Bay Area Scientists in Schools Presentation Plan

Lesson Name Glow in the Dark Science
Presenter(s) Allie Obermeyer, Katherine Mackenzie

Grade Level 5th **Standards Connection(s)** When two solutions are mixed, a reaction can occur. This gives the mixture different properties than the starting two solutions. We will see this when we mix two solutions and they either give off light or turn into a viscous goo.

Next Generation Science Standards:

5-PS1-3. Make observations and measurements to identify materials based on their properties.

5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

Common Core Standards:

ELA/Literacy:

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

Mathematics:

MP.2 Reason abstractly and quantitatively.
MP.5 Use appropriate tools strategically.

FOSS Connections:

Grade 5 Module: *Mixtures and Solutions*
Investigation 3: *Fizz Quiz*

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. Develop a model to describe phenomena. (**5-PS1-1**) *Planning and Carrying Out Investigations* Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (**5-PS1-4**) Make observations and measurements to produce data to serve as the basis for evidence for	*PS1.A: Structure and Properties of Matter* Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon; the effects of air on larger particles or objects. (**5-PS1-1**) The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. (**5-PS1-2**) Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) (**5-PS1-3**) *PS1.B: Chemical Reactions* When two or more different substances are mixed, a new substance with different properties may be formed. (**5-PS1-4**)	*Cause and Effect* Cause and effect relationships are routinely identified, tested, and used to explain change. (**5-PS1-4**)

Teaser:

We are going to be exploring how light can be given off by different materials. By using chemical reactions or high energy light (such as a black light), nearly any object can be made to glow-in-the-dark! We will both demonstrate and experiment with different forms of glow in the dark materials. An impressive display of how glow sticks and fireflies work will demonstrate the power of chemical reactions to give different properties to the products of reactions. A hands-on experiment with making glow-in-the-dark "goo" will reveal how everyday items such as band-aids, stickers, and toys are made to give off light! We will end with discussing and showing pictures of how some animals have developed the ability to make themselves glow in the dark!

Vocabulary/Definitions: *3 – 6 important (new) words*

- **chemical reaction**: process that leads to a chemical change where the atoms of molecules rearrange to give new products with new properties
- **reactant**: molecule that undergoes chemical change during a reaction
- **product**: new molecule that is formed in a chemical reaction
- **chemiluminescence**: the release of light from a chemical reaction
- **phosphorescence**: the release of light from a chemical/material that has been previously charged with energy (excited); not from a chemical reaction

Materials:

What will you bring with you?

Topic Introduction:

- pictures of : oil and water mixture, baking soda volcano

Chemiluminescence Demonstration:

- 2 1 L flasks
- 2 70 mL aliquots of methylene chloride
- 2 6 mL aliquots of 2.0M oxalyl chloride in methylene chloride
- scintillation vial with ~5-10 mg perylene
- scintillation vial with ~5-10 mg rubrene
- 2 6 mL aliquots of 30% hydrogen peroxide
- a few glow sticks/glow stick bracelets
- pictures of fireflies

Phosphorescent Goo Demonstration:

- 1 baggie per student with 20 mL of glue/water/phosphorescent paint solution
- 2 500 mL bottles of 2 % w/v solution of borax in water
- 5 small plastic pipets (disposable ones)

What should students have ready?

- pencils
- cleared desks

Classroom Set-up:

The lesson will be broken up in two parts; the first half will be two graduate students introducing the ideas behind chemical reactions and how light can be a product of a reaction through chemiluminescence, illustrating this with a demonstration. The second half will be a hands-on demonstration in which the students will get to make their very own glow-in-the-dark slime.

The room does not need to be rearranged in any particular way as long as all the students can see the front of the classroom. If there are shades or blinds on the windows, they should be closed to enable the room to be darkened as much as possible during the second part of the presentation. Once the demonstrations are over, students should wash their hands to remove any residual chemicals

We will need some space on the chalkboard (or whiteboard) to write up our vocabulary words.

Classroom Visit

1. Personal Introduction: 5 Minutes

Who are you? What do you want to share with students and why? How will you connect this with students' interests and experiences?

We are both college graduates that are now in graduate school and have gone on to study chemistry and biology in more detail. We are working to make new materials that can help people around the world. Some of the things we are working to make are ways to purify water, deliver medicine exactly to your sicknesses, and take the light from the sun and turn it into energy. Here today we have (introduce ourselves by first name).

2. Topic Introduction: 10 Minutes

What questions will you ask to learn from students? Big Idea(s), vocabulary, assessing prior knowledge…

Today we are going to be learning about chemical reactions and glow in the dark science. So before we get started, can anyone tell us what a chemical reaction is? (wait for students to answer). That's right. A chemical reaction is when one or more molecules undergo a chemical change and what is really happening is that some of the atoms are rearranging to make a new molecule or substance. So does anybody know how a chemical change is different than a physical change? (wait for students to answer). Correct. In a physical change, only the state of matter is changing but the molecules are not changing. In a chemical change, though a reaction is happening and the original molecules are changing to become new molecules with different properties. For example, when ice melts into liquid water that is just a physical change, because both are just forms of water. In contrast, when you burn something like wood or gasoline, it turns into other chemicals - smoke, carbon dioxide, and water. When we are talking about chemical reactions, there are a few terms that we need to be familiar with. The first one is reactant. Can anybody define what a reactant is? (wait for an answer). That's right, let's all put that down on our worksheet (and we will write it on the board). A reactant is the molecule that undergoes the chemical change during a reaction. Now what about a product? (wait for an answer). Excellent, let's copy that to our worksheets (write on the board). Can anyone think of examples of chemical reactions they've seen before? (Alka-Seltzer + water, vinegar + baking soda, rust). Frequently, it's hard to tell if a reaction has happened; not all products look or act different than the reactants. Sometimes mixtures of two things do look different even though they haven't reacted (Coca-Cola and OJ). So today we are going to explore a couple of reactions that have products with very different properties than the reactants.

3. Learning Experience(s): 35 Minutes

What will you do, what will kids do? Demonstrations, hands-on activities, images, games, discussion, writing, measuring… Describe in order, including instructions to kids.

Chemiluminescence: For this first reaction, we're going to mix this clear, colorless liquid with this clear, slightly colored liquid. Does anyone want to guess what will happen? (Mix) How can you tell a reaction happened? (Make sure they mention something about light, not just the color change) This reaction is special because one of the products is light. When a reaction gives off light, it is called "chemiluminescence" (spell on board). All chemicals have a certain amount of energy. When a reaction occurs, if the reactants have more energy than the products then the extra energy from the reactants is released. Usually this is released as heat which can be difficult to detect; in this special reaction, it is released as light. That makes this reaction especially easy to see. Can anybody think of a common item that gives off light after undergoing a reaction? (glow sticks).

Phosphorescent Goo: Now you will get to see a different reaction and how it proceeds through completely new mechanism. In this baggie is a chemical called poly(vinyl acetate), which is what makes up Elmer's glue, mixed with some water. You are all probably familiar with it – kind of slimy, it dries into a hard solid but can be washed away with water. Poly(vinyl acetate) is what is known as a polymer, meaning it is made up of really long chains of repeating units, like a candy necklace. We have a second solution, containing Borax, which is a white powder often used in detergents and cosmetics. We're going to come around and add a little bit of the Borax solution to your plastic baggies. Start squishing them around as soon as we add the Borax.

Did a chemical reaction occur? How do you know? How does the product differ from the reactants?

The two liquid solutions became a slime because the long chains of the polymer became crosslinked by the Borax (show image). Before, each chain of poly(vinyl alcohol?) could slip past each other chain in the water, so it was still a liquid solution. Now, the borax links some chains to others, keeping them all connected to each other – this is why it has become more solid. If you add a lot more Borax, more of these links form, creating an even harder, more solid product. If you add something like glitter or a colored paint to the glue, it will stay in the slime because it gets caught up in the net of polymer chains forming.

We also added a small amount of glow in the dark paint to the glue solution to make the slime glow in the dark. Now we're going to see if the slime glows in the dark. (Turn off lights)

We just did a reaction, and the product glows in the dark. Is this the same as the first reaction? How is it different?

- First reaction emitted light that you could see without turning off the lights
- Light was emitted immediately upon mixing the reactants in the first reaction
- Light before faded over time. This can be recharged.

Do you think this material emits light via the same process as the first reaction? Why or why not?

This slime is emitting light because of phosphorescence, a different process from the first reaction. In phosphorescence, molecules can be "charged" with energy by shining light on them. They can hang on to this energy for a short period of time and then release it later as light, similar to how a rechargeable battery can be charged and then run something, or a wind-up toy will perform only after being wound up. This is what causes glow-in-the-dark stickers and paint to glow – you charge them with light and they immediately start to emit it, and after a while they lose their glow

because all the energy stored up has been released. In our slime, it wasn't the reaction that caused this glowing; the glow-in-the-dark paint we added undergoes phosphorescence by itself, and the molecules of paint are just caught up in the polymer net we made during this reaction.

4. Wrap-up: Sharing Experiences 5 Minutes

Putting the pieces together – how will students share learning, interpret experience, build vocabulary?

So today, we have seen two different chemical reactions that were easy to watch, but proceeded very differently. In the first reaction, we knew that a chemical change had taken place because we saw chemiluminescence when we mixed the two solutions. In the second reaction, we could tell a reaction happened because the products had very different physical properties than the reactants. The goo we made also gave off light, because of phosphorescence. Can anyone describe the difference between chemiluminescence and phosphorescence?

5. Connections & Close: 5 Minutes

What else might kids relate this to from their real-life experience? How can they learn more? Thanks and good-bye! Clean-up.

Today we have seen lots of things that give off light or glow in the dark. Can anyone think of some other examples things in nature that glow in the dark? (fireflies, jellyfish/deep sea fish, bio-luminescent protozoans/algae, anything expressing GFP!). (we will have some pictures, they will be awesome)

TOTAL 50 – 60 Minutes

Differentiated Instruction:

English Learners: Repeat directions, if necessary, and physically and orally demonstrate how to combine substances. Write vocabulary words on the board and read words aloud. Vocabulary words can also be visually demonstrated using an illustration or action and redefined in very simplistic terms.

Advanced Learners: Have students write down hypotheses about why certain animals need to glow in the dark.

Follow-up Possibilities

ELA Activity:
Suggest students write a letter explaining "How we learned about chemiluminescence and phosphorescence…"

Reading Connections:

- Cold Light: Creatures, Discoveries, and Inventions That Glow by Anita Sitarski - Luminescence sheds light on the adventure of science. Scientists and many others have explored the science and wonder of cold light - the chemistry of animals and things that make light but not heat. Awe-inspiring, full-color photographs accompany the compelling, fact-filled text in these scientific explorations. http://anitasitarski.com/home

(Amazon: http://www.amazon.com/Cold-Light-Creatures-Discoveries-Inventions/dp/1590784685/)

- Creatures that Glow (Glow in the Dark Book) by Joanne Barkan -- (Grade 3-5) Luminous photographs and page headings are this book's outstanding features. It actually glows in the dark--an effective property in an introduction to bioluminescence. Barkan briefly explains the chemical process behind the ``cold light,'' and then describes some characteristics of 16 organisms. A clear, full-color photograph of the creature accompanies each discussion; appropriate portions shine eerily in the dark. http://www.amazon.com/CREATURES-THAT-GLOW-Glow-Dark/dp/0385419783/

- Creatures That Glow (Creatures of the Sea) by Kris Hirschmann -- (Ages 8 and up) Read about amazing glowing creatures that make up 80 to 90 percent of sea animals. Includes how bioluminescence affects communication, reproduction, hunting and defense. http://www.amazon.com/Creatures-That-Glow-Sea/dp/0737723408/

Mathematics Activity:

Students research different phosphorescent animals and graph the types and rough numbers of these animals. Students can also write equations for different chemiluminescence and phosphorescent substances.

Other:

Glow-Up: You light up my life (Exploratorium) - In this activity, learners explore chemiluminescence and fluorescence. Learners examine 3 different solutions in regular light, in the dark with added bleach solution, and under a black light. This resource includes information about chemiluminescence and fluorescence including how these properties pertain to molecular and cell biology. http://www.exo.net/~jyu/activities/glowup.pdf

Luminescence (Mount Holyoake College) – In this two-part activity about luminescence, learners explore the chemistry that happens inside glow sticks and other light producing reactions. First, learners build a ground state model and a excited state model of light. Then, learners use glow sticks to perform chemical reactions to make light (chemiluminescence) and test how well the reactions work at different temperatures. These activities are part of the "Passport to Chemistry Adventure" kit but the kit is not necessary to have in order to facilitate the activities. https://www.mtholyoke.edu/courses/magomez/ChemistryPassport/List_of_3-6_Kits_files/LuminescenceKit.pdf

Glow in the Dark Science

New Vocabulary:

chemical reaction:

example: _____

reactant:

example: _____

product:

example: _____

chemiluminescence (chem - ee - loom - en - eh - cents):

example: _____

phosphorescence (fos - for - eh - cents):

example: _____

1611 San Pablo Avenue, Suite 10 B
Berkeley, CA 94702
(510) 527-5212 | www.crscience.org