Nuclear Chemistry- Particle Decay

(7-8 Days)

Authors

Nancy Miller

Stephanie Gonzales

SUBJECT/GRADE LEVEL

Subject Area: Science (Chemistry)

Grade Level: High School (9-12)

Materials/Hyperlinks

- Computer
- Lab Notebook
- Pen/Pencil
- Alpha decay simulation model
- Teacher resources for exploration
- PhET Student Worksheet (A)
- PhET Student Worksheet (B)
- Canva Presentation
- Audience Response Sheet
- Presentation Tips
- ChemMatters
- Research Project Rubric

STANDARDS

Next Generation Science Standards

- HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
- HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Mathematics Standards | Common Core State Standards

- MP.2: Reason abstractly and quantitatively
- MP.4: Model with mathematics
- HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.SL.11-12.1.A-D: Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
- RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.11-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

LESSON OBJECTIVE(S)

Students will be able to:

- Describe and differentiate characteristics of Alpha Particles, Beta Particles, and Gamma Rays to explain how each decay
- Conduct literature research review for the different types of nuclear and radioactive applications

CAREER CONNECTION(S)

Mentor Background: Dr. James Carroll (Physicist & Team Leader)

Dr. James (Jeff) Carroll has more than 35 years experience in experimental nuclear physics, has published over 140 peer-reviewed journal articles on discoveries in physics, including two papers in Nature, and given over a hundred presentations around the world. Before joining ARL in 2010, he had been a Professor of Physics for 15 years and maintains a strong interest in outreach to educators and to the next generation of scientists and engineers. He has served numerous times as a Judge for the tri-service National Junior Science and Humanities Symposium and mentored numerous undergraduate and graduate students, and RESET educators in 2022 and 2023, during both shorter-term and long-term research experiences. Interacting with motivated and interested young scientists is truly one of the joys of his work.

STEM Careers: Physicist, Nuclear Physicist, Nuclear Chemist, Radiologist, Nuclear Engineer, Medical Physicist, Environmental Chemistry, Research Scientist, Nuclear Technician, Positron Emission Tomography Technologist, Nuclear Medical Technologist, Radiation Therapist, Nanotechnology Scientist

ENGAGEMENT

Brief Description: Create an open dialogue with students to generate prior knowledge and help with

scaffolding. This is accomplished using each component separately and then opening the classroom to discussion. Anchor charts, shoulder partner, and gallery sticky notes could be used with any of the components. If the norm in the classroom let students conduct self regulated discourse, redirect where needed.

Procedures:
The lesson will begin with the following driving question: "What comes to mind when you hear the word radiation?" Allow students 1-2 minutes for a shoulder partner turn and talk. The teacher should conduct aggressive laps/aggressive monitoring listening for key vocabulary usage and common themes among students. The total time for sharing as a class is 2-3 minutes.

Continue the lesson introduction by showing the following video covering alpha, beta, and gamma radiation. **Start the video at 54 seconds!** Use the engagement strategy that works best for your class setting after watching.

The article from ChemMatters can be assigned as individual reading or as a class. Have students annotate the passage making sure to identify new words and their thoughts. This is supposed to be used as an idea catcher and not as a heavily graded assignment.

All of these are engaging discussions to help generate interest in the nuclear topic.

EXPLORATION

Brief Description: Students will carry out an activity that allows them to learn about the forces that keep a nucleus stable and the reasons that size of the nucleus helps to explain why Alpha decay occurs.

Procedures:
This introductory activity is designed to take 1 class period for the data collection and additional time to complete part 3, Analysis. In part 1 students will create nuclei for elements with low atomic mass. These models will connect the models to the periodic table but will only represent the Strong Nuclear forces. In part 2, as the nuclei become larger, they will begin to investigate the impact of the electrical forces (+/+ proton repulsion). As they attempt to make their nuclei larger, they will see the nuclei becoming less stable and the protons and neutrons will leave the nuclei, simulating Alpha Decay. This makes the nuclei smaller and thus reduces the impact of the +/+ proton repulsion. Finally, Part 3 provides an opportunity for the students within the groups to analyze the events and make connections to the behaviors of elements on the periodic table. Alpha decay simulation model

EXPLANATION

Brief Description: The Canva presentation will reinforce nuclear concepts and give the class a chance to review. The research project at the end of the slides is used during the elaboration portion of the 5E lesson plan. After the slideshow students will use PhET simulations to generate cohesive predictions and explanations about particle decay. PhET worksheets are available from the University of Colorado Boulder Interactive Simulations under activities.

Procedures:
Teachers should view the Canva presentation before reviewing with the class. The slides should take 15-20 minutes. Projecting the slides and allowing students to write in their ideas on the "Brain Dump" slide creates the opportunity for "student centered" activities. The handout for the elaborate activity should be distributed at the end of the slides. Walk students through the rubric and clarify any questions they may have. There is a rubric to help students navigate the research project at the end of the slides. The due date of the project should be unique to each classroom.

For the second portion of the lesson, allow students to interact with both simulations for a few minutes. (Alpha Decay, Beta Decay) This will allow them to become familiar with the different settings available to them. Using the worksheets for each alpha and beta decay the students will explain the different types of decay and their properties. It is important to monitor that the students are trying to predict the model even if it does not match the outcome.

ELABORATE

Brief Description: The AACT simulation reviews radioactive decay by basics, decay type, and shielding. Based on the research project from the Canva presentation students should have their research ready to present. The bulk of this activity should be the presentations and response forms.

Procedures:
Use the AACT simulation to allow students to refresh their knowledge before taking the quiz. This is a good indicator on how prepared they are for the assessment at the end of the unit. This can be assigned at the beginning of class and as out of class review.

Before beginning presentations, have the students go over etiquette for both the presenter and the audience. Setting classroom norms creates easy transitions for these activities.

Reviewing presentation tips beforehand can help relieve stress and drive engagement opportunities. Students who are the "Audience" can fill out this form to keep track of their listening skills.

EVALUATION

Brief Description: Assessments can be used based on course needs. The Quizizz and the Research Project can be used as either summative or formative assessments.
If students do not master the content, use the reteach/tutorial resources to reinforce the concepts. These tools can be assigned as needed for student study as well.

Procedures: If an informal setting is being used the following link for the assessment is best to create a relaxed environment. Quizizz The button to the right will allow you to set it up as a quiz game.
For a more formal setting the PDF & GoogleDoc are available. Change the formatting on the time as needed, you know your students best!

Reteach/Tutorial Resources:

- cK-12 Flex Book

- Alpha Decay
- Beta Decay
- Beta Decay
- Study Guide
- Khan Academy

REFERENCES

- Provide links to resources that you used in the creation of this unit.
- Glossary
- NGSS Standards
- English Common Core
- Mathematics Common Core
- cK-12
- Khan Academy
- PhET Simulations
- AACT
- Canva