Modeling Fission and Fusion

Companion Lesson to X-STEM All Access Episode "We're All Nuclear"

Grade/ Grade Band: High School	**Topic:** Chemistry

Brief Lesson Description: Students develop and compare models of fission and fusion decay using balloons.

Performance Expectation(s):

HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and energy released during the processes of fission, fusion, and radioactive decay. (Clarification Statement: Emphasis is on simple qualitative models such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.) (Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.)

Specific Learning Outcomes:

Students will know and be able to:
-Explain how nuclear processes impact their daily lives.
-Develop a model for nuclear fission and nuclear fusion.
-Describe key characteristics of nuclear fission and nuclear fusion.
-Explain how the model can be improved based on evidence from multimedia.

Narrative / Background Information

Prior Student Knowledge:

Students should have a basic understanding of the following concepts:
-The atomic structure of an atom including protons, neutrons, and electrons.
-Radiation is a form of energy.
-The law of conservation of energy and the law of conservation of mass are followed in nuclear processes.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Developing and Using Models **Modeling in 9-12 builds on K-8 and progresses to using, synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.** ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	PS1.C: Nuclear Processes ● Nuclear processes including fusion, fission and radioactive delays of unstable nuclei, involve the release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Energy and Matter** ● In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Possible Preconceptions/Misconceptions:

1. **Confusing fission with fusion and vice versa:** Students might not understand the distinction between fission and fusion. They may mistakenly believe that fission involves the merging of atomic nuclei (fusion) or that fusion involves the splitting of atomic nuclei (fission).
2. **Believing that fission and fusion always result in explosions:** Students might associate fission and fusion exclusively with explosive energy releases, similar to nuclear bombs. While these processes can indeed release large amounts of energy, they occur under controlled conditions in nuclear reactors and the sun, respectively, where the energy release is harnessed for various purposes.
3. **Thinking that fusion is a more efficient energy source than fission:** Some students may assume that fusion is inherently superior to fission as an energy source due to its association with stars like the sun. While fusion has the potential to produce vast amounts of energy and generates less radioactive waste than fission, it currently faces significant technological challenges, such as achieving and sustaining the high temperatures and pressures required to initiate and maintain fusion reactions.
4.

LESSON PLAN – 5-E Model

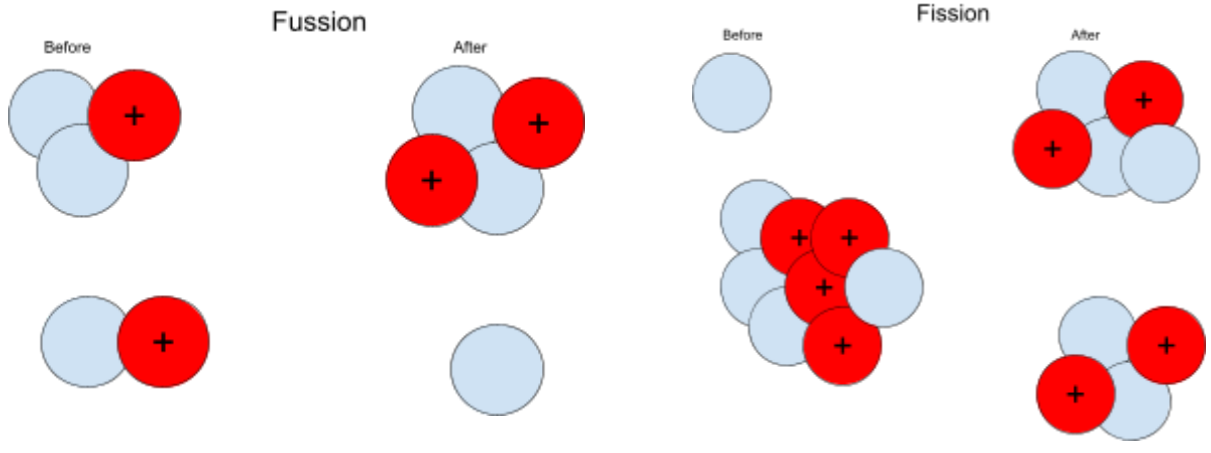
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

1. Begin the lesson by having students discuss the following prompt: ***"What does the word nuclear mean to you? How does this term impact your daily life?"*** Have students share as a class and create a list of possible ideas.
2. Show the X-STEM All Access Episode "We're All Nuclear" featuring nuclear engineer Dr. Ciara Sivels.
3. After the video, ask students to ***add to their list from the beginning of class based on what they learned during the episode.***
4. Explain to students that in this lesson, they are going to look at three of the processes that are core to Nuclear Engineering: Fission, Fusion, and Radioactive Decay.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

1. Show the Video "The Differences Between Nuclear Fission and Fusion" to introduce the concepts of nuclear reactions.
2. After the video, have students work in small groups to create a short synthesis of how each process works.
3. Next, have students work in small groups to brainstorm how they might represent these processes using balloons.
4. Provide each group with balloons of different colors. (5 balloons of 4 different colors)
5. Instruct them to use the balloons to create models illustrating fission, fusion, and radioactive decay. They can use markers to label the balloons and scissors to cut them as needed.

Examples of possible models:



6. Encourage creativity and teamwork.
7. Provide students 15 minutes to complete their model and be prepared to share with their classmates.

*Note: If you have a student with a latex allergy, other alternative materials can be used such as M&Ms, Skittles, Playdough or Modeling clay that come in multiple colors.

EXPLAIN:

1. Have each group present their model to the class.
2. Facilitate a discussion ***about the characteristics of each model and how they represent nuclear reactions.***
3. Guide students to identify the key components involved in each process such as the splitting of nuclei in fission or the merging of nuclei in fusion.

ELABORATE: Applications and Extensions:

1. Have students watch "Crash Course Chemistry #38: Nuclear Chemistry." As they watch the video, ask students to consider changes that should be made to their models.
2. After watching the video, have students work in their small groups to suggest 3 or more possible improvements to their models. For each improvement, the group should explain how the improvement would make their model more accurate and support this with information from the video.
3. Have each group present their model to the class.
4. Facilitate a discussion about ***how the improvements changed their understanding of these processes.***

EVALUATE:
Formative Monitoring (Questioning / Discussion):
Questions throughout the lesson in ***bold and italics*** can be used to check students' understanding throughout the lesson. You can also assess student understanding during their presentations to the class on the Explore and/or Elaborate sections of the lesson.

Summative Assessment (Quiz / Project / Report):
Option 1:
Have students take a short quiz on the process of fission and fusion. One possible option is this Quiziz.

Elaborate Further / Reflect: Enrichment
Have students repeat the lesson process of making a model and suggesting improvements using Radioactive decay. The video "Radioactivity: Expect the Unexpected" as the basis of the second model.

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency Addressed: Self Awareness, Responsible Decision Making, Social Awareness

Dr. Sivels gave advice that taking risks is important. However, oftentimes students come with the misconception that all risk is negative. This lesson will have students explore positive and negative risks and how to differentiate between them.

1. Start the lesson by having students define the word risk and give examples of risks they face in their daily lives.
2. Discuss the concept of risk-taking behaviors, emphasizing that not all risks are negative and that taking calculated risks can lead to growth and success.
3. Divide students into small groups.
4. Provide each group with index cards and markers.
5. Instruct students to brainstorm various scenarios where they might encounter risks, both positive and negative (e.g., trying out for a sports team, experimenting with drugs).
6. Have each group write down their scenarios on the index cards.
7. Gather all the index cards and place them face down in the center of the room.
8. Students take turns rolling the dice and drawing a card corresponding to the number rolled.
9. For each scenario drawn, students discuss as a group whether it represents positive or negative risk-taking behavior and why.
10. Encourage students to share their thoughts and perspectives while respecting each other's opinions.
11. Facilitate a whole-class discussion based on the game, focusing on the following questions:
    a. What are some factors that influence our willingness to take risks?
    b. How can we differentiate between positive and negative risk-taking behaviors?
    c. What are the potential consequences of taking risks, both positive and negative?
    d. How can we make informed decisions when faced with risks?
12. Encourage students to reflect on their own experiences and share strategies they use to manage risks effectively.

INTERDISCIPLINARY CONNECTIONS/IDEAS

Mathematics: Use the Radioactive Decay Model from Exploratorium to collect data and propose a mathematical relationship for a nuclear process.

English Language Arts: Students can write an argumentative essay or persuasive speech on the benefits/consequences of nuclear power as a solution to climate change.

American History: Use one of the many lessons from the Harry S Truman library to understand the impact of the atomic bomb and ending World War Two.

Materials Required for This Lesson/Activity	
Quantity	**Description**
5 E Lesson Plan	
20 Balloons per group	Each group will need 5 balloons of 4 different colors*
1 Per Group	Permanent Marker
1 per group	Roll of Tape

SEL Lesson Plan	
1 Pack	Index Cars
1 Per Group	Permanent Marker
1 Per Group	Dice

*Note: If you have a student with a latex allergy, other alternative materials can be used such as M&Ms, Skittles, Play Doh or Modeling clay that come in multiple colors.

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