NGSS Unit: Energy Solutions

Lesson 1. When a candle burns, where does the wax go?

Phenomenon: Watch the candle disappear - time lapse video.

HS-PS1-2: *Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties*

HS-PS1-7: *Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction*

Candle Combustion lab

Construct and revise explanation

- Types of bonds in candle (Assume $C_{31}H_{64}$)
- Periodic table pattern of electronegativity rules bond type
- Outcome of reaction - review stoichiometry – balanced reaction – conservation of mass
- Calculate carbon dioxide emissions based on weight of candle before and after and use balanced chemical equation

How much CO2 is released when we burn one gallon of gasoline?

Use mathematical representation

Principle of conservation of mass – stoichiometry of combustion of fuel

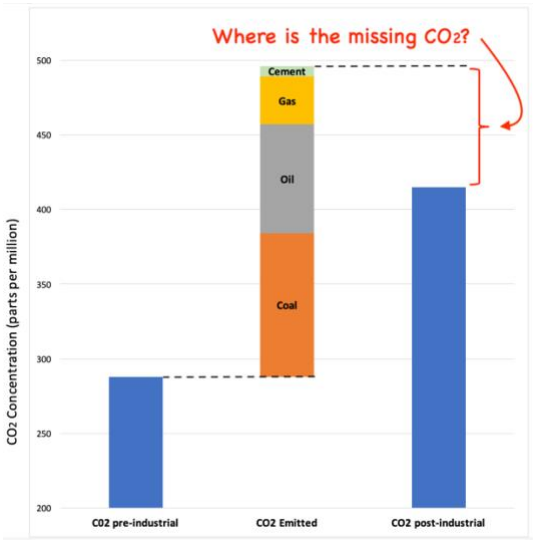
- Calculate molar mass, convert given mass to mole and atoms (Avogadro's number)
- Review stoichiometry – balanced reaction – conservation of mass
- Calculate carbon dioxide emissions for one gallon of gas
- Calculate how much oxygen needed and products formed – atoms, moles and mass

Extrapolate to global CO2 emissions and global warming.

- Graphs
- Greenhouse effect

Lesson 2. Where did the missing CO2 go?

Phenomenon: Since the industrial revolution, humans have emitted more CO2 than the increase measured in the atmosphere. See graph.



***HS-PS1-5**: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.*
***HS-PS1-6**: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium*

Water acidification Lab. Test with cold/hot water.

Effect of temperature and concentration on reaction rate.

- Kinetic energy variation with temperature → reaction rate impact
- Reaction rate change with concentration
- Outcome of reaction when changing a parameter

Change in conditions that would produce increased amounts of products at equilibrium.

- Introduce Le Chatelier principle – penny (or candy) equilibrium experiment
- Carbon dioxide dissolution in oceans
- Problem for coral and shelled creatures – calcium carbonate reacting with acid
  $CO_2 + H_2O <-> (H^+) + (HCO_3^-)$

Lesson 3. Design a way to generate electricity that doesn't pollute

Phenomenon: Scientists mimic parts of photosynthesis to get energy directly from the sun, instead of burning hydrocarbons to get it second hand.

HS-PS3-3**:** *Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy*

Learn about chemistry of solar cells

- What is a semi-conductor;
- Chemical reactions occurring in the solar panels;
- Photovoltaic (PV) compared to dye-sensitive solar cell (DSSC)

Design, build, and refine a device

LAB: Design Solar Cell

- Make a DSSC with different dyes (beet or cabbage…).

Lesson 4. How can we store intermittent renewable energy so we can use it where and when we need it?

Phenomenon: The amount of energy from the sun that strikes the Earth in one hour is more than the entire world consumes in a year.

***HS-ETS1-1**: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.*

Global Challenge - We want to use clean, renewable energy, but it is not always available in the places people need to use it and must be used as it is produced.

- Read journal articles. Constraints of renewables for marine/jet fuel; challenges for power grids using intermittent solar and wind.
- Write: Define problem, and criteria and constraints of a solution.

***HS-PS1-2 (Continued):** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties*

Do lab.

- LAB: Get the most "juice" out of your lemon/potato. Design the best battery to light up LED → array

Introduce the concept of batteries as a way to store and transport energy (include lithium and Hydrogen fuel cells).

- Learn about different types of energy – Solar PV
- Learn about batteries
    - Batteries store energy for use later with a simple chemical reaction.
    - Li-Ion batteries in solar panel - study chemistry – what happens to the ions. How do they get recharged?

***HS-ETS1-2**: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*

Break down different storage requirements for different energy needs (residential power vs. industrial power vs. cars vs. boats). Pick a single need and propose a battery or fuel cell storage solution.

***HS-ETS1-3**: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.*

Evaluate the solution they came up with by revising and adding to their original list of criteria and constraints.

Share out and refine based on feedback.