Conservation of Mass, Energy and Charge

Unit: Matter

MA Curriculum Frameworks (2016): HS-PS1-3, HS-PS2-8(MA)

Mastery Objective(s): (Students will be able to…)

- Explain conservation of mass, energy, and charge.
- Apply conservation of mass, energy, and charge to situations.

Success Criteria:

- Explanations account for mass, energy, and charge in a variety of changing situations.
- Students can set up and solve equations of the form *initial* + *change* = *final* in the context of problems involving conservation of mass, energy, and charge.

Tier 2 Vocabulary: conservation

Language Objectives:

- Explain what happens to mass, energy and charge in situations where these quantities are transferred from one object or system to another.

Notes:

<u>conservation law</u>: a statement that says that a quantity is the same before and after some change; a "before = after" statement.

<u>Conservation of Mass/Matter</u>: matter (mass) cannot be created or destroyed (except in a nuclear reaction), only changed in form. The *total* mass before any chemical or physical change equals the total mass after the change. Also the mass of *each element* (each kind of atom) before any chemical or physical change equals the mass of that same element afterwards.

<u>Conservation of Energy</u>: energy cannot be created or destroyed (except in nuclear reactions), only changed in form. The energy that was present before any change equals the energy that is present after the change.

<u>Conservation of Electrical Charge</u>: electrical charges cannot be created or destroyed, only transferred from one atom/molecule/etc. to another.

Use this space for summary and/or additional notes:

Sample problem:

Q: 12.5 g of sodium hydrogen carbonate is added to a beaker containing 100. g of dilute hydrochloric acid. The reaction produces carbon dioxide gas, sodium hydroxide, water, and sodium chloride, according to the following chemical equation:

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

If the contents of the beaker have a mass of 108.2 g after the reaction is complete, how much CO_2 gas escaped?

A: The total mass of the chemicals before the reaction must equal the total mass afterwards. The initial mass is 100 + 12.5 = 112.5 g. The mass afterwards must also be 112.5 g. If 108.2 g is still in the beaker, then the remaining mass, 112.5 − 108.2 = 4.3 g, must be the CO_2 that escaped.

Nuclear Reactions

In a nuclear reaction, mass can be converted to energy according to the formula:

$$E = mc^2$$

Where:

E = energy m = mass c = the speed of light

Note that the speed of light is a very large number: $3.00\times10^{8}\,\frac{\text{m}}{\text{s}}$. Therefore, c^2 is even larger: $9.00\times10^{16}\,\frac{\text{m}^2}{\text{s}^2}$. This means that a very small amount of mass creates an extremely large amount of energy. This is where the energy in a nuclear explosion comes from—mass that was turned into energy.

This law is called the law of Conservation of Mass and Energy. This law (and its equation, $E = mc^2$) describes the only we know of that mass can be destroyed, and the only way we know of that energy can be created.

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Homework Problems

1. Suppose your breakfast contained 500 Calories of energy. Suppose you missed your bus (or your ride) and you had to walk 2 miles to school, which burned 200 Calories. How many Calories of energy from your breakfast are left for you to get through your morning classes?

   Answer: 300 Calories

2. In your car's gas tank, the following chemical reaction occurs:

   $$C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$$

   The gasoline (C_8H_{18}) in a typical car's fuel tank weighs about 80 pounds. Burning that much gas uses about 300 pounds of oxygen from the Earth's atmosphere, and it produces 120 pounds of H_2O. How many pounds of CO_2 did that tank of gas produce?

   Answer: 260 lbs.

3. A nuclear reactor converts 4×10^{-9} kg of uranium to energy. How much energy is produced?

   Answer: 3.6×10^{8} J or 360 MJ

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