Love and Hate in Particles

Anatomy of an Atom

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Grade Level	9th – 10th Grade	**Time Frame**	60
Subject	Science	**Duration**	1-2
Course	Chemistry, Physical Science		

Essential Question

How can patterns of magnetism help explain the forces within an atom?

Summary

This lesson serves as a stellar introduction lesson of what protons, neutrons, and electrons are and how they relate to each other. Students will study attractive forces in magnets to draw conclusions about the sub-atomic particles, diagram an atom, and discover how they can classify an atom based on its composition of protons, neutrons, and electrons. Although this lesson does not directly address ion or bond formation, the end of this lesson serves as an excellent segue into those topics.

Snapshot

Engage: Students predict the contents of a black box, relying on their powers of observation without being able to see the inside. This mimics the study of related scientific principles.

Explore: Students observe attractive forces between magnets and record data.

Explain: Students use the data they collect to predict the relationships between protons, neutrons, and electrons. They apply these predictions by diagraming an atom.

Extend: Students use a PhET simulation to build atoms and make predictions about how particles influence element classification and net charge.

Evaluate: Students reflect on their learning and make a statement about how they can classify an atom based on its composition of protons, neutrons, and electrons to determine its element, and its charge status.

Standards

Hawaii Content and Performance Standards for Science (Grades 9, 10, 11, 12)

SC.PS.6.7: Explain how elements are arranged in the periodic table and describe trends among elemental properties

Attachments

- Attractions and Subatomic Particles—Love and Hate in Particles.docx
- Attractions and Subatomic Particles—Love and Hate in Particles.pdf
- Lesson Slides—Love and Hate in Particles.pptx

Materials

- Black boxes (a class set of one black box per pair of students—see "Teacher's Note: Creating Black Boxes" in the Engage phase for more information on how to build these)
- Attractions and Subatomic Particles handout (attached; one per student)
- Bar magnets (one per student)
- Internet-enabled student devices (one per student)

15 minutes

Engage

Teacher's Note: Creating Black Boxes

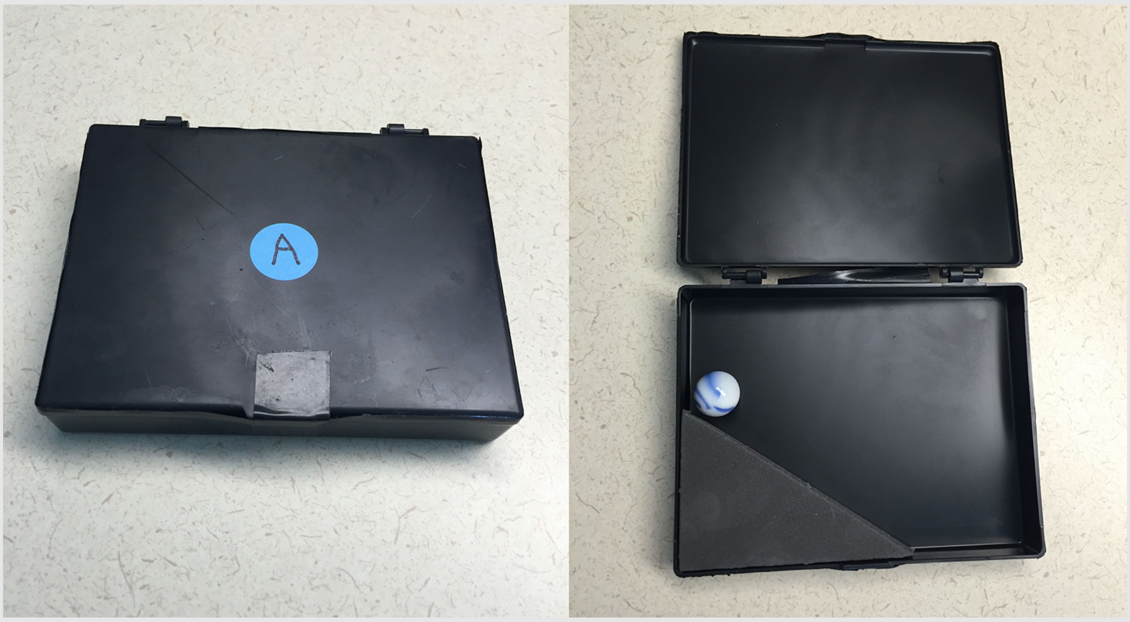
This lesson makes use of black boxes—mysterious containers with foam shapes fixed inside. These black boxes come in many shapes and sizes, and each should be unique. Students should not be able to open these boxes to view the inside. In fact, the goal of the black box in this activity is to force students to use other observations to make inferences about what they can't observe. They can't see what's inside, so they have to rely on what they hear and feel outside the box to figure out what is inside.

These black boxes don't necessarily need to be boxes. They also don't need to be black—just opaque enough that students cannot see inside it.

As you construct each black box, try to use containers with an inner space limited to about 1.5 cm tall. This is so that, when a marble is inserted to help students map the inside of the box, it rolls in two dimensions, not three. Use foam (or anything else sturdy enough to withstand marble collisions) to cut out shapes that act as ramps or walls. Fix the foam shapes into each box with an adhesive. Make sure they are simple shapes; otherwise, students may struggle to deduce what the shapes are once the boxes are closed and sealed.

Once the foam shapes are fixed in place, insert a marble into each box. The marble should roll freely and rattle when the box is picked up.

Depending on how much you trust your students, you may choose to seal the edges of each box with glue or tape to ensure there is no peeking.



Place these black boxes out on display for students as enter the classroom. Additionally, display the objective "What is the layout within the box?" using the attached **Lesson Slides (slide 3)** (or using a whiteboard space or overhead projector).

To begin the lesson, have students pair up and take one black box with their partners. Students should notice the boxes rattle.

Move to **slide 4,** and ask students how they can determine what the inside of the box looks like without opening it. Using the Question Generating strategy, have pairs brainstorm questions about barriers or challenges they anticipate that could prevent them from completing the task. Have students share their questions with the whole group and discuss possible answers.

Ask your students to tilt and rotate their boxes, listening to how the marble inside rolls around. Ask students if they hear the marble hitting any unexpected barriers inside the black box, given its shape.

Pass out a copy of the **Attractions and Subatomic Particles** handout to each student. This handout will be used throughout the entire lesson. First, ask students to look at **part 1** of the handout, "Black Box." Invite students to use their powers of observation and deduction to draw what they think is inside the box on the handout.

Move to **slide 5** and read the essential question: *How can patterns of magnetism help explain the forces within an atom?* Move to **slide 6** and, briefly, read aloud the learning objectives.

Optional Activity: To Show or Not to Show?

Optionally, you can share with students what the inside of each box actually looks like. However, it is recommended that the insides are never revealed. This mirrors the study of real scientific principles.

If students struggle emotionally with this, consider the following optional activity: have pairs rotate their boxes and use their powers of observation to, again, draw what they think the layout of this second box looks like. Repeat until each group has observed each box. Then, as a class, discuss each black box and come to a consensus on what the inside of each looks like. Keep in mind, though, that this extension alone can easily take up a class period or two.

20 minutes

Explore

Pass out two bar magnets to each pair of students. Before your students explore the attractive forces between the two magnets, ask them to look at **part 2** of the handout, “Magnet Attractions,” and answer the two guiding questions:

1. How will you know if the poles are attracted to each other?
2. How will you know if the poles are repelled from each other?

Invite partners to share their answers.

Move to **slide 7.** Ask students to work with their partners and use their bar magnets to document the relationships between the positive and negative poles of the magnets. Students should fill out the chart on the second page of the handout as they experiment.

Allow students enough time to finish recording their observations and answer the next question on the handout:

3. What do the patterns and relationships you observed tell you? Does the data you recorded above align with your prior knowledge?

20 minutes

Explain

Display **slide 8,** and share the definition on the slide with your students: *"Sub-" is a prefix that means "smaller than." What does **sub**atomic mean?*

Allow students to discuss this briefly and record an answer in **part 3** of their handouts, "Subatomic Particles." Then, move to slides **9-11,** sharing the definitions of *proton, neutron,* and *electron*.

- Proton: positively charged particle (shorthand: p+)
- Neutron: neutrally charged particle, about the same size and mass as a proton (shorthand: n0)
- Electron: negatively charged particle, much smaller than protons or neutrons (shorthand: e-)

These definitions include the academic language of protons, neutrons, and electrons. Move to **slide 12.** In a brief class discussion, ask students to predict the relationships between protons and electrons based on their experiences with the magnets in part 2 of the handout. Students should record their responses in part 3 of their handouts.

Next, invite students to work through **part 4** of the handout, "Subatomic Particle Attractions," with their partners. Students should use the table on the handout to predict the relationships between particles and then answer the following discussion questions:

1. Why do you think your prediction is correct? What data did you rely on and adapt for your prediction?
2. Why were neutrons not included in the table?

Ask for a few volunteers to share their responses with the class.

Continuing to work in pairs, have students move on to **part 5** of the handout, "The Atom." Students should read the paragraph about how protons, neutrons, and electrons interact with each other. Once they have completed the reading, they should label the atom diagram.

Consider having students check their labels against the information provided in the paragraph again. Provide them time to make revisions to their work as needed.

20 minutes

Extend

Transition to **slide 13**. Invite students to navigate to the PhET Atom Builder simulation with the URL https://tinyurl.com/preucs2. Students should do the following to set the simulation up correctly (these directions can also be found on slide 14 and **part 6** of the handout, “Atoms of Different Elements”):

- Select “Atom.”
- At the bottom, make sure the “Stable/Unstable” box is checked.
- Also make sure the “Mass Number” and “Net Charge” drop-downs are expanded.

Have students use the simulation to answer the questions in part 6 of their handout:

1. Which subatomic particle defines what element the atom is?
2. Which subatomic particle provides stability to the nucleus?
3. What proton-to-neutron ratio generally (but not always) provides the best stability?

Move to **slide 14** and share the information on the slide with your students: *Any atom with a net charge of zero is called **neutral.** Any atom with a net charge other than zero is called an **ion.***

Ask students the guiding question, “*How is net charge calculated?*” Ask for volunteers share their responses. Have your students complete the remaining guiding questions in part 6 with their partners.

5 minutes

Evaluate

Finally, move to **slide 15,** and ask students to complete **part 7** of the handout, “Synthesis of Knowledge.” Here, students should write out how they can classify an atom based on its composition of protons, neutrons, and electrons to determine 1) its element, and 2) its charge status.

Teacher’s Note: Next Steps

This is not the end of your class’s journey with particles. From here, exploring ion formation—and thus bonding predictions and intramolecular ratios—is a natural next step.

Resources

- K20 Center. (n.d.). Question generating. Strategies. https://learn.k20center.ou.edu/strategy/167
- The University of Colorado. (n.d.). ?Build an Atom?. *PhET*. https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html