using the Einstein Moment, guide students in creating an equation that represents the process of ***fermentation*** *as stated in TM.A. Record the equation on the writing surface while students record in their notes.*


Our end goal in the process of ***fermentation*** in this case is energy. This energy is obtained when sugar is changed to ***ethanol*** and carbon dioxide. We can represent this process by using an equation. So, remind me again, what is the end process that we want in this ***fermentation*** process? Energy is the correct answer, so in our equation we can write an E on the right hand side of the equals sign. Let's set this up in our notes below the definition for ***fermentation***:

= E


What is the input to the equation, or the first ingredient? Yes, sugar is what we start with. This sugar can come from a number of types of plants, including corn. So, in our equation, let's use an S to represent sugars. This will go on the far left of our equation.

S = E


Remember we said before that the energy is obtained when sugar is changed to ***ethanol*** and carbon dioxide, so the sugar goes through a transformation. Since we are working in mathematical terms with our equation, we could say the sugar is divided by two into ***ethanol*** and carbon dioxide. Let's show how this might look in our equation:

S / 2 → Eth + CO_2 = E


Notice in our equation we used an arrow to represent what happens after sugar ferments. This arrow means "yields." To rephrase the statement above, the process of fermenting sugar yields ***ethanol*** and carbon dioxide, which equals energy. This equation can come in handy as a quick reference when thinking about what happens in the ***fermentation*** process.

OBJECTIVE 2. Recognize the reactions that occur in the fermentation process.

A. Yeast feeds on the sugars and releases carbon dioxide.
B. Bubbling or the release of carbon dioxide should be present.

*Use AS.A to complete two experiments that will help students see the reactions that occur in the **fermentation** process through hands-on experience. The instructor should read through the experiments in advance and make determinations as to whether the experiments should be conducted in groups or individually and whether they should take place separately or simultaneously depending on time. Use the Hole-In-One Moment to guide students through the process of conducting the experiments. Prior to continuing, pass out a copy of AS.A to each student.*

Experiment Note: If time does not allow the proper sequence of lab steps, you will have to simultaneously run Experiment A and B at the same time or spend two different days completing the lab.


Now that we know what ***fermentation*** is and what occurs during the ***fermentation*** process, let's see it firsthand! In front of you, you have an activity sheet outlining two experiments. Who can read for us the purpose of the experiment?

Great! Who can read for us the description under the heading "***Fermentation*** Experiment"?

Awesome, take your activity sheet and a writing utensil to the lab stations. Be sure to put on safety glasses.

Hole-In-One Moment
At this point the instructor will guide students through the process of the experiments utilizing this moment. The instructor should read the steps slowly and have students think about what they will be doing as they conduct the experiment. Students can be encouraged to go through the motions, but not actually perform the actions until instructed to do so.


Who here has ever played golf? As you know, golf is a little different than other games. In golf you want to get the lowest score, with the least number of strokes. The best score we can get on any hole is one or a hole in one. In other words, we want to do it right the first time. To get a hole in one on the golf course, many golfers think through the process and take a few practice swings. Before we start these experiments, we are going to think through the process and take a practice swing so we can get a hole in one, or complete each experiment in one shot.

I am going to read through the list of materials. As I do this, locate each material in front of you. Then I will read through the steps. In your mind, think about what each step will look like. If you would like to pretend like you are going through the step, you can practice the motion, but don't actually perform the action until we are finished with our practice stroke. What questions do you have about this process? Remember, we are practicing so we can do it right the first time, our goal is to get a hole in one!

At this point the instructor should read through the materials list, the steps in the experiment, and the questions allowing time for students to process what is being read and to practice the motions if they so desire. Depending on time constraints, the instructor can read through both experiments or read through the first, have the students conduct experiment A, then perform the Hole-In-One Moment for experiment B.


Now that we've taken our practice shot, let's complete the experiment. Be sure to record your observations and answer the questions legibly. Also, be prepared to share your observations and responses with the class. What questions are there? Okay, experiment!

The instructor should circulate through the room to assist students in conducting the experiment and answering questions. After students have completed the experiment, talk through responses with the class to come to a consensus on the outcome.


Great job performing this experiment! It looks like everyone got a Hole-In-One because of the practice shot we took. Let's review what happened in the experiment and see what we came up with for answers to the questions. Take a look at experiment A. Fermenting Foods. Who can tell us what you saw after 10 minutes in Beaker 1? *For each beaker, elicit two to three responses to come to a consensus.*

What about Beaker 2? Beaker 3? Beaker 4?

Great! Now, after 10 more minutes, what did we see in Beaker 1? *Again, elicit two to three responses to come to a consensus.*

What about Beaker 2? Beaker 3? Beaker 4?

Now lead a discussion with the students based on their responses to the questions. These discussions will vary based on student responses. The instructor should guide students through the discussion to logical conclusions.

Continue with experiment B. by repeating the process for the Hole-In-One Moment for the steps in experiment B. After the students have conducted experiment B., talk through student responses, similar to experiment A.


We've done a great job of conducting these experiments to see what happens during the process of ***fermentation***.

REVIEW/SUMMARY

*Use the student learning objectives to summarize the lesson. Have students explain the observations and concepts learned during the **fermentation** lab associated with each objective. Student's responses can then be used to determine which objectives need to be further explained and which objectives are fully understood.*

 Let's think back to the beginning of the lesson where we created a definition for ***fermentation***. Find your notes and read through that definition silently. Now, look at the equation we created for the ***fermentation*** process. Think about how you would describe this equation to someone else. *Pause. Have students share with one another how they would describe this equation.*

Partner up or get into groups of three. In your own words, share with the people in your group how you would describe this equation.

The instructor should circulate through the room to listen to student descriptions. After all have shared within their groups, the instructor can ask for 2-3 volunteers to share their description with the entire class.

 As I was walking around I heard some great descriptions. Who will share your description of the equation we created for the ***fermentation*** process?

These are great descriptions! It sounds like we really understand ***fermentation***.

Review the experiments with the students by having them record one important point they learned from each experiment. Have students share these important points in groups of 2-3.

 Make sure you have your notes and experiment sheets (*AS.A*) in front of you. When I say "reflect" we are going to take 2 minutes to write down one important point from each experiment we conducted today. So, you will write down one important point you learned from experiment A. and one important point you learned from experiment B. Be prepared to share these points in small groups. What questions are there? Okay, "reflect!"

Allow about 2 minutes for students to reflect, adjust depending on student pacing. Then have students get back into small groups to share important points. Finally, pass out the evaluation for students to complete.

 Great job reflecting! Let's get back into those groups of 2-3 again. Within your group, share your important points from each experiment.

What questions are there about the ***fermentation*** process? We've done a great job today of defining ***fermentation*** and creating a better understanding of the process by creating an equation and conducting hands-on experiments! Let's show what we know by completing an evaluation for today's lesson.

APPLICATION

Extended classroom activity: *Instructors can lead students in making cheese or bread in the classroom, focusing on the fermentation process and comparing the process to the content learned in the current lesson.*

FFA activity: *Students can plan and conduct an agriscience experiment on the fermentation process and enter the project in the local or state Agriscience Fair.*

SAE activity: *Students can extend their SAE projects by adding an agriscience project on fermentation that may tie to their current SAE project(s) or it may be a new project not related to any other project. For new FFA members, an agriscience project on fermentation may be a great project to start the SAE process.*

EVALUATION

Assess.A

Answers to Assessment:
Fill in the Blank:
1. Fermentation
2. Carbon dioxide
3. Sugar

Short Answer:
1. The warmer the temperature the more likely fermentation will occur. However, in extreme temperatures of hot and cold such as freezing and boiling, yeast will become inactive or die off.

TM.A

Fermentation

is a

sequence of

reactions

which

release

energy

from

organic

molecules

in the

absence of oxygen

AS.A

Fermentation Experiment

Purpose This experiment will test different foods and the amount of fermentation that occurs.

Fermentation Experiment
Ethanol is made from a variety of plant substances including corn, sorghum, sugar cane and wood. The process used to make ***ethanol*** is called fermentation. Fermentation was discovered many years ago when bubbles were formed while making wine and beer. Studies by Louis Pasteur described fermentation as changes caused by yeast growing in the absence of air. Fermentation is an energy yielding process caused by enzymes (provided by yeast) in which fuel molecules such as glucose (sugar) are broken down in the absence of oxygen.

You will test different substances while observing for fermentation (bubbling). State your findings in the space provided.

Materials:
8 or more packages of yeast
Ice
Measuring spoons
Flour
Salt
Sugar
Vinegar
Stirrers
Heating element
4 clear glasses

A. Fermenting Foods
1. Empty a pkg. of yeast into each half-liter (1 pint) beaker of warm water. Stir for 1 minute.
2. Add 10 ml (2 tsp.) of flour to each beaker and stir again.
3. Add 5 ml (1 tsp.) of salt to the first beaker, 5 ml of sugar to the second beaker, 5 ml of vinegar
to the third beaker, and do nothing to the fourth. Stir again.

4. Wait 10 minutes. Record your observations:

Beaker 1 _____

Beaker 2 _____

Beaker 3 _____

Beaker 4 _____

5. Wait 10 more minutes and record your observations:

Beaker 1 _____
Beaker 2 _____

Beaker 3 _____

Beaker 4 _____

Questions:
1. What evidence shows that reactions are going on in any of the containers?

_____

_____

____

2. How are these observations related to fermentation?

_____

_____

____

3. Draw conclusions about which of the substances tested was most helpful to yeast fermentation:

_____

_____

____

B. Changing Temperatures
1. The second part of this exercise you will observe the effect of different temperatures of water on fermentation. The teacher will prepare boiling water for the first beaker. Fill the second beaker with warm water (just slightly warmer than skin temperature). Fill the third beaker with cold tap water. Fill the fourth beaker with ice water.

2. Empty one packet of yeast into each beaker and stir to dissolve. Add 10 ml of flour and 5 ml of
sugar to each jar and stir again.

3. Wait 10 minutes. Record your observations:

Beaker 1_____

Beaker 2_____

Beaker 3_____

Beaker 4_____

4. Wait 10 more minutes. Record your observations.
Beaker 1_____

Beaker 2_____

Beaker 3_____

Beaker 4_____

2.9

Questions:
1. Were there any conditions under which fermentation did not proceed, or went very slowly? What were they? Explain each one.

_____

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2. Draw a conclusion about what temperature is best for yeast-flour-sugar fermentation.

_____

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_____

Assess.A

Fill in the blank with the correct term:

1. ***Ethanol*** is a product of _____.
2. The two products of fermentation are ***ethanol*** and _____.
3. Yeast feeds on _____ or carbohydrates that are found in the raw material.

Short Answer:

1. Explain how temperature affects the fermentation process?