Berkeley Engineers and Mentors

QUIT OVERREACTING!!!

John John Huddleston, Carina Kim, Aditya Murali, Marisa Wong | Fall 2021

Field(s) of Interest: Chemistry

Brief Overview (1-3 sentences):
In this lesson students will learn about the differences between physical and chemical reactions, components of a solution, and how viscosity affects non-Newtonian fluids. They will learn how to determine whether a chemical or physical change has taken place

Agenda:
- Introduction (5 min)
- Module 1: My chemistry puns rarely get a physical reaction (5-10 min)
- Module 2: Don't be the problem, be the solution (15-20 min)
- Module 3: I'm drawing ooblank...(10-15 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:
- ➔ **Physical reactions** - reactions that do not make new substances
- ➔ **Chemical reactions** - reactions that make new substances
- ➔ **Solution** - homogeneous mixture consisting of a solute dissolved into a solvent
- ➔ **Catalyst** - a substance that increases the rate of a chemical reaction
- ➔ **Viscosity** - a fluid's resistance to flow
- ➔ **Non-Newtonian fluid** - fluids that act like solids when pressurized and liquids when not pressurized

Background for Mentors

Module 1 • Physical reaction • Chemical reaction • Reversible changes • Irreversible changes	Reactions happen all around us. A reaction takes place when two atoms or molecules interact with one another, However, there are different types of reactions. In this lesson, we will dive into what distinguishes the two main different types of reactions. **Physical reactions** take place when an object's composition stays the same but the object changes its form. For example, cutting paper doesn't change the composition of paper but the paper is now divided into two pieces. In addition, physical reactions are easily reversible. **Chemical reactions**, on the other hand, take place when there is not only a change in the form or appearance of the starting reactants but there is also a change in the molecular structure of the substances which comprise the newly created product. For example, when starting to bake a cake, the ingredients are distinct from one another. After they react with one another, the product(i.e. the cake) looks quite distinct from the starting ingredients. Moreover, the cake is no longer a mixture of the various ingredients. Instead, the cake now consists of a different structural arrangement of the molecules which formed the ingredients. Although physical reactions and chemical reactions appear to be polar opposites (chemistry pun :)), both physical reactions and chemical reactions can either be reversible or irreversible changes. **Reversible changes** are changes which can be undone, For example, pouring a full glass of water into an empty glass is a physical change and can easily be reversed by pouring the water back into the original cup. **Irreversible changes**, on the other hand, cannot be easily undone. Physical changes such as cutting up a piece of paper is irreversible because it is very difficult for the paper fibers which line the site of the tear to bind to one another once again. Roasting a marshmallow (chemical change) is also irreversible because a chemical reaction is required to restore the original reactants. Note that irreversible does not necessarily mean impossible to undo. It may simply require a lot of effort or a chemical change to create the original reactants. Moreover, the materials available also influence how easily a reaction can be reversed. Without any other materials, the ionization of water is quite unfavorable and is unlikely to take place. However, in the presence of an electrical current, water can be ionized quite easily.

Background for Mentors

Module 2

- Solution
- Solute
- Solvent
- Catalyst

When we combine multiple chemicals together to create a reaction, we may end up making various solutions along the way. A **solution** is a homogeneous mixture consisting of a solute dissolved into a solvent. The solution is formed one one thing dissolves into another. The, usually smaller, amount of material that is dissolved into a solution is called the **solute**. While the material that is dissolving the solute in the solution is called the **solvent**.

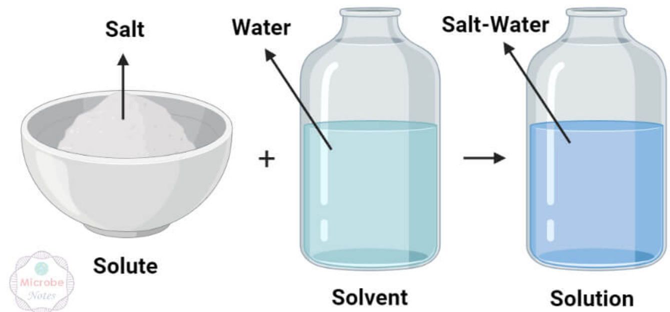


Figure 1: Solutions, solutes, and solvents.

It is important to clarify that solutions can only be made from chemical reactions. A physical change like mixing corn and cheese is not a solution but just a physically mixed group of items. In this module, students will see two types of explosive reactions. One of which will be made due to chemical catalysts and another due to physical.

The first demonstration that will be performed is making elephant toothpaste. For this experiment we will need hydrogen peroxide, dish soap, and yeast. Hydrogen peroxide naturally decomposes into hydrogen and water. If we add some dish soap to the hydrogen peroxide we can see this hydrogen off-gassing by the soap forming bubbles. However, this process is very slow. We can cause the reaction to go much faster by adding yeast to the solution. In this case, yeast is a **catalyst** because it causes the reaction in hydrogen peroxide to happen much faster. So much faster that the hydrogen is released almost instantly from the hydrogen peroxide and quickly forms an explosive array of bubbles with the soap.

Figure 2: Elephant Toothpaste Explained

The second demonstration is the interaction of coke and mentos. Although it may seem that the explosive combination of these two items is a chemical reaction, it is, in fact, physical. When the mentos are dropped inside the coke, the imperfect surface of the candy acts as nucleation sites for CO2 to come out of the coke solution. This happens very rapidly and, due to the *viscosity* of the coke, the bubbles form an explosive foam. Interestingly enough, diet coke is often used instead of regular coke since it has a lower viscosity (due to artificial sugars) resulting in a larger explosion.

Figure 3: Coke and Mentos: Frame By Frame

Background for Mentors

Module 3

- Viscosity
- Non-Newtonian Fluid
- Stress

Viscosity *is a measure of a fluid's resistance to flow*. It is the opposite of **fluidity.** Viscosity comes from the internal friction between molecules of a fluid. If a fluid has a high viscosity, it has more internal friction and is more resistant to flow. If a fluid has a low viscosity, it has less internal friction and is less resistant to flow.

For example, If you have a styrofoam cup with a tiny hole at the bottom, and you pour water in, the water is going to drain quickly from the cup. However, if you pour honey into the cup, the honey is going to take longer to drain.

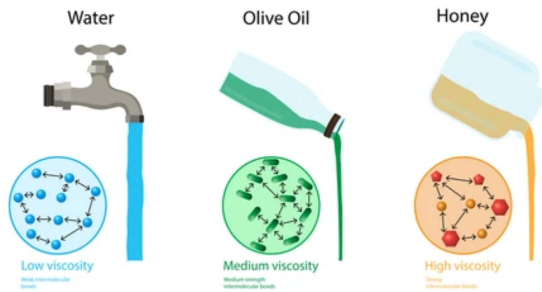
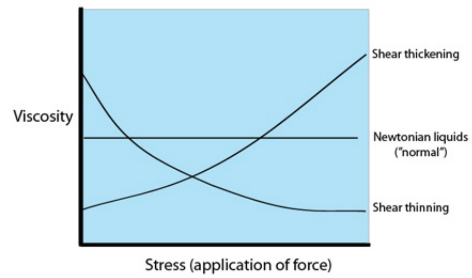


Figure 1: Viscosity of water, olive oil, and honey

A **Newtonian fluid** is a fluid that flows at a predictable, constant rate. Water is an example of a Newtonian fluid. A **Non-Newtonian fluid** *is a fluid that does not have a constant viscosity.* Non-Newtonian fluids change their viscosity under **stress.** *Stress is a force applied to a body*. **Strain** is the result of that stress. For example, if you flip a ketchup bottle upside-down, the ketchup does not come out right away. Instead you apply stress by hitting the bottle or shaking the bottle. The strain is the ketchup coming out of the bottle.

The example of a Non-Newtonian fluid used in this lesson is Oobleck, which is made by mixing cornstarch and water. Oobleck acts like a solid when it is pressurized and acts like a liquid when it is not pressurized. Therefore, if I hit the oobleck with a hammer, it will act like a solid and provide an upwards force against the hammer.

There are four types of Non-Newtonian fluids. Thixotropic fluids (think stirring honey) become less viscous with stress over time. Rheopectic fluids (think whipping cream) become more viscous with stress over time. The tomato sauce is an example of shear thinning in which viscosity decreases with increased stress. Lastly, the oobleck is an example of dilatant or shear thickening in which viscosity increases with increased stress.

	 ***Figure 2: Shear thickening and shear thinning fluids*** Quicksand is like tomato sauce! When left alone, quicksand becomes less viscous and more solid. However, when stress is applied, the quicksand becomes more fluid. So, if you ever find yourself in quicksand, you should lay on your back and kick your legs to loosen up the sand near your feet. Otherwise, the quicksand will fill in the empty spaces.

Introduction

Concepts to Introduce	Questions to Pique Interest
• Physical reactions • Chemical reactions • Reversible changes • Irreversible changes • Solution • Solute • Solvent • Catalyst • Viscosity • Non-Newtonian fluid • Stress	• What happens to water when it freezes/melts? • How can you turn ingredients like flour, sugar, eggs, etc. into something completely different like a cake? • Why do some reactions happen faster than others? Why does food rot slower in the fridge vs. outside? • How does quicksand work?
Scientists, Current and Past Events	**Careers and Applications**
• Elephant toothpaste, although a novelty reaction, has been completely over engineered to get the best results by YouTube's own Mark Rober. World's Largest Devil's Toothpast... • Oobleck is very difficult to model, being a non-newtonian fluid. However, recent discoveries allow for modeling that may result in more use for the material like filling potholes when it rains. Oobleck's Weird Properties Demystified | Live Science	• Chemist - A chemist investigates different properties of matter at the level of atoms and molecules. Chemists try to understand unfamiliar substances or make new compounds. • Pharmacist - A pharmacist distributes prescription drugs to people. A compounding pharmacist will create custom medications from base ingredients for patients.

Module 1: My chemistry puns rarely get a physical reaction

In this module, the mentees will learn about the difference between physical and chemical changes through a guessing game.

Teaching Goals	Materials
1. **Physical reaction:** reactions in which the substances change their form but their composition stays the same 2. **Chemical reaction:** reactions in which there is a change in the form or appearance of the substances, as well as the molecular structure 3. **Reversible changes:** changes which can be undone 4. **Irreversible changes:** changes that cannot be easily undone	• List of different physical and chemical reactions • Candy

Procedure

1. The students will be playing a game where they will attempt to determine whether a reaction is a physical or chemical reaction,
2. Read out each reaction and choose a random student, Do not choose the same student unless no one else knows the answer.
3. Write down the names of each student who wins candy. Distribute the candy at the end of class.

<u>List of Reactions</u>

1. Dissolving sugar into water - Chemical
2. Popping a balloon - Physical
3. Chopping wood - Physical
4. Roasting a chicken - Chemical
5. Breaking a pencil - Physical
6. Painting a door - Physical
7. Iron rusting - Chemical
8. Driving a car (burning fuel) - Chemical
9. Melting an ice cube - Physical
10. Soda fizzing - Chemical
11. Baking a cake - Chemical
12. Bending a paperclip - Physical
13. Boiling water - Physical
14. Making Trail Mix - Physical

Classroom Notes

Be sure to remind mentees to wait until they are outside or home to eat the candy.

Module 2: Don't be the problem, be the solution

In this module, we will demonstrate the difference between physical and chemical reactions by doing a Coke and Mentos experiment, as well as an Elephant Toothpaste experiment.

Teaching Goals	Materials
1. **Solution:** homogeneous mixture consisting of a solute dissolved into a solvent 2. **Solute:** material that is dissolved into a solution 3. **Solvent:** material that is dissolving the solute in the solution 4. **Catalyst:** substance that increases the rate of a chemical reaction	• Coke • 10 Mentos Mints • Liquid dish soap • ½ cup of Hydrogen Peroxide • 1 tbsp of Dry yeast • Warm water • 10 drops of food coloring • Funnel (paper)

Procedure

Coke and Mentos

1. Go outside and find a large flat area suitable for spills to occur. Make sure the students are standing 10 - 15 feet away for safety purposes.
2. Set the bottle of coke on the ground and open the lid.
3. Take 10 Mentos mints and pour them into the bottle of coke. Immediately move away from the bottle.
4. Watch the explosion occur.
5. After the students settle down, ask them the following questions:
    a. Is this a physical or a chemical reaction?
    b. How high did the eruption go?
    c. How quickly did it start? Stop?
    d. How much liquid is left in the bottle?
6. Empty the soda bottle to be used for the elephant toothpaste experiment.

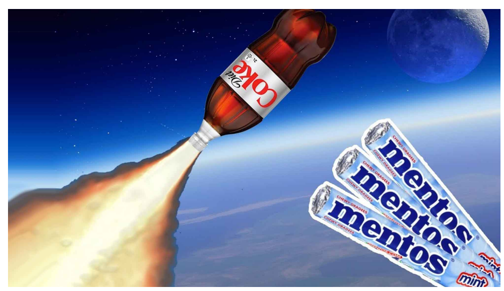


Figure 1: *Coke and Mentos*

Figure 2: *Elephant Toothpaste*

Elephant Toothpaste

1. Pour ½ cup of hydrogen peroxide into the now-empty soda bottle.
2. Add a big squirt of dish soap. Swirl the bottle to mix.

3. Place 10 drops of food coloring along the inside rim of the bottle's mouth.
4. Mix 1 tbsp of dry yeast with warm water in a measuring cup. Stir for 30 seconds.
5. Pour the yeast mixture into the bottle, then step back immediately.
6. Ask some follow-up questions:
    a. Was this a physical or a chemical reaction?
    b. What was the solvent? Solute?
    c. Was there a catalyst? If so, which ingredient was it?

Classroom Notes

Make sure to do these experiments outside with mentees standing at a safe distance.

Module 3: I'm drawing ooblank...

In this module, mentees will learn about density and get to explore what a Non-Newtonian fluid is by making their own oobleck balloons.

Teaching Goals	Materials
1. **Viscosity:** measure of a fluid's resistance to flow 2. **Newtonian fluids:** fluids that flow at a predictable, constant rate. 3. **Non-Newtonian fluids:** fluids that act like solids when pressurized and liquids when not pressurized 4. **Stress:** stress is a force applied to a body	• Cornstarch • Water • Balloons • Funnel

Procedure

1. The mentor will create oobleck at the front of the classroom and demonstrate the solid and liquid properties of the Non-Newtonian fluid.
2. Mentors will hand out one balloon to each mentee.
3. Mentors will hold the balloon open for the mentees.
4. The mentees will fill up the balloon using a measuring cup.
5. The mentees will tie a knot in the balloon. The mentors can help any of the mentees who are struggling to tie a knot.
6. The mentees will use the balloons to test out the properties of oobleck themselves.
7. Ask the mentees questions about the properties of the oobleck.
    a. When is the oobleck solid?
    b. When is it a liquid?
    c. Compile a list of properties of solids and liquids

Figure 1: *Demonstrate oobleck for the mentees*

Figure 2: *Use a funnel to fill a balloon with cornstarch and water.*

Figure 3: *Have the mentees squeeze the balloon to mix the cornstarch and water.*

Classroom Notes

Be aware of whether or not students need help to tie the balloon because this step could be messy.

Conclusion

In this lesson, mentees get to learn about different aspects of chemistry, including reactions, solutions, and viscosity. Wrap up the lesson by asking the mentees what their favorite experiment was and why.

References

- Make Elephant Toothpaste - Scientific American
- Lesson play for Oobleck BEAM UCLA
- What is Viscosity? (brookfieldengineering.com)
- Diet Coke and Mentos eruption - Wikipedia
- Spurting Science: Erupting Diet Coke with Mentos - Scientific American

Summary Materials Table

Material	Amount per Site	Expected $$	Vendor (or online link)
Coke	2 bottles	$3.98	Target
Mentos	1 pack	$4.39	Target
Cornstarch	2-3 packs	$4.78	Target + Bechtel
Water	N/A	$0.00	N/A
Balloons	1 per student	$0.00	Bechtel
Liquid Dish Soap	A few globs	$0.00	Bechtel
Hydrogen Peroxide	1 bottle	$1.29	Target
Dry Yeast	1 pack	$6.69	Target
Funnel (Paper)	A few sheets	$0.00	Bechtel
Container for Elephant Toothpaste	1	$0.00	(Empty Soda bottle from first experiment or water bottle)
Candy	20 pieces	$0.00	John John
Measuring cup	1	$0.00	Bechtel?
Total Cost		$21.13 (includes lesson testing)	