



LIT

LIGHT IN TRANSMISSION

PERCY ECHOLS II, CURATOR
FEBRUARY 5 - MAY 9, 2021

PLAYING WITH PLASMA
LESSON PLAN - GRADES 6-12

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PLAYING
WITH

PLASMA

At a Glance

TARGET GRADES: 6-12

NEXT GENERATION SCIENCE STANDARDS (NGSS)

nextgenscience.org

MS-PS1-1 Matter and its Interactions

Develop models to describe the atomic composition of simple molecules and extended structures.

MS-PS1-4 Matter and its Interactions

Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

HS-PS1-5 Matter and its Interactions

Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

MS-PS1-8 Matter and its Interactions

Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

HS-PS3-3 Energy

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-PS1-4 Matter and its Interactions

Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

LEARNING OBJECTIVES

Students will understand the difference between plasma and other states of matter (solid, liquid, gas), why plasma can conduct electricity, and what plasma may look like.

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Featuring images from Pixabay



ACTIVITIES INCLUDED

- 01 Let's Get Charged Up!** —Use a balloon to manipulate atomic charges.
- 02 Plasma Matters** —Build models to understand the four states of matter.

- 03 Plasma Lamp** —Create your own dynamic lamp to simulate plasma atoms.
- 04 Microwaveable Science** —
Create your own plasma using just a grape.

LESSON PREPARATION

- One of the activities in this lesson plan requires the use of a microwave. Be sure to ask an adult for permission to use this appliance.
- Be sure to follow all instructions carefully as to not cause any damage to your appliance.

INTRODUCTION TO PLASMA

You have probably heard of the three main states of matter before. **Even if you haven't, you definitely have had experience with all three.** Solid, liquid, and gas are states of matter that are all around us. Think of the table you are working on right now, or the glass of water you are drinking, or the air that you are breathing. Anything that has mass and can take up space is a form of matter.

However, there is a fourth state of matter that you might not be as familiar with: **plasma**. This state of matter is not as common as the other three but is just as important.

Throughout this lesson, we will explore what **plasma** is, how it is created, and how we use it in everyday life.

VOCABULARY

- **Plasma** —A gas made up of free-flowing ions (electrically charged atoms) and electrons (negatively charged particles)

- **Matter** —Material substance that occupies space, has mass, and is composed of atoms)

- **Atom** —The smallest particle of an element

Proton —An elementary particle that carries a positive charge

Neutron —An uncharged elementary particle

Electron —An elementary particle that carries a negative charge

- **Ion** —An atom or group of atoms that carries a positive or negative electric charge as a result of having lost or gained one or more electrons

Ionization —The act or process of ionizing something; conversion of a substance into ions

- **State of matter** —Four distinct forms in which matter can exist (solid, liquid, gas, plasma)

Solid —A figure or element having three dimensions

Liquid —A fluid that has no independent shape but has a definite volume

Gas —A fluid that has neither independent shape nor volume

- **Static electricity** —Electricity that is produced by friction

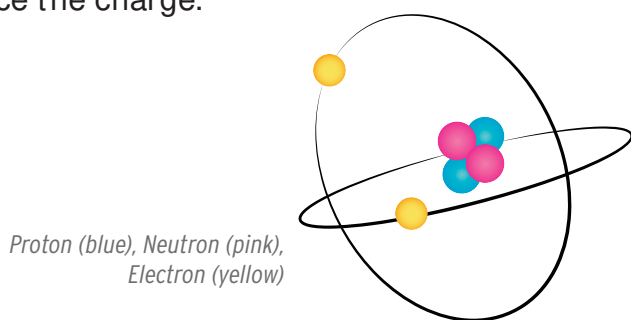
- **Phosphorus** —A chemical element that exists in two major forms, white phosphorus and red phosphorus. Because it is highly reactive, phosphorus is never found as a free element on Earth. The glow of phosphorus is caused by oxidation of white phosphorus —a process called chemiluminescence.

LET'S GET CHARGED UP

OVERVIEW

To learn about what **plasma** is, we want to start by charging up some atoms.

All matter is made up atoms, which have a positively charged center made up of particles called **protons** and **neutrons**, and a negatively charged outside made up of particles called **electrons**. Depending on how many protons and electrons a particular atom has, it will either be positively or negatively charged. Most atoms have the same number of each, canceling each other out, and we don't even notice the charge.

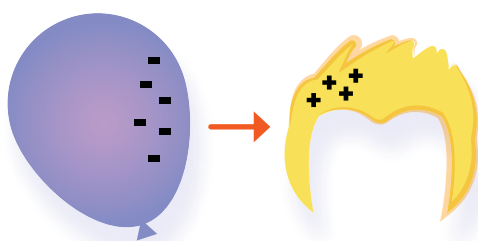


GUIDING QUESTIONS

- What will happen to the balloon when we rub it against our hair?
- What materials will be attracted to the balloon? Repelled by the balloon?
- How long will the balloon remain charged?

MATERIALS

- Balloon (be aware of any latex allergies in your household)
- Volunteer's hair
- Wool fabric
- Rice cereal
- Paper confetti
- Sink
- Stopwatch
- A wall
- Metal object (baking sheet, pan, etc.)



Opposite charges attract

PROCEDURE

- 1) Inflate your balloon.
- 2) Rub the balloon against your (or a lucky volunteer's) hair or against a piece of wool fabric. Some materials are more likely to lose or gain their electrons than others. In our case, balloons are much better at gaining electrons than losing them.

When you rub the balloon against your hair or the wool fabric, some **electrons** are added to the surface of the balloon, making the balloon negatively charged.

By rubbing two things together, we are creating something called **static electricity**. This is the same process as when you rub your socks on the carpet to create a static shock, or when clouds rub together to create a lightning bolt.

3) Make observations as you move this charged balloon over your hair, rice cereal, or paper confetti.

4) As the negatively charged balloon is brought near other materials, some of these materials will be attracted to the balloon, while others will be repelled.

Think of a magnet, which has a north and south pole. When like poles are brought together, they repel each other. However, when opposite poles are near each other, they are attracted to each other. Charges work in a similar way. Negative and positive charges will be attracted to each other, while like charges will repel each other.

5) Run water from your sink and bring the balloon close to the stream of water. Observe what happens.

The water is neutral with both positive and negative charges. When the negatively charged balloon is brought near the water, it will repel the electrons away from the stream of water, leaving it slightly positively charged. Now that the water is slightly positive, it will bend towards the balloon.



6) Recharge the balloon, hold it up to a wall, and let go. Using your stopwatch, time how long it takes for the balloon to fall off the wall.

7) Recharge the balloon, hold it against a piece of metal and then up to the wall, and let go of the balloon. Using your stopwatch, time how long it takes for the balloon to fall off the wall.

Electrons are looking for a way to ground themselves. Think of a lightning bolt that will strike the tallest tree in order to get to the ground. When the negatively charged balloon comes into contact with the wall, it will be attracted to the positive charges in the wall. The balloon's extra electrons will slowly be grounded out of the balloon until the balloon is too weak to remain attracted.

When the balloon comes into contact with the metal object, the metal will gain all of the extra electrons (just like how the balloon gained all of the electrons from your hair). When this balloon comes into contact with the wall, it has already lost of its extra electrons and will not stick to the wall for long, if at all.

REFLECTION QUESTIONS

- What three particles make up an atom?
- What particle makes the balloon negatively charged?
- Does the balloon hold onto this charge forever?

PLASMA MATTERS

OVERVIEW

Now that we've learned that electrons carry negative charge, let's look at why it matters! We're going to build some atoms...that is, models of atoms! Real atoms are way too small for us to see, but millions of them together make up everything around us —the air, water, this paper!

MATERIALS

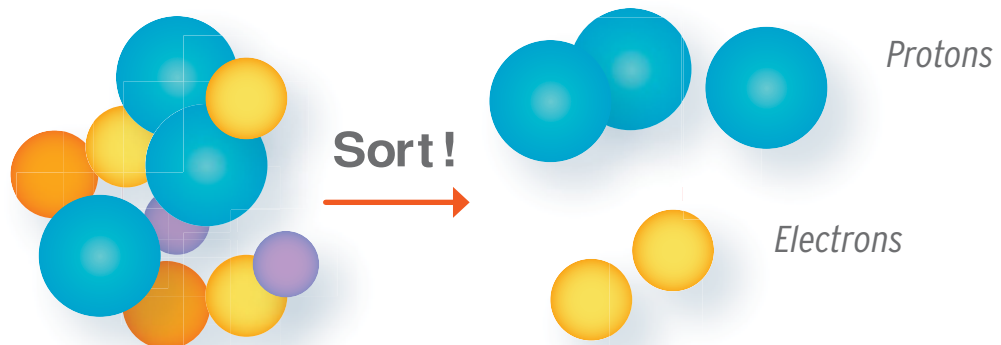
- Four mason jars or resealable zip bags
- Liquid glue
- Glycerin, baby oil, or (in a pinch) tap water
- 80 beads, marbles, pom-poms, pebbles, or craft buttons of two different sizes or colors

GUIDING QUESTIONS

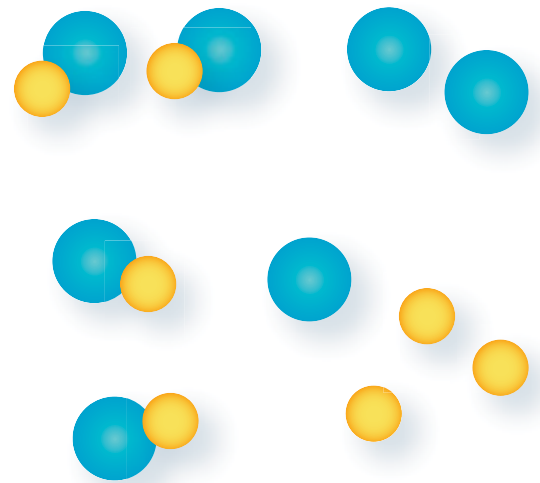
- What makes some atoms different than others? Why does water slosh around but this paper is keeping its shape?
- Why do we only put one electron on each proton? Could protons have fewer electrons? What would happen if they had extra electrons?
- Which group of your atom models would be neutral —the glued or unglued pairs?

PROCEDURE

- 1) From your beads, marbles, pom-poms, pebbles, or buttons, pick a color or size that can represent the **protons** of the atom. These are the positively charged parts of an atom.
- 2) Pick a different color or size to represent the **electrons**, the negatively charged parts.
- 3) Scientists need to keep their laboratories organized at all times. Sort your electrons from your protons!



- 4) Now that we have our protons and electrons, we can start to make atoms. (Note: Atoms also have **neutrons**, but we won't worry about that for this experiment!)
- 5) Take 30 of your protons and glue each one to an electron.
- 6) A lot of the **matter** around us is made from neutral atoms. These are atoms that have one electron for each proton. Take 10 of your **neutral atoms** and glue them all together into a blob. You can form them into a sculpture if you would like! Just make sure they can fit into your jar or zip bag.
- 7) Let it dry! Once you are happy with its structure, glue the whole thing to the inside of your jar or zip bag. Set it aside to dry.
- 8) Use 10 of your remaining **neutral atoms** for this next step: Put them right into an empty mason jar or zip bag and seal it up. What **state of matter** do these ones represent? Solids, liquids, or gases? (Hint: Are they flying around, or do they stay near the bottom of your container? What happens if you shake it or tilt the container? Do they hold their positions near each other, or move past each other?)
- 9) Take the last of your **neutral atoms** and put them into an empty mason jar or zip bag. Carefully fill the container with glycerin, baby oil, or tap water. Seal it tight! What **state of matter** do these atoms model when you shake it?
- 10) All we have left to use is our protons and electrons that have not been glued together. These aren't neutral atoms—they're **ions**, or non-neutral atoms! Put them all into your last empty mason jar or zip bag. Carefully fill it with glycerin, baby oil, or tap water. Seal it tight!
- What is this modeling?



REFLECTION QUESTIONS

- Is your structure modeling solids, liquids, or gases? Why?
- Would changing the supplies we're using affect that answer? What if we used concrete instead?
- For each jar: What will the shape of this structure be like once it is dry? If they are all stuck together, could they change position from each other if you held it upside down? If you put it in a different container, what would happen to its shape?

PLASMA LAMP

OVERVIEW

Let's make a model to show how atoms move as a plasma! Our colored water will act as the atoms. Adding Alka-Seltzer (or shaking the container) will act as a phase change, turning the atoms from a liquid to a gas and plasma—just like adding an electrical current might change a noble gas into a plasma.

MATERIALS

- Clear bottle or jar
- Water
- Oil (vegetable oil or baby oil)
- Food coloring
- Alka-Seltzer
- Flashlight (optional)

PROCEDURE

- 1) Fill bottle or jar a third of the way with oil.
- 2) Fill the bottle or jar the rest of the way with water.
- 3) Add a few drops of food coloring.
- 4) Drop in a third of an Alka-Seltzer tablet.
- 5) Close the lid.
- 6) (Optional) Illuminate it with a flashlight.
- 7) Observe!



GUIDING QUESTIONS

- If the colored water is acting as the “atoms” of the model, what would the oil be?
- What state are the model “atoms” starting in?
- What state do the “atoms” become when adding the Alka-Seltzer?
- What is the Alka-Seltzer in the model acting like?

REFLECTION QUESTIONS

- What happened to the ingredients when Alka-Seltzer was added?
- Why did the model atoms stop moving?
- Do plasmas stay plasmas forever? What could make them change states?
- What could we add to the model to make it even more like a plasma?

MICROWAVEABLE SCIENCE

GUIDING QUESTIONS

- How can we create our own plasma?
- What is being produced when the grape halves are microwaved?

OVERVIEW

Now that we have learned more about what plasma is and how we use it, let's try and create some of our own in our kitchen!

WARNING: We will use a microwave in this experiment. Ask an adult for assistance and be careful to follow all instructions to protect yourself and your equipment.

MATERIALS

- Grape
- Knife
- Microwave
- Microwave-safe plate
- Glass cup



PROCEDURE

- 1) Carefully cut the grape (almost) in half so that it is just barely connected by a little piece of skin.
- 2) Place the cut grape on a microwave safe plate and into your microwave, with cut sides facing up.
- 3) Place a glass cup over the grapes so that the experiment does not damage your microwave.



- 4) Turn on the microwave for eight seconds and observe what happens. ***Do not microwave for longer than 10 seconds.***

When you microwave the grape halves, you will start to see brilliant flashes of light being produced from where the grapes are touching. When gas atoms are heated up to hot enough temperatures, electrons are ripped away from those atoms forming an ionized gas. This flash of light is the ionized gas **plasma**.

According to recent studies, scientists believe that the size, shape, and water content of grapes make for the perfect combination to produce this reaction. When the microwaves come into contact with the grape, the grape will “trap” a single wavelength of microwave and amplify it.

The grape will create a hotspot between the two halves, where these microwaves will hop from one half to the other, heating up the gas near the grapes. Once this gas is heated enough, it will strip the gas of its electrons and produce plasma.

The glass will act as a cage to contain the experiment. Without this cage, the plasma that is created can spiral out and interact with the walls of your microwave, causing damage.

REFLECTION QUESTIONS

- Does this experiment work with whole grapes?
- Does this experiment work with any other fruits? Blueberries? Strawberries?





ED KIRSHNER

Ed Kirshner studied architecture and sculpture at Cornell University, the University of California, Berkeley, and the Kokoschka School in Austria. He studied glass art at CCA in Oakland, Pilchuck Glass School, Corning Museum of Glass, and North Lands in Scotland. His plasma sculptures have been exhibited throughout the US, Europe, and Asia. His work is represented in the Corning Museum's 25 Years of New Glass Review. Ed's sculptures are also in such permanent collections as the di Rosa Center in Napa, California, the Swiss National Science Center, and the Bergstrom-Mahler Museum of Glass.

Ed has taught in the US, Europe, and Asia and has been on the faculties of The Crucible in Oakland and the Glass Furnace in Turkey. He held a five-year Fulbright international teaching fellowship. Ed served on the Boards of the Museum of Neon Art (MONA) and the Glass Art Society (GAS).

Lesson Recap and Content Review

- Plasmas are **ionized** gases. Their electrons move freely, which makes them great at conducting electrical charge (and magnetic fields)!
- Atoms with extra or missing electrons are called **ions**.
- Solids hold their structure, while liquids, gases, and plasmas can change shape because the atoms aren't stuck together.
- Atoms of gases and plasmas move around more freely than liquids.