

High School Physical Science: Nuclear Waste Disposal Dilemma

Standard

PS4. Obtain, evaluate, and communicate information to explain the changes in nuclear structure as a result of fission, fusion and radioactive decay.

4a. Develop a model that illustrates how the nucleus changes as a result of fission and fusion.

4b. Use mathematics and computational thinking to explain the process of half-life as it relates to radioactive decay. (Clarification statement: Limited to calculations that include whole half-lives.)

4c. Construct arguments based on evidence about the applications, benefits, and problems of nuclear energy as an alternative energy source.

Background

Here is good background info for teachers on how radioactive decay is a random process that can be predicted in a way that is closely aligned to the actual decay sequence. <https://www.youtube.com/watch?v=HRwey6cwGHo>

Teaching Tips

Preparation Students will need internet connected devices for the simulation and research.

Directions for this lesson are written for teachers. Provide students with the Investigation Lab Report from appendix.

Phenomenon: Present phenomenon in lesson without explanation before or after students view it.

What Do you Notice? Engage students in writing an explanation (or labeled drawing) that tells what, why, how.

What Do you Wonder? Engage students in asking their own questions, which will form the basis for their research.

Student Research After each student writes a question, consider placing each question on a sticky note, grouping them in categories, and allowing students to learn more in small groups according to their interests. A curated collection of articles is provided for use in small groups, using the Jigsaw protocol. <https://www.jigsaw.org/>

Teacher-Directed Activity Discuss this article with the whole class: How Stuff Works: How Nuclear Power Works <https://science.howstuffworks.com/nuclear-power.htm> Clear up a common misconception about nuclear power: that it generates electricity in a novel way. In fact, energy given off by enriched uranium (U-238) simply heats water into steam. Then the steam is used to turn a turbine that generates electricity, just as with coal, wind, or hydropower. However, since no fossil fuels are burned to create the steam, generation of nuclear power does not emit greenhouse gases that contribute to climate change (although the mining and transportation of U-235 may use fossil fuels).

Zero Heroes Lesson Activity Engage students in the nuclear power generation simulation and in calculating the half-life of spent U-238 nuclear fuel rods. Students will make and defend a claim about nuclear waste disposal.

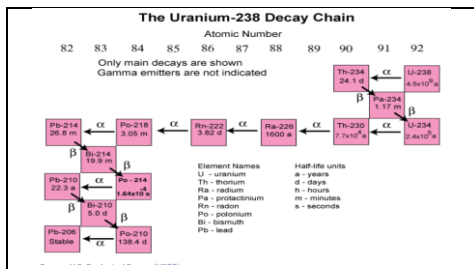
Revised Explanation Allow students to revise their initial explanations of the phenomenon, reflecting what they have learned. Provide these prompts for students to write a C-E-R (Claim – Evidence – Reasoning) argument:

- Claim: State your claim regarding whether the merits of nuclear power outweigh nuclear waste disposal issues.
- Evidence: Provide evidence *including data regarding the half-life of nuclear waste* to identify related issues.
- Reasoning: Use the law of conservation of matter as the reasoning that connects the data to the claim. This scientific principle says that matter is neither created nor destroyed, but can change forms. As uranium throws off alpha, beta and gamma rays in the process of decaying from one element to another, the U238 decay chain progresses toward stable lead over a period of time revealed by the half-life.
- Revised Claim: If the evidence does not support the original claim, revise the claim. Identify major benefits and risks presented by nuclear power and draw a conclusion about the relative merits of this power source.



Physical Science - Investigation: Nuclear Waste Disposal

The Phenomenon



Engage students in writing about what they noticed when observing the phenomenon. This will serve as their tentative, initial explanation. At the end of the lesson, allow students to revise and refine their explanations to reflect new information and understanding. Explanations may take the form of labeled drawings. Make an initial claim about whether nuclear waste disposal issues outweigh the value of nuclear energy.

Phenomenon image: <https://www.epa.gov/radiation/radioactive-decay>

What do you Wonder? (student questions)

Engage students in asking their questions about the phenomenon. The questions will form the basis for student research.

Curated Articles for [Research Jigsaw](http://www.jigsaw.org/) www.jigsaw.org/

- Nuclear Waste Transportation Issues
www.ucsusa.org/resources/safer-storage-nuclear-waste or www.epa.gov/radtown/transportation-radioactive-material
- EIA: Nuclear Power and the Environment
<https://www.eia.gov/energyexplained/nuclear/nuclear-power-and-the-environment.php>
- CK12 Nuclear Waste Disposal
<https://app.kiddom.co/search/content/6795/nuclear-waste-disposal?q=HS-PS1-8>
- CalAcademy- Nuclear Energy: What's Your Reaction
<https://www.calacademy.org/educators/lesson-plans/nuclear-energy-whats-your-reaction>
- Radioactive Waste Facts for Kids
https://kids.kiddle.co/Radioactive_waste
- How Stuff Works: Nuclear Waste Disposal
<https://science.howstuffworks.com/environmental/green-science/reducing-solid-waste.htm>
- Lumen Nuclear Chemistry for Non-Majors: Half-Life – We're Putting it Where?
<https://courses.lumenlearning.com/cheminter/chapter/half-life/>
- Rethinking Nuclear Energy <https://youtu.be/poPLSgbSO6k>
- Curious Kids - Why Does the World Store Nuclear Waste Instead of Shooting It Into the Sun? <https://theconversation.com/curious-kids-why-does-the-world-store-nuclear-waste-and-not-just-shoot-it-into-the-sun-or-deep-space-108675>

Investigation – Nuclear Power Generation and the Half Life of U238 Waste

- Manage a nuclear plant with this simulation:
- Idaho Public Television- Nuclear Power Plant Simulator Game <http://www.nuclearpowersimulator.com/#Start>
- Calculate the Half-Life of Spent Nuclear Rods <https://sciencing.com/calculate-half-life-equations-8519366.html>

Revised or Refined Explanation

Make a **claim** about whether nuclear waste disposal issues present risks that are significant enough to outweigh the benefits of nuclear power, using the law of conservation of mass as the scientific principle that provides the **reasoning** that connects the **evidence** (data on the U238 decay chain and the half-life of spent fuel rods) to the **claim**.

Suggested Format: My claim was that nuclear power is _____ relative to the risks presented by nuclear waste disposal issues. When U238 nuclear fuel rods are spent, they change in this way: _____, as evidenced by this data: _____. Because we know that matter is neither created nor destroyed but can change forms (law of conservation of matter) we can conclude that the data means this about the disposal of nuclear waste: _____. This (supports / does not support) my original claim. Other factors that should be considered include: _____. Knowing what I know now, I (would / would not) change my claim because _____.

