Part 1: Background Information and Context

Activity
Egg in a Bottle
During this activity, students will learn about pressure and combustion by observing an egg being pulled into and pushed out of a bottle.

Suggested NGSS Dimensions to Address (click on the titles to learn more from the K-12 Framework)

Science and Engineering Practices

- Asking Questions/Defining Problems
  - Students can observe the teacher performing this activity as a demo, record observations, and ask questions.
- Planning and Carrying Out Investigations
  - Students could then develop an experiment to test their ideas or the teacher could develop the experiment, and students could conduct it.
- Modeling
  - Students could draw an initial model of the egg entering the bottle and then revise it after further explorations. To be most effective, students should explore other examples of changing air pressure. See below for suggestions.
- Constructing Explanations/Designing Solutions
  - After students explore different examples of changing air pressure, the students can explain the demonstration using their model.

Disciplinary Core Ideas

- PS1.A Structure of matter
  - 3-5: Matter exists as particles that are too small to see, and so matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials. (5-PS1-1)
  - 6-8: The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter. (MS-PS1-2, MS-PS1-4)
- PS3.A Definitions of energy
  - 3-5: Moving objects contain energy. The faster the object moves, the more energy it has. (5-PS1-4)
  - 6-8: Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter. (MS-PS1-4, MS-PS3-4)

Crosscutting Concepts

- **Cause and Effect**
  - Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
- **Systems and System Models**
  - Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
- **Scale, Proportion, and Quantity**
  - In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Part 2: Lesson Facilitation for Phenomenon

Teacher Background

Solids, liquids, and gases have different properties properties of substances can change when the substances are mixed, cooled, or heated. Solids have a defined volume and shape, liquids have a defined volume but no defined shape, and gases have neither a defined volume or shape. Initially, the pressure outside and inside the bottle is equal. Combustion of the isopropyl alcohol in air creates carbon dioxide and water and, in the process, heats up and expands the air inside the bottle forcing it out the top. Placing the egg on top of the bottle creates a seal, extinguishes the flame due to lack of oxygen, and the gas inside the bottle cools. The cooler gas molecules move slower, create less collision between molecules, and results in a lower air pressure. The air pressure outside the bottle is higher and is pushing down on the egg making the air outside and inside unbalanced. Due to the higher pressure outside the bottle, the egg is pulled inside the bottle. To get the egg out of the bottle, there has to be higher pressure inside the bottle to push the egg out. This can be done by the reaction between baking soda and vinegar or by turning the container upside down and heating the container with a hair dryer or flame. In the case of the vinegar and baking soda approach, the pressure of the carbon dioxide gas created by the reaction pushes the egg out of the bottle because of the gas molecules moving more rapidly and colliding with each other increasing the gas pressure inside the bottle. In the case of heating, as gas inside the container heats up the rapid movement of the gas molecules creates a pressure inside the container that can push the egg out again. Another example of this concept can be illustrated when you use a straw to try to pick up a ping pong ball by breathing in through the straw or shoot out a paper wad using a straw. When we breathe in through a straw, we create a suction at the end of the straw that can hold a ping pong ball onto the straw and when we blow out through the straw, we create a pressure at the end of the straw.

Combustion:

alcohol + oxygen —–> carbon dioxide + water

$C_2H_5OH + O_2$ —-> $CO_2 + H_2O$ + heat

baking soda + vinegar ——-> carbon dioxide + sodium acetate + water

$Na(HCO_3) + H(C_2H_3O_2)$—–> $CO_2 + Na(C_2H_3O_2) + H_2O$

Materials

1. Hard-boiled egg
2. Glass bottle with an opening that the egg will not slip into
3. Matches
4. Cotton balls
5. Rubbing alcohol or ethanol
6. 2 100 mL beaker
7. Vinegar
8. Baking soda
9. Pie plate
10. Hair dryer (optional)

Procedures

Preparation

1. Pour rubbing alcohol or ethanol into a beaker
2. Pour vinegar into a beaker
3. Boil eggs and peel hard boiled eggs

How to get the egg into the bottle

1. Place egg on the opening of the bottle
2. Take a cotton ball and soak in alcohol or ethanol
3. Light a match to light the cotton ball on fire
4. Remove the egg from the bottle and drop the lit cotton ball into the bottle
5. Quickly place the egg on top of the bottle
6. Observe the egg being pulled inside the bottle

How to get the egg out of the bottle

1. Tip the bottle with the egg in it so that the egg lays near the opening of the bottle (try to aim the egg pointing straight towards the opening of the bottle)
2. Put baking soda all around the egg, especially on the sides
3. Pour in vinegar and quickly flip the bottle upside down with the egg closing the opening above the pie plate
4. Alternative: Use a hair dryer to heat the bottle while holding the bottle upside down

Safety Concerns

This activity should only be conducted by someone who has been trained to work with fire and a fire extinguisher should be available at all times. Presenters should be cautious when handling fire. They should keep the fire away from the audience, especially children. Make sure matches are extinguished after lighting the cotton ball. Isopropyl alcohol is very flammable.

3-Dimensional Questions

1. What did you notice during the demonstration?
2. What did you wonder during the demonstration?
3. What do you think is causing the egg to enter the flask?
4. How could you test your ideas on how the egg is entering the flask?
5. What role does the fire/combustion play in the phenomenon?

5E Model Alignment/Suggestions

Engage:

Consider using this activity as a demonstration and having students ask questions about what they see through a prompt such as "Make 5 observations and 3 questions about the following demonstration". Consider either showing the students how to get the egg out or have them brainstorm ways they think the egg could come out without breaking it. This would also be a good opportunity for students to model their initial thinking around why/how the phenomenon is occurring.

Explore:

1. After students have made preliminary predictions and explanations, they could explore these predictions by conducting an investigation involving different displays of temperature and pressure. Students could either **develop the investigation** or simply **conduct** it using provided procedures.
2. After conducting an investigation, students could *revise* their original thinking about the phenomenon.

Explain:

After the teacher has helped the students make meaning of their activity through direct teaching, video, or text, the students can then explain their learning back to the teacher. Through experience and instruction, students should learn about the relationship between pressure, temperature, and kinetic energy in moving particles (more kinetic energy results in more collisions and thus more pressure).

The students can **construct an explanation** or write a **Claim-Evidence-Reasoning** on the relationship between temperature, particle movement, collisions, and pressure. This would also be an appropriate time for students to show their thinking through revising their models.

Elaborate:

1. Students could **apply their knowledge to a new situation** by predicting/modeling/explaining what would happen in a new scenario that involves temperature and pressure. They could test their predictions through an investigation they design and conduct it or simply stop at the design.