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STEM Leadership Seminar SCED 545
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Making the Connection - Cars and Carbon Dioxide

Background

This proposal is for Option 3: Prepare and Write a Practitioner Article. Instead of an article, I am writing a middle school lesson plan for the University of Colorado's TeachEngineering or the North American Association for Environmental Education NAAEE eePRO teacher resource websites. This lesson is an extension of the NASA website, "*A gallon of gas = 20 pounds of CO2!*" (Earth Science Communications Team, n.d.).

The impact of CO_2 on the environment is commonly misunderstood (Bernardelli, J, 2020). CO_2 being a tasteless, odorless, colorless gas, contributes significantly to this misunderstanding. This lesson plan uses investigations and activities to help middle school students understand the science of combustion and how running small errands and making everyday trips produces volumes of CO_2.

Content of Lesson Plan

Using proportions, percentages, and physical models (A gallon of gas..., n.d.), middle school students use math and chemistry (*What Is a Chemical Reaction? | Chapter 6: Chemical Change | Middle School Chemistry*, n.d.) to discover how one 6.3 pound gallon of gasoline produces 20 pounds of CO_2. Building with molecular modeling sets (Home Science Tools, 2010) shows that during combustion, the carbon molecules swap light hydrogen (AMU of 1) atoms for heavy oxygen (AMU of 16) atoms. At this point, most students have a basic understanding of the science behind CO_2 production volumes from fossil fuel combustion.

Chain of Inquiry and Activities Matrix

Lesson Phase	Chain of Inquiry	Activity
Engage	What happens when we use gasoline as fuel for combustion? Reactants → Products	Explore Gas Laws with 5' 7" Cube. Observe Chemical Reactions during combustion demonstration.
Explore	What is in gasoline? What do these molecules look like?	Find the hydrocarbons used in gasoline formulation and model using Build your own Molecule.
Explain	How do different hydrocarbons produce different amounts of CO_2 during combustion?	Use models to balance equations with different hydrocarbons showing chemical reactions.
Elaborate	What is the carbon ratio for different hydrocarbons in gasoline?	Create a Carbon % Spreadsheet and use a graphic organizer.
Evaluate	What makes a better fuel, gasoline or ethanol?	Evaluate trade-offs using a matrix.

STEM Area, Activities, and Standards Matrix

STEM Area	Activities	Standards (Links to details in Appendix A)
Science	Gas Laws Chemical Reactions	MS-PS1-4 Matter and Interactions MS-PS1-5 Chemical Reactions
Technology	Build Your Own Molecule (*Build Your Own Molecule*, n.d.)	MS-PS1-1 Matter and Interactions
Engineering	Trade-off matrix	MS-ETS1-2 Analyze Data
Math	Gasoline Formulation and Carbon % spreadsheet Conversion Factors Percentages and Ratios	5.MD.1 Measurement CCSS.Math.Content.7.RPA.1

(Return Chain of Inquiry and Activities Matrix)

Assessments

Using a multiple-choice pre-assessment quickly identifies the students' current knowledge of chemical reactions. Students needing help will be tutored using the ACS Middle School Chemistry Lesson Plan 6.1 Chemical Change (*Chapter 6: Chemical Change | Middle School Chemistry Unit*, n.d.). Example questions pre-assessment are in Appendix B.

Using a rubric to assess progress on the Carbon % Spreadsheet provides for a formative assessment. Students can employ peer review to check work product quality, and the teacher can use the rubric to judge learning and skills progress. An example of this rubric is at Carbon % Rubric.

Using constructed-response questions (Tankersley, K, 2007) on the post-assessment questions allows students to demonstrate full knowledge. Example questions are in Appendix B.

Student Work

There are two types of student work in this lesson. To create the lesson, I am working with the district career center's practicum students to provide the following:

- Engineering - continue development of combustion chamber prototype
- Animation - create a story to show the "*A gallon of gas = 20 pounds of CO_2!*" message
- Digital Graphics - create a flyer for a CO_2 summer camp class and an infographic
- Video Production - two-minute introductions for the four sections of the lesson

Work products for the students in the class include:

- Carbon % Spreadsheet
- Lab Report with the Make your Own Molecule activity
- Trade-off matrix for last activity

Best Practices

A pre-assessment is used to identify current student understanding (Guskey, T.R, 2018) and establish a starting point for the lesson. Additionally, the Mastery Teaching Technique (Guskey, T.R, 2010) is employed to improve student learning by providing enrichment or extra time for student work product development.

Appendix C - References

Appendix A

Standards

Link to NGSS Document	Standard
MS-PS1-4 Matter and Interactions	Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
MS-PS1-5 Chemical Reactions	Develop and use a model to describe how the total number of atoms does not change in a chemical reaction, and thus mass is conserved.
MS-PS1-1 Matter and Interactions	Develop models to describe the atomic composition of simple molecules and extended structures
MS-ETS1-2 Analyze Data	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
5.MD.1 Measurement	Solve problems using measurement conversions.
CCSS.Math.Content.7.RPA.1	Analyze proportional relationships and use them to solve real-world and mathematical problems.

(Return to STEM Area, Activity, and Standards Matrix)

Appendix B

(Return to Assessments)

Example Pre-Assessment Questions
ACS Unit 6 Test Bank (*Chapter 6: Chemical Change | Middle School Chemistry Unit*, n.d.)

1. A chemical change is different than a physical change because in a chemical change
    a. Chemicals are used
    b. Molecules do not physically touch
    c. A new substance is formed and in a physical change no new substance is formed
    d. The change can be seen but in a physical change it cannot

2. In a chemical reaction
    a. The atoms of the reactants always stay together to form the products
    b. The atoms of the reactants unbond, rearrange, and then rebond to form the products
    c. New atoms are formed which combine to make the products
    d. Some atoms disappear while others multiply to form the products

Example Post-Assessment Questions
(Return to Assessments)

1. The chemical formula for pentane is C_5H_{12} and the chemical formula for octane is C_8H_{18}. Sketch these two compounds and develop a pattern for the relationship between hydrogen and carbon that works for both compounds.

2. Show what happens when enough energy is supplied to start the combustion of hexane C_5H_{12}. Include an equation and a sketch in your answer.

Appendix C

(Return to Proposal)

References

Bernardelli, J. (2020, February 27). *10 common myths about climate change—And what science really says*. https://www.cbsnews.com/news/climate-change-myths-what-science-really-says/

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Earth Science Communications Team. (n.d.). *A gallon of gas = 20 pounds of CO2!* [Educational]. Https://Climatekids.Nasa.Gov/. Retrieved January 24, 2021, from https://climatekids.nasa.gov/review/carbon/gasoline.html

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Home Science Tools. (2010). *Molecular Model Sets*. https://www.youtube.com/watch?v=RncqUESIHqg

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