Lesson Plan: Lab Safety and Safety Data Sheets (SDS)

FOR THE TEACHER

Summary
In this lesson, students will identify various safe lab practices with a focus on the importance of labeling and knowing the background safety information for all reagents used in a lab. Students will design a series of tests to determine the identity of an unknown substance using properties found on safety data sheets.

Grade Level
High School and Middle School

NGSS Alignment
This activity will help prepare your students to meet the performance expectations in the following standards:

- **Scientific and Engineering Practices:**
  - Asking Questions and Defining Problems
  - Analyzing and Interpreting Data
  - Planning and Carrying Out Investigations
  - Engaging in Argument from Evidence
  - Obtaining, Evaluating, and Communicating Information

Objectives
By the end of this lesson, students should be able to

- Identify safe laboratory practices and use them while conducting a scientific investigation.
- Identify physical and chemical properties that can be used to identify unknown substances.
- Design an investigation to identify an unknown substance based on properties from safety data sheets.

Chemistry Topics
This lesson supports students’ understanding of

- Laboratory safety
- Chemical properties
- Physical properties

Time
**Teacher Preparation:** 45 minutes
**Lesson:** 2-2.5 hours

Materials
- Safety Demonstration
  - Refer to downloadable script for this safety demo
  - Empty, unlabeled bottles and jars to be filled with:
    - Water
    - Vinegar
    - Baking soda
  - Food coloring (added to liquids in jars)
  - Balance
  - Bunsen Burner
  - Coffee mug
  - Graduated cylinders and beakers of assorted sizes

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• Article Reading
  o Class set of copies of the December 2015 ChemMatters article “Safety Data Sheets: Information that Could Save Your Life” (available to download)
  o Class set of copies of methanol SDS
  o Class set of copies of reading questions handout (available for download)

• Lab Investigation (per group)
  o Copies of SDS for:
    ▪ sodium chloride
    ▪ sodium bicarbonate
    ▪ dextrose (glucose)
  o Copies of student lab worksheet
  o 2 or more beakers (50 – 150 mL)
  o well plate
  o stirring rod
  o pipettes
  o Bunsen burner
  o Test tubes
  o Test tube tongs
  o Wooden splints for each group
  o Sample of sodium bicarbonate, unlabeled (5 – 10g)
  o Vinegar available (if students ask to test sample with acid)
  o Isopropyl alcohol available (if students ask to test solubility)

Safety
• Always wear safety goggles when handling chemicals in the lab.
• Students should wash their hands thoroughly before leaving the lab.
• When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
• Always use caution around open flames. Keep flames away from flammable substances.
• Always be aware of an open flame. Do not reach over it, tie back hair, and secure loose clothing.
• Open flames can cause burns. Liquid wax is hot and can burn the skin.
• Exercise caution when using a heat source. Hot plates should be turned off and unplugged as soon as they are no longer needed.
• When lighting the match and wooden splint, be cautious with the flame.
• An operational fire extinguisher should be in the classroom.
• When working with acids, if any solution gets on students’ skin, they should immediately alert you and thoroughly flush their skin with water.
• When diluting acids, always add acid to water.

Teacher Notes
• Safety Demonstration (20-30 minutes)
• Start this lesson with an unsafe lab demonstration using the reaction between baking soda and vinegar based on Flinn’s Laboratory Safety challenge. A condensed version of this script is provided for download and you can watch this video to get a picture for the purpose of the demonstration.
  o This demonstration typically takes about 5 minutes if you are using the condensed version of the script.
  o This demonstration is most effective if you can get a guest to come into your classroom and perform it. I recommend getting an administrator to come in as a guest scientist.
  o The attached script will give you ideas for what the demonstrator can do. The demonstrator can feel free to have fun with it and play along to make the students think they are being serious.
It is important that the demonstrator makes it clear that they are not entirely sure what substances they are mixing together because nothing is labeled.

- After the demonstration, ask students to get out a half sheet of paper and write down all the unsafe things they saw during the demonstration. You can collect this if you wish.
- Once students have written down everything they saw, ask students to share out. Let students share until they run out of unsafe lab practices.
- Tell students you want to focus in on the demonstrator not knowing what substances that they mixed together.
- Ask students, “Why do you think it is important to know what substances you are working with?”
  - Students may answer about different chemicals reacting in different ways or some substances could be poisonous.
- Ask students, “Is there any more information you would want to know about a chemical before using it besides just its name?”
  - Students may answer a multitude of different properties like reactivity and flammability
  - This question should lead into the Safety Data Sheets article.

Article reading (20-30 minutes)
- Introduce the article to students by telling them even teachers do not always use best laboratory practices. When working in the laboratory, it is extremely important to know about the substances you are working with because they may be very dangerous if not used properly. In the article we are going to read about an accident that could have been prevented if proper lab safety had been used.
- You can also show this YouTube video, which is a news story of the explosion from the article.
- Pass out the ChemMatters article “Safety Data Sheets: Information that Could Save Your Life”, the associated reading guide worksheet and the SDS for methanol to students. Ask students to read and complete the worksheet individually or in pairs.
- When students complete the worksheet, ask students to share their answers with the class.
- Ask students, “How do you think this article relates to the demonstration we saw?”
  - Students should conclude that the demonstrator did not know anything about the substances they were mixing and that could have been really dangerous.
- Tell students that you found three substances in the storeroom that look like the white powder the demonstrator used. If you have reagent bottles of sodium bicarbonate, sodium chloride and dextrose available, you can show them to your students. Otherwise, just tell students that you pulled the safety data sheets for all three substances.
- Tell students you need them to identify what substance the demonstrator was using so you can properly dispose of what is leftover.

Investigation (90 minutes)
- Pass out the safety data sheets for sodium bicarbonate, sodium chloride and dextrose and the investigation worksheet to each lab group.
- Tell students they must use the information on the safety data sheets to determine the identity of the unknown white powder. They will only be given the unknown powder and materials after the teacher has approved their procedure. Each group must devise at least 3 different tests in order to determine the identity of the compound.
- After reviewing the safety data sheets, students should decide to test:
  - If the substance is soluble in alcohol and water.
  - If the substance reacts with acid.
  - If the substance melts or decomposes when heated.
  - *Students may come up with other tests and it is up to teacher discretion whether you feel the test would be safe for students to perform.
• Guidelines for testing:
  o **Solubility:** Dissolve the unknown substance in water and in alcohol. Students should stir a small amount of the unknown powder in a beaker with water and then a beaker with alcohol. Students should observe differences in solubility. They should observe that the unknown substance (baking soda) will dissolve in water but not alcohol. This will help them with identification since both sodium chloride and dextrose will dissolve in alcohol. Students do not technically need to test for water solubility because all three powders are water soluble but it may be helpful for students to compare solubility differences.
  o **Reacting with acid:** Students should react a small amount of the unknown white powder with vinegar (acetic acid). This can be done in a well plate to minimize how much acid students are using. Acid should be dispensed using a pipette. They should observe that baking soda will react with acid (bubble/fizz). This will help them with identification since both sodium chloride and dextrose will not react with acid.
  o **Heating and splint test:** Students should heat the unknown white powder in a test tube and then insert a flaming splint into the mouth of the test tube to test for carbon dioxide. They should observe that baking soda will not have a visible change when heated but a flaming splint test will reveal it has decomposed, producing carbon dioxide (flame on splint is extinguished when introduced to the test tube). This will help them with identification since dextrose will melt when heated and sodium chloride will remain unchanged.

• Once students have their lab procedures approved, allow them to conduct their tests using proper safety techniques. You may need to guide students as they work through their tests. Some common student mistakes are:
  o Using the entire unknown sample for one test and not saving any for subsequent tests.
  o Not stirring the powder and liquid when testing solubility.
  o Not using a pipette to dispense acid.

• Notes about heating, and using the Bunsen Burner for testing:
  o If your students are comfortable with Bunsen burners, they will need to heat the substance in a small test tube for 2-3 minutes. Students will see that the substance does not appear to melt. Students can perform a flaming splint test to determine if carbon dioxide is given off (as indicated by the SDS for sodium bicarbonate).
  o If your students lack experience or are not comfortable with Bunsen Burners, you can perform this test as a whole class demonstration or you can call one lab group up at a time to see you demonstrate the test.
  o If students have never seen a flaming splint test, take a minute to explain to them that we often cannot see gases produced by chemical reactions but we can test for them in other ways. The three gases we test for using a flaming splint test are hydrogen, oxygen and carbon dioxide. If hydrogen is present, you will hear a “pop” because the hydrogen gas combusts (think Hindenburg explosion). If oxygen is present, the flame will get bigger because oxygen fuels combustion (think building a fire). If carbon dioxide is present, the flame will go out (think fire extinguisher).

• Once students have collected their data, they will complete the claim-evidence-reasoning (CER) table to explain their findings and the identity of the unknown substance. Students should find that the substance reacts with acid, is soluble in water and insoluble in alcohol and loses carbon dioxide when heated. This should lead students to the conclusion that the *unknown substance is sodium bicarbonate*.

• Each lab group should present their findings to the class. If you have large whiteboards, it would be helpful for each group to put their CER table on a whiteboard so the class can see their findings.
  o For more information on using claim-evidence-reasoning (CER) tables, read this article from ChemEdX by Ben Meacham.
- If any group does not find that the unknown substance to be sodium bicarbonate, encourage students to ask the group about their lab procedure and findings. Some question stems to help students are:
  - How do you perform...
  - How did you know...
  - Why do you think...
  - What if you...

- Once each group has presented and the class agrees on the identity of the unknown substance, ask students “how should I safely dispose of the leftover white powder?” and “what precautions should the demonstrator have taken while using this substance?”