Part 1: Background Information and Context

Activity
Money on Fire
By submerging a U.S. dollar bill into a solution, one may light the dollar bill on fire and the bill will not actually burn; even though it looks like it is damaged in the flame, it is not.

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. Because of the flammability aspect, take caution in allowing children to conduct experiments on their own.
- Modeling
  - Students could draw an initial model of the money burning and then revise it after further explorations. To be most effective, students should explore other examples of flammable and non-flammable substances. See below for safe facilitation suggestions.
- Constructing Explanations/Designing Solutions
  - After students explore different substances with varying flammability, the students can explain the demonstration using their model.

Disciplinary Core Ideas

- PS1.A Structure of matter
  - K-2: Matter exists as different substances that have observable different properties. Different properties are suited to different purposes. (2-PS1-1, 2-PS1-2, 2-PS1-4)
  - 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, 5-PS1-3, 5-PS1-4)
  - 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)
- PS1.B Chemical Reactions
  - **3-5**: When two or more different substances are mixed, a new substance with different properties may be formed. (5-PS1-4)
  - **9-12:** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of

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
- **Energy and Matter**
  - Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

	molecules that are matched by changes in kinetic energy. (HS-PS1-4)	

Part 2: Lesson Facilitation for Phenomenon

Teacher Background

By now you've probably guessed that the money will actually burn if you dip it into a pure alcohol solution. The secret, of course, is the addition of water to the mixture. The water from the water-alcohol mixture evaporates and absorbs much of the heat energy that is generated when you ignite the bill. The water is first heated to its boiling point and then vaporized by the heat of combustion from the burning alcohol. The evaporation of the water keeps the temperature below the ignition temperature of paper, which is 233°C or 451°F. If you read Fahrenheit 451, a novel by Ray Bradbury about book burning, you will recognize this famous temperature. If you reduce the amount of water in the mixture, the paper money is likely to char or even catch on fire.

TRY THIS
Alcohol burns with an almost invisible blue flame. One trick is to add a little table salt to the water-alcohol mixture to give the flame a more yellowish color and make it more visible. You can also try to change the ratio of rubbing alcohol to water to see how it affects the way the bill burns, but you're likely to accidentally burn up your dollar bill. It's a good idea to test your mixture with a heavy construction paper first.

Materials

1. US dollar bill : 1 or 2
2. 70% Isopropyl alcohol – 90mL
3. Water: 30mL
4. Metal tongs
5. Lighter or matches
6. 250mL beaker

Procedures

1. Create water-alcohol mixture: 3 ounces (90mL) of TAYI isopropyl alcohol and 1 ounce (30mL) water – 3:1 ratio. Stir well.
2. Using tongs, dip dollar bill into the liquid mixture – make sure bill is completely soaked.
3. Remove bill, move mixture to the side (safety purposes)
4. Light the bottom of the dollar bill on fire – the mixture will burn (dollar will appear to be burning.)
5. Allow bill material to burn until completion – approximately 25 seconds.
6. Immediately after flame has stopped, dollar bill will be cool to the touch – only water remains.

Safety Concerns
Be careful with open flames and have a fire extinguisher handy. For this particular activity, it is strongly suggested to be conducted by a teacher experienced with chemistry/ fire.

3-Dimensional Questions

1. What did you notice during the demonstration?
2. What did you wonder during the demonstration?
3. What factors do you believe influence this activity and the fact that the dollar bill did not burn? How could you design an experiment that could test whether those factors are important or not?

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 having the students make predictions about what the liquid is and why the money doesn't burn. Do not tell the students what the mixture is!

Explore:

1. After students have made preliminary predictions and explanations, they could explore the concept further by experimenting with substances (including alcohol and water) that are flammable or non-flammable or slightly flammable. A safe way to conduct this investigation would be for younger students to **design it** and then the teacher conducts the suggestions in front of the class. Middle school students could conduct controlled flammability tests with proper safety precautions and strict policies. In this case, the students could be given procedures or the teacher could lead the class in **designing** the experiment together to ensure it's designed safely. The idea is that after exploring various liquids they begin to get the idea that there was a combination of a flammable and nonflammable liquid that allowed the money to catch on fire but not burn.
2. After conducting an investigation, students could *revise* their original predictions/explanations about the money burning through written **explanations** or **modeling**.

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.

The students can **construct an explanation** or write a **Claim-Evidence-Reasoning** on flammability and how the dollar caught on fire without burning. This would also be an appropriate time for students to show their thinking through modeling.

Elaborate:

1. Students could **apply their knowledge to a new situation** that involves flammability or could predict/model/explain what would happen if the dollar were soaked in pure water, pure alcohol, or the ratio was altered. They could test their predictions for various ratios using paper. Again, this could be designed by the students but conducted by the teacher for safety reasons.