|  |  |
| --- | --- |
| **TEAM Lesson Plan Template** | |
| Teacher: Holland Brewer | |
| Subject/Grade: High School Chemistry 1 | |
| Lesson Title: Alpha, Beta, and Gamma Rays | |
| **STANDARDS** | **Identify what you intend to teach.** State, Common Core, ACT College Readiness Standards and/or State Competencies; Enduring Understandings and Essential Questions. |
| CHEM1.PS1 10) Compare alpha, beta, and gamma radiation in terms of mass, charge, and penetrating power. Identify examples of application of different radiation types in everyday life (such as its application in cancer treatment).  This lesson emphasizes:  Science and Engineering Practice: Obtain, evaluate, and communicate information; Develop and use models  CCC: Energy and matter  Learning performance: Student will obtain, evaluate, and communicate information in order to show the difference in alpha, beta, and gamma rays highlighting the exchange of energy and matter. | |
| **OBJECTIVE(s)/Sub-Objectives** | **Connect prior learning to new learning.** Clear, Specific, Observable, Demanding, High Quality, Measurable, Aligned to Standard(s), and Integrated with other subjects, build on prior student knowledge  Student-Friendly (I Can Statement) |
| I can read and understand a science article.  I can distinguish between radiation and radioactivity.  I can write an alpha decay equation or beta decay equation.  I can construct models to visualize alpha particles, beta particles, and gamma radiation and describe the relationships among them. | |
| **MATERIALS AND RESOURCES** | **Content-related:** Clearly supports lesson objective(s); rigorous & relevant; Incorporates multimedia & resources beyond the textbook. |
| **Activities & Materials**  **Per student**: Anticipation guide, Activity Guide, Radioactivity-Radiation reading  ( <https://newsela.com/read/lib-convo-radiation-and-radioactivity/id/28307/> ) Alternate source:  (<http://theconversation.com/explainer-the-difference-between-radiation-and-radioactivity-20014> )  **Per group/pair**: Pink and yellow food coloring, toothpicks, One 2.5-gallon Ziploc plastic bag, One quart Ziploc bag, 40 Large marshmallows, 20 Mini marshmallows, Fuzzy sticks, White board and markers[[1]](#endnote-1). Optional: Projector/computer/screen/internet access.  This lesson is inspired by a lesson featured on the American Nuclear Society’s “In The Classroom” website. It may be helpful to look at their materials.  <http://nuclearconnect.org/in-the-classroom/for-teachers/modeling-radioactive-stable-atoms>  <http://nuclearconnect.org/wp-content/uploads/2013/04/Radiation_Types_Modeling_Radioactive_Atoms.pdf>  This activity will require some work by the teacher before the demonstration: large marshmallows must be dyed pink and yellow. Pink marshmallows will simulate protons, and yellow marshmallows will simulate neutrons. Each group should have a minimum of 20 neutrons, 20 protons, and 20 electrons.  Allow marshmallows to dry for at least a day. Stick a toothpick in each large marshmallow. Prepare a cup of pink water and a cup of yellow water with food coloring. Dunk each marshmallow into the colored water for 2 to 3 seconds and then stick the free end of the toothpick into a foam tray to let the marshmallow air dry. Make half the large marshmallows pink and the other half yellow. Let these dry for several days. Use a fine or medium tipped marker to put a “+” (plus sign) on each of the pink marshmallows. Notice that we have pink protons, yellow neutrons, and small white electrons.  For each group of students, create the following particles:  Twenty of each of the protons, neutrons and electrons described above.  Alpha particle: select two protons and two neutrons. Use toothpicks and glue join these, forming an alpha particle.  Pink neutron: put a “-“ (minus sign) on one of the mini marshmallows. Stick a toothpick into the minus sign. Glue the other end of the toothpick into a pink marshmallow, hiding its “+.” This particle represents a neutron (the plus and minus signs are hidden). Later, the electron will fly off, leaving a proton to represent beta (-) decay.  **What if the technology is not working?** The technology here is a zipper on a Ziploc bag. Just hold the bag closed. For a minute.  **Routine for distributing materials:** Class will begin with a brief whole-group discussion and individual work. Place marshmallows in a bag for each group in a central location. When students transition to group work, one member of Students will come pick up a bag and activity guide. | |
| **ACCOMMODATIONS/ADAPTATIONS** | **Learning styles and interests.** Anticipate learning difficulties, regularly incorporate student interests & cultural heritage; differentiate instructional methods. |
| **Modifications/Plans for Diverse Learners *(NOTE: Clearly identify where you will use each of these in your lesson; do not just check the box!)***  **Differentiation**  **\_\_x\_\_ Content** Assignment of lighter elements to some groups and heavier elements to other groups modifies the difficulty of the activity slightly.  **\_\_x\_\_ Process** It may be appropriate to tell some groups how many marshmallows to put in their nucleus bag. Other groups may be told to determine the number of marshmallows from a periodic table.  **\_\_x\_\_ Product** Most groups will complete a written activity guide. For other students it may be appropriate to observe them using the model and allow them to verbally describe the decay products as alpha or beta particles.  **Accommodations**  **\_\_\_ Preferential Seating \_\_\_ Extended Time \_\_\_ Small Group \_\_\_ Peer Tutoring**  **\_\_\_ Modified Assignments \_\_\_ Other**  **Early Finishers:** Use marshmallows to represent a different isotope of the group’s chosen element; Look up a decay process for that isotope (e.g. Wikipedia “isotopes of *element*” <https://en.wikipedia.org/wiki/Isotopes_of_fluorine>. ) Model this decay. | |

|  |  |
| --- | --- |
| **MOTIVATING STUDENTS/ANTICIPATORY SET** | **“Hook”: Engage students’ attention and focus on learning.** Personally meaningful and relevant. |
| **Do not eat the marshmallows. Do not throw the marshmallows (except a gentle throw of a mini marshmallow during beta decay, and even then not at anyone).**  After a brief whole-group discussion about “What is radiation?” have students complete the anticipation guide.  After students have individually completed the anticipation guide, distribute the reading passage on the difference between radiation and radioactivity. Follow the steps in “Instructional procedures” below.  Write on a board or project: Pink protons, Yellow Neutrons, Mini electrons | |
| **INSTRUCTIONAL PROCEDURES** | **Step-by-Step Procedures-Lesson Sequence: Basic to Complex.** Lesson includes visuals, modeling, logical sequencing and segmenting (beginning, middle, ending); essential information; concise communication; grouping strategies; differentiated instructional strategies to provide intervention & extension; seamless routines; varied instructional strategies; key concepts & ideas highlighted regularly. |
| The model in this activity ignores significant details of nuclear decay processes. There is no mention of neutrinos, electron capture or beta+ decay. Also, it is possible for students to model a decay process that does not actually occur (elements from boron to antimony do not undergo alpha decay). The “pink neutron” looks special in the model, but any neutron can undergo beta- decay. A neutron does not have to be special for this to happen. The point is for students to visualize the relative size of the various decay products to help students understand the corresponding shielding requirements.  **Beginning:**  In a whole-group lecture setting, the teacher will begin by asking students to explain what radiation is. Most students will know that it is used to treat cancer but will not have a thorough understanding of exactly how it is used. This activity will help to further understanding of alpha, beta, and gamma rays; additional explanation will be needed for students to take this information and understand how it is used to treat cancer. The teacher will have students complete an anticipation guide. The anticipation guide is a series of true and false statements that students will use their previous knowledge to answer; of course, the anticipation guide incorporates information over radiation that students may not yet know. The teacher will have students complete this before introducing a reading passage over the difference between radiation and radioactivity. Students will revisit the anticipation guide after reading and discussing the passage. The passage will be chunked into parts and paired with literacy-enhancing strategies to encourage thorough student understanding.  -Students read the first section up to but not including “What is Radioactivity?” Students will then complete a two-column chart/graphic organizer supplying main ideas with coordinating details from the passage.  -Teacher will stop and review with students.  -Students will read section two then and complete a three-column chart/graphic organizer explaining the three types of radiation, what happens with each type, and the results caused be each of the types.  -At this point, teacher will step away from passage to lecture/provide instruction over results of alpha, beta, and gamma rays to assist students with completing the results portion of the graphic organizer.  -Students will read section three of the passage, and teacher will stop and have students summarize concepts presented in that section in their own words.  -Students will read sections four, five, and six of the passage to complete another three-column chart/graphic organizer explaining the three types, what happens, and results of radiation.  -Teacher will revisit anticipation guide at this time and discuss possible response changes from **before** reading and instruction to **after** reading and instruction.  **Middle:**  Arrange students in groups with the Ziploc bags and marshmallows. Remove the marshmallows from the bag. The teacher will conduct a demonstration of the activity. Each bag represents a nucleus.  To model alpha decay for Flourine-18  Start with an empty bag. Place an alpha particle in the bag. Place 7 yellow and 7 pink marshmallows in the bag. Observe that there are 9 protons in this nucleus, so the element represented is Fluorine. Take the alpha particle out of the bag. Note that it looks like a Helium nucleus. Place the alpha particle in a separate small Ziploc bag. Counting the remaining pink protons, notice that now we have Nitrogen-14.”  This shows alpha decay.  To model beta (-) decay for Flourine-18  Start with an empty bag. Place the special “pink neutron” in the bag. Place 8 yellow and 9 pink marshmallows in the bag. Observe that there are 9 protons in this nucleus, so the element represented is Fluorine. Remove the mini marshmallow from the pink neutron, remove it from the bag, and gently throw the mini marshmallow away from the bag. Note that there are now 10 pink marshmallows. Notice that now we have Neon-18.  This shows beta decay.  To model gamma decay for Flourine-18  Start with an empty bag. Place 9 yellow and 9 pink marshmallows in the bag. Observe that there are 9 protons in this nucleus, so the element represented is Fluorine. Shine a light through the bag and observe the light leaving the nucleus. This shows gamma decay.  Students will then work with their groups to complete the activity. They will record their work on the activity guide. Students will select three elements from the elements carbon through calcium. Students will create the nucleus of the element they have chosen with the correct number of protons and neutrons (representing some of these with the alpha particle or pink neutron as appropriate). With their first element, students will represent alpha decay as in the teacher’s demonstration. With their second element, students will represent beta decay as in the teacher’s demonstration. With their third element, students will represent gamma decay as in the teacher’s demonstration. This will be repeated with a new element chosen by student and with gamma and beta rays. In each case, students will record information from the model on the graphic organizer in the activity guide.  **End/Closure:**  Students will come back together as a whole group after the activity to discuss the differences between a stable atom and a radioactive atom. Students can use desk partners or activity groups for these discussions. Teacher should be moving around the classroom listening to student discussions. The teacher will also revisit concepts presented in the original article to highlight key differences between radiation and radioactive decay. Emphasize: Which one is big? Which one is smaller? Which one just looks like light coming out of the nucleus?  **Motivating Students**  \_x\_ Relate to Real World Nuclear isotopes in radioactive waste from power plants are dangerous. On the other hand, nuclear isotopes used in medicine can be lifesaving.  \_x\_ Game. Everyone loves marshmallows. This model makes a game out of radioactive decay.  **Presenting Instructional Content**  \_x\_ Discussion The lesson begins with a discussion of what “radioactivity” and “radiation” mean.  \_x\_ Reading Students are asked to read scientific text to understand what “radioactivity” and “radiation” mean.  \_x\_ Graphic organizer: Students use graphic organizers to keep track of ideas as they read, and they record their actions from the hands-on activity on another graphic organizer.  \_x\_ Hands on: Students simulate moving protons, neutrons, and electrons into and out of the nucleus.  \_x\_ Modeling: The teacher will model (pedagogical verb) how to use the model (science noun) for each type of decay.  ***Instructional strategies:***  **Modeling and Guided Practice *–*** Model each type of decay with one element. Observe students as they model each type of decay for their particular elements.  **Check for Understanding (CFU) –**  ***What am I doing for students that progress at different rates?***  Encourage students to help each other within their groups. If one group is significantly ahead of another, ask one group to help the other. If necessary, assign a group an element with lower atomic number to speed things up. Assign a higher atomic number or ask students to model orbital electrons with mini marshmallows and fuzzy sticks to slow things down.  ***What do I do if they get it?***  If they get it, press them to classify each of alpha, beta, and gamma radiation as ionizing or non-ionizing. Close the lesson with a discussion of relative sizes and shielding requirement for each type of radiation.  ***What do I do if they don’t get it?***  If a student does not get it, have the student hold the alpha particle in one hand and an electron in the other hand. After getting the names straight, ask which one is harder to stop. Ask the student to think in terms of throwing the particles through a chain link fence. Which one is more likely to get through? | |
| **QUESTIONING/THINKING/PROBLEM SOLVING (embedded throughout)** | **Balanced mix of question types.** Utilizes Blooms Taxonomy/Webb’s Depth of Knowledge; high frequency; purposeful & coherent; require active responses; balance based on volunteers/non-volunteers, ability, & gender; lead to further inquiry & self-directed learning.  **Implement four types of thinking (Analytical, Practical, Creative, & Research-based) & Teach/Reinforce problem-solving types**. Provide opportunities for students to generate ideas & alternatives; analyze, evaluate & explain information from multiple perspectives& viewpoints. |
| **Questioning** These questions will occur throughout the activity as prompts based on groups’ or individual students’ progress.  **Knowledge:**  Which color represents a proton?  What is the charge of a proton?  Which is bigger, an alpha particle or a beta particle?  **Comprehension:**  Why do we use large marshmallows to represent protons and mini marshmallows to represent electrons?  Why don’t we put mini-marshmallows in the bag (except for the one on pink neutron)? [ *radioactive decay is a nuclear process. The orbital electrons are irrelevant for radioactive decay. Also, the electrons are a long way from the nucleus. At this marshmallow scale, the electrons would extend out to about 4 miles away*. ]  **Application:**  What shielding would you recommend to protect against alpha radiation? [*a piece of paper or anything thicker* ]  What shielding would you recommend to protect against beta radiation? [ *a quarter inch of plexiglass* ]  What shielding would you recommend to protect against gamma radiation? [ *thick lead* ]    Why do we care about radiation? *[ production of nuclear energy; protection from waste from nuclear energy; medical imaging; cancer treatment . . .* ]  **Analysis:**  In beta decay, a neutron releases an electron and becomes a proton. Does the charge remain balanced?  **Synthesis:**  In beta decay, a neutron releases an electron and becomes a proton. Imagine if this process reversed. Write a nuclear equation to describe what happens if a nucleus of Gallium-67 undergoes this process called electron capture. [ We get Zinc-67 ]  **Evaluation:**  **Thinking**    \_x\_ **Practical** –Students read about and discuss the practical aspects of understanding radioactivity such as the need for shielding and using radioactive isotopes in medicine.  \_x\_ **Creative**– Students get to choose their own elements (within the approved range) with which to model radioactive decay.  \_x\_ **Analytical** – Students **compare** the sizes of the different decay particles. Students **evaluate** the need for shielding and **explain** shielding needs in terms of the size of the particles.  \_x\_ **Research-based** – Students use a periodic table to determine the number of marshmallows to use in their model. If students finish early, they are invited to use the internet to research decay processes for particular isotopes and model these.  **\*What am I going to do to give Students an opportunity to?**  **1. Generate variety of ideas:**  Students begin the activity thinking about their own knowledge of radioactivity with the anticipation guide.  **2. Analyze problems from multiple viewpoints:**  Is radiation good? (Yes; we use it to generate power and treat cancer). Is radiation bad? (Yes; UV rays cause sunburn which can lead to cancer and ionizing radiation damages cells in our bodies and can kill us.)  **Problem Solving *Note: Teach 2 or more types of problem solving (NOTE: Clearly identify where you will use each of these in your lesson; do not just check the box!)***  \_x\_\_ **Abstraction** The alpha and beta decay equations are abstractions of actual processes  **\_x\_\_ Categorization** Students have to classify radiation as alpha, beta, or gamma  **\_x\_\_ Predicting Outcomes** Students have to predict the element formed by each of their decay processes. They also have to predict the shielding required based on the type or radiation. | |

|  |  |
| --- | --- |
| **GROUPING** | **Maximize student understanding & learning** Varied group composition (race, gender, ability, & age); clearly understood roles, responsibilities & group work expectations; accountability for group & individual work; student opportunities for goal setting, reflection & evaluation of learning. |
| * Heterogeneous groups of two or three * Roles. Facilitator: collect materials and keep group on task; Communicator: may ask teacher questions if no group member can answer the question and answers questions for the group; Reporter: records data for group, shares with the class/whole group and submits paperwork required by teacher. * Group members assign roles and acknowledge their understanding of their role during the lesson introduction. * Transition to groups. Lesson begins with individual work. After completing the reading passage and graphic organizers, students will move to their groups, assign roles, and complete the rest of the activity. * Product. The group will complete an activity guide. | |
| **ASSESSMENT** | **Formative and/or summative assessment.** A variety of assessments, including rubrics, measure achievement of objectives and informs instruction. |
| ***Assessments: aligned with state stds; measurement criteria; measure student performance in more than 2 ways (project, experiment, presentation, essay, short answer, multiple choice test) (NOTE: Clearly identify where you will use each of these in your lesson; do not just check the box!)***  **\_\_x\_ Teacher Made Test** A future test could ask students to determine the decay product for, for example, Fluorine-18 Beta decay or Livermorium alpha decay.  **\_\_x\_ Exit Ticket** described below  *\****Students should achieve \_\_\_\_\_% mastery of this objective: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** | |
| **CLOSURE** | **Reflection/Wrap Up.** Summarizing, reminding, reflecting, restarting, connecting. |
| * ***Review/Summary: wrap up what has been learned and accomplished in the lesson (even if they are in the middle of an exercise, it is still important to summarize to the point where they are now). Ideally involve students in this synthesis.*** * ***Preview for next lesson: link what they did to day with where they are going next.*** * ***Upcoming assignments: remind them of any upcoming assignments.***   ***Today we…. Turn to your partner and…. Let’s review our I Can statements……***  **Here is your exit ticket for today**: Complete the alpha decay equation for Livermorium and the beta decay equation for Hassium.  This should show that students understand what is happening to each of these elements during alpha and beta decay. These are more complex elements with higher atomic number and mass, but the process is the same.  **Follow-up Activities/Extension *These may be designed to create a longer or more intense lesson. For example, if the class is able to cover the material in a lesson much faster than expected, extensions may prove helpful. Extensions may also be useful in various parts of a lesson where the teacher (and class) decides they should spend more time on a skill or topic.***  ***Reflection: You must reflect on every lesson you teach.*** | |

**NOTES:**

This work is licensed under the Creative Commons Attribution-ShareAlike 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-sa/4.0/> or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

1. The marshmallow model is adapted from a lesson plan created by the Center for Nuclear Science and Technology Information of the American Nuclear Society ( <http://nuclearconnect.org/in-the-classroom/for-teachers/modeling-radioactive-stable-atoms> ). [↑](#endnote-ref-1)