SEEC 2021

Rocket Chemistry

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Grades: K-12* **Prep Time**: ~1 hour
Lesson Time: 2-4 class periods depending on the depth of the lesson

NGSS Standards: 2-PS1-1, 2-PS1-2, 2-PS1-4, 5 PS1-1, 5-PS1-4, 5-PS2-1, MS-PS1-2, MS-PS1-4, MS-PS1-5, MS-PS2-2, HS-PS1-2, HS-PS1-2, HS-PS1-5

What Students Do: They will explore the internal chemistry behind rocketry while experiencing three hands-on activities demonstrating both the chemistry and physics which propel a rocket above and beyond Earth's atmosphere.

Table of Contents:

Science Concepts:

Performance Expectations: Standards (Domains) Covered		
Physical Science	2-PS1-1 , 5-PS1-1	Structure and Properties of Matter
Physical Science	2-PS1-2	Structure and Properties of Matter
Physical Science	2-PS1-4 , 5-PS1-4	Chemical Reactions
Physical Science	5-PS2-1	Types of Interactions
Physical Science	MS-PS1-2, HS-PS1-2	Chemical Reactions and Properties of Matter
Physical Science	MS-PS1-4	Definitions of Energy and Properties of Matter
Physical Science	MS-PS1-5, HS-PS1-5	Chemical Reactions
Physical Science	MS-PS2-2	Forces and Motion

SEP: Science and Engineering Practices	**DCI:** Disciplinary Core Ideas	**CCC:** Crosscutting Concepts
Developing and Using Models	Chemical reactions	Energy and Matter
Planning and Carrying out Investigations	Definitions of Energy	Patterns
Constructing Explanations and Designing Solutions	Science Models, Laws, Mechanisms, and Theories Explain Phenomena	Stability and Change
Engaging in Argument from Evidence	Forces and Motion	Cause and Effect
Asking Questions and Defining Problems	Structure and Properties of Matter	Scale, Proportion, and Quantity

Materials Needed:

1. General Supplies:
    a. Mobile Device is preferred for use of applications
    b. Safety Goggles

2. 1st Activity (Stomp Rockets):
    a. PVC pipes and connector (for constructing launch system)
    b. Construction Paper (for constructing rockets and fins)
    c. 2 Liter plastic Bottles
    d. Playground Physics
    e. Rocket Launch Simulation
    f. Projectile Motion Interactive

3. 2nd Activity (Fizz Rockets):
    a. Water
    b. Vinegar
    c. Antacid Effervescent Tablets
    d. Inner-Locking Film Canister, typically opaque in color. (The canister must have a cap that snaps inside the rim instead of over the outside of the rim.)
    e. Construction Paper (to construct fins and cone)
    f. Application that records slow motion video (Lapse It or iMotion)

4. 3rd Activity (Factors Affecting Reaction Rates):
    a. Beaker or another container
    b. Water at 3 different temperatures (Hot, Cold, Room Temp.)
    c. Ice for cold water
    d. Percolater to provide Hot Water
    e. Antacid Tablet
    f. Mobile device
    g. SciJournal application (if technology is unavailable, you will need stopwatches)
    h. Thermometers (optional and recommended for older grades)
    i. Vinegar (optional)

    If mobile devices are unavailable or fail
    - Stopwatch to time reaction in 3rd activity
    - Mobile applications are not required and will only enhance their experience

5. Printed Student Materials (if there is no online capability or if interactive notebooks are used)
    - Background and Mission handout for students
    - Claim-Evidence-Reasoning Sheet

Preparation Before Lesson:

A. **Application Download**: Download all applications prior to class.

B. **Classroom Setup**: Set up an area in the classroom and label it as the "Rocket Testing Area". Masking tape can be used to demarcate borders from which the launches can safely take place.

C. **PVC Pipe Launcher Construction:** Instructions on constructing your pipe launcher for the 1st activity.[1]

Activity and General Procedure:

Most of my units begin with the exploration of a phenomena. This could be a natural phenomenon related to weather or the morning dew on grass or it could be a phenomenon related to a current event or news story such as the increased reports on shark attacks or recent space exploration endeavors. The session will focus on how teachers can use rockets to engage students in chemistry and the structure and properties of matter while covering a variety of standards. There will be a few hands-on activities that will be presented with the opportunity to perform at least two during the session.

Students will experience parts of a unit that will include hands on activities to demonstrate the chemistry behind modern rockets. Topics related to the lesson include opportunities to explore Newton's third law, states of matter, thermal energy, density, aerodynamics, and chemistry.

I like to start this unit by showing two different videos (which you may be familiar with). The first video is meant to show students earth's place in the universe and students are then directed to write their reflections of how that makes them feel. The second video is one that highlights the story of the universe and how the universe is in us. Students are then directed to write a reflection of whether that changes their perspective on their place in the universe.

This provides an appropriate segue to discuss the recent missions and how different companies (Space X, NASA, Boeing, Northrop Grumman, etc.) who produce rockets

[1] Instructions found in Resources section of handout

have taken different approaches to the fuel they use for those rockets. The lesson focuses on providing information rather than stating an opinion on which types of fuel are better.

The first activity (Stomp Rockets) will demonstrate Newton's 3rd Law and exhibit how the force exerted on the rocket will affect the height at which it launches. Participants will be provided with a rocket launcher in which they will stomp on a plastic bottle to exert a force on their rockets.

The second activity (Fizz Rockets) will show participants how varying the amount of solid booster (in the form of an antacid tablet) can affect the strength of their rocket. This will exhibit the effect of the type of materials (They will use water in one trial and vinegar in the second trial) that are used in rockets. Additionally, participants can vary the surface area that is reacted in another trial to observe the effect of surface area on reaction rate. To assist in analyzing their data, participants can take slow motion videos of their launches using a mobile device.

A third activity will use an application called Science Journal to help participants observe the effect of changing factors on the reaction rate of a chemical reaction. In this activity, participants will learn how to measure the reaction rate using sound while observing how a change in temperature and/or concentration will affect the reaction of an antacid tablet with water. They will calculate reaction times using the Science Journal application which will use the internal sensors of their devices to detect the start and end of the reaction.

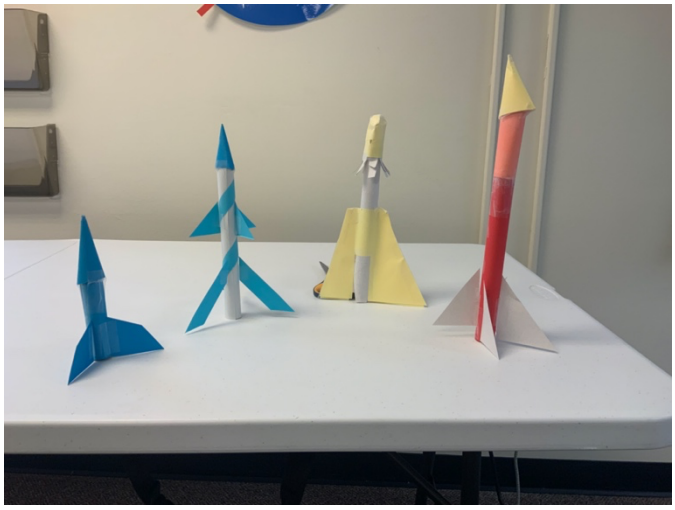
Students should use their science notebooks (if available) to record their ideas and observations, however they can also be given printed handouts, if that is preferred.

Connections to Space Exploration:

Chemistry is at the heart of what makes rockets fly. This session will focus on the internal chemistry involved in both solid and liquid boosters. The SLS, Falcon-9/Falcon Heavy will be discussed in terms of the types of reactions involved in their launch. Additionally, participants will learn how using the phenomena of rockets becomes an opportunity to explore current NASA missions (Commercial Crew program, Artemis, etc..) and empower students to understand the different stages so they can make necessary connections while watching live launches

1st Mission: Stomp Rockets Procedure

1. Construct your PVC pipe launcher using the instructions located in the "Preparation Before Lesson" section.



2. Design your custom rocket using construction paper and tape. The only constraint is that your rocket must slide easily over the open portion of the top vertical pipe of the launcher.

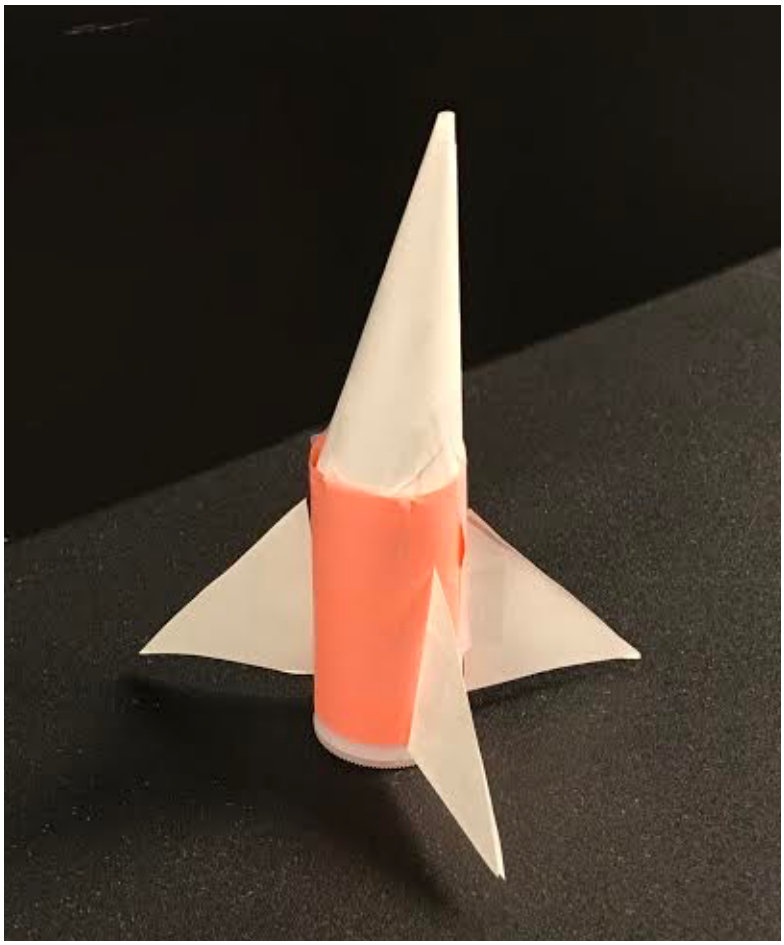
3. Make sure to attach your 2 Liter bottle to your PVC pipe for use as a source of thrust.

4. Place your completed rocket over the top vertical pipe of the launcher. You may adjust the angle of the pipe depending on your mission objective.

5. Stomp on your source of thrust and launch your rocket.

6. Students should determine the optimal rocket design and sketch their design in the Rocket Design section of their mission worksheet.

2nd Mission: Fizz Rockets Procedure[2]



1. Construct your rocket out of construction paper, tape, and your film canister.
    a. Remove the lid and keep it in a safe spot to keep it from getting lost
    b. Use the construction paper to cut a body for your rocket
    c. Wrap and tape the body around the film canister. Make sure not to cover the open end!
    d. If you would like to add fins, cut out some fins for your rocket and tape them on to the sides of the rocket body
    e. Design a nose cone for the top of your rocket. To create a basic nose cone, you can cut out a portion of a circle (1/4 of a circle). You can then overlap and twist the open ends of the circle to create a cone. Tape and cut as needed
    f. Tape the cone onto the closed end of your film canister
2. Make sure the cover of your film canister is the bottom of your rocket.
3. Decide how much of your tablet you are going to put in your rocket.
4. Practice closing the lid of the film canister to ensure you hear a "click" noise. This will ensure that you close the canister fully and will give you a more successful launch.

[2] NASA lesson on Fizz Rockets with sample worksheets and design templates found in resources section of handout.

5. Set up your device, if you plan on recording a slow-motion video.

6. With the lid off of the film canister, flip your rocket upside down and fill the canister at least ⅓ full of water (or vinegar).

7. Some safety considerations: Make sure that eye protection is used during the launch. Additionally, a launch area section should be taped off at a safe distance to prevent injury from rockets launching.

8. Drop in your tablet and quickly snap your lid back on your canister.

9. Place your rocket on your launch pad and quickly stand back behind the tape to watch it go!

10. Allow students to design new variations to see how different types and amounts of fuel have different effects on the propulsion of their mini rocket. For example, they may want to test different types and amounts of liquids or different amounts of their tablet to see which launches are more successful. You may also have students document their different trials, note the differences and similarities in their trials, and finally construct a claim-evidence-reasoning scientific argument as a final assessment.

3rd Mission: Factors Affecting Reaction Rates Procedure

1. Prepare a beaker or container so that it is marked at the 200 mL point. If you use the same container for multiple trials, this makes it more convenient to mark the desired water level.

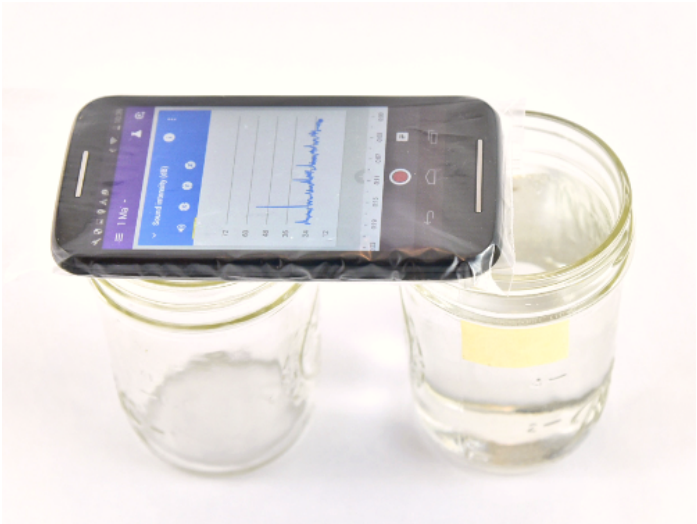
2. You will fill the drinking glass with the same volume of water at three different temperatures: hot water, room temperature water, and ice water.

3. Open the Science Journal app and start a new experiment. Choose the sound intensity sensor and make sure you know where the microphone is located on your phone by doing a quick test to see if your sound measurement is working. For example, you could record yourself clapping to check if the sensor behaves as expected.

4. Once you have confirmed that the sensor works and you are familiar with the app, you can start with the experiment. You should do this experiment in a quiet environment.

5. You can measure the temperature of the water (in Celsius [C]) in the first glass that you prepared and record it in your lab notebook. Remove the thermometer from the glass before continuing with the next step.

6. Place the second, same-sized glass, next to the container filled with water and lay your device on top of the second glass so that the microphone (or sound sensor) is located right at the center above the glass filled with water, as shown in the picture.



7. Take one whole Alka-Seltzer tablet out of its package and hold it above the glass filled with water. In the app, start a new recording for your first experiment and press the record button. Make sure to label your recording appropriately such as "hot water," "cold water," or "ice water." You can also rename your recording afterwards.

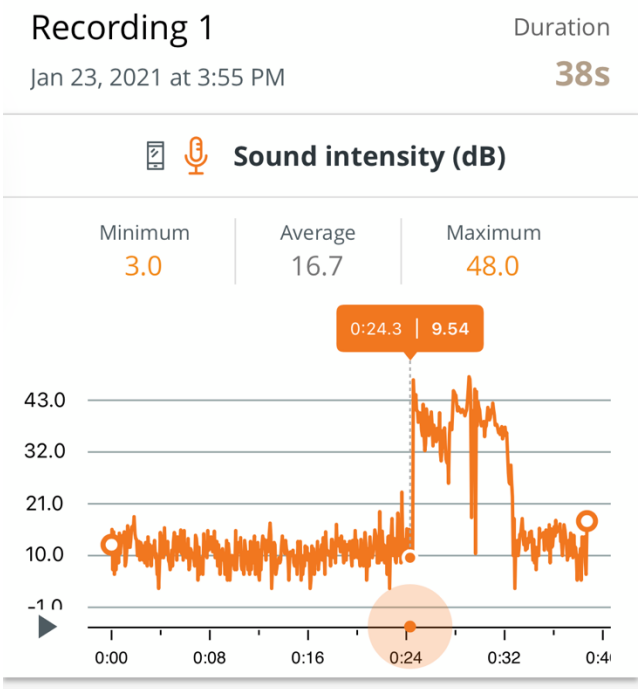
8. Once the recording starts, drop the tablet into the water. Note: You have to be very quiet during the experiment. Any sound that you make will be recorded and could affect your data. Try to be as quiet as possible while you are recording your data!

9. You will immediately see and hear bubbles of CO_2 streaming out from the tablet.

10. The tablet will gradually disintegrate. Observe the graph recorded by the app, and how the sound meter is responding to the fizzling while all of the solid white material from the tablet disappears.

11. When the solid material has completely disappeared, and you see on the graph that the sound intensity has reached background levels again or does not change anymore, wait 20 more seconds until all the bubbles have stopped forming, and stop recording your data.

12. Your data should look something like the graph in the picture to the right. Your graph should show an increased sound intensity for as long as the reaction took place. You can ignore the spiky part at the beginning and end of the graph (this occurs when you tap the phone). The sound level of the reaction might be louder in the beginning and decrease as the tablet gets smaller.



13. Drag the cursor along the graph to measure the time between the beginning of your reaction (when you dropped the tablet, and the sound intensity started to increase) and the end of the reaction (when the sound intensity reached background levels again or does not change significantly anymore). For example, the reaction in Figure 4 started at 2.9 seconds and ended at about 55.0 seconds.

14. Calculate the difference between these two points. In Figure 4 this would be 55.0 s - 2.9 s, which is 52.1 s. The result is the reaction time for your first trial. Record the reaction time (in seconds [s]) in the data table in your lab notebook.

    Tip: Be careful when opening the packets and handling the Alka-Seltzer tablets. The tablets are thin and brittle, so they break easily. If some of the tablets are whole, and some are broken into many pieces, the separate trials will not be a fair test. You should only use whole tablets.

15. Calculate the average reaction time for each of the three water temperatures. Record your results in your lab notebook.

16. Students are now ready to fill out the remainder of their mission worksheet using evidence from missions two and three.

17. Finally, students can formulate a scientific argument using the claim-evidence-reasoning format to make their final design specifications for their rocket designs.

Student Printed Materials

Rocket Design Background and CER Sheet

Background on Your Rocket Fuel:

Describe the type of fuel your rocket will utilize. Explain why you chose this type of fuel and how it is superior to other choices.

Chemical Reactions:

Summarize the important elements of your rocket fuel here. List the chemical equations that you believe are relevant to how your fuel choices will affect your rocket's performance. Include descriptions of energy and structure and properties of matter to help you make your argument.

Rocket Design:

Sketch the design of your rocket in your notebook. Provide reasoning related to any science concepts you learned as to why your design will be more aerodynamic and help your rocket deliver your payload to safety efficiently.

Claim-Evidence-Reasoning Tool

Claim: What is a claim you could argue? What is the answer to the question you would like to investigate?

Evidence: Explain the evidence you have gathered from your missions that supports your claim above. Please include observations and/or analysis from each phase of your mission.

Reasoning: Explain why your evidence supports your claim. Please include and possibly critique the strength and quality of your evidence.

Resources:

NGSS Resources:

https://districtadministration.com/ngss-science-promotes-phenomena-based/

App Download Links:

Lapse It: https://apps.apple.com/us/app/lapse-it/id539108382

iMotion: https://apps.apple.com/us/app/imotion/id421365625

Arduino Science Journal: https://apps.apple.com/us/app/arduino-science-journal/id1518014927?mt=8

Rocket Resources:

https://www.sciencelearn.org.nz/embeds/132-rocket-launch-challenge

https://www.nasa.gov/pdf/556922main_Adv-RS_321_Pop.pdf

https://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html

https://www.nasa.gov/sites/default/files/atoms/files/rockets-educator-guide-20-pop-rocket-launcher.pdf

https://www.nasa.gov/exploration/systems/sls/fs/solid-rocket-booster.html

https://www.nasa.gov/exploration/systems/sls/factsheets.html

https://www.spacex.com/vehicles/falcon-heavy/

NASA Exploration Resources:

https://www.nasa.gov/mission_pages/msl/index.html

https://www.sciencealert.com/here-s-how-nasa-plans-to-explore-time-and-space-across-the-next-10-years

https://www.nasa.gov/feature/goddard/2019/with-mars-methane-mystery-unsolved-curiosity-serves-scientists-a-new-one-oxygen

NASA Downloadable Books:

https://www.nasa.gov/content/goddard/hubble-e-books

https://www.nasa.gov/sites/default/files/atoms/files/hstoverview2019.pdf