1. Learning Context:

School district: Alpine School District

Name of school: Westlake High School

Title 1 school? No

Demographics:

<table>
<thead>
<tr>
<th>Demographics of Westlake High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total students</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>American Indian/Alaskan Native</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Black</td>
</tr>
<tr>
<td>Pacific Islander</td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td>Low Income</td>
</tr>
<tr>
<td>Free or Reduced Lunch</td>
</tr>
<tr>
<td>Special Education</td>
</tr>
<tr>
<td>English Language Learner</td>
</tr>
<tr>
<td>Graduation Rate</td>
</tr>
</tbody>
</table>
### SAGE Results for WESTLAKE HIGH

<table>
<thead>
<tr>
<th></th>
<th>Language Arts</th>
<th>Mathematics</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47%</td>
<td>51%</td>
<td>57%</td>
</tr>
</tbody>
</table>

#### 2017 SAGE % Proficient

<table>
<thead>
<tr>
<th></th>
<th>Language Arts</th>
<th>Mathematics</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>45.6%</td>
<td>51.1%</td>
<td>55.4%</td>
</tr>
<tr>
<td>ALPINE DISTRICT</td>
<td>47.5%</td>
<td>55.4%</td>
<td>51.2%</td>
</tr>
<tr>
<td>WESTLAKE HIGH</td>
<td>47.4%</td>
<td>55.4%</td>
<td>56.6%</td>
</tr>
</tbody>
</table>

### SAGE Results for WESTLAKE HIGH by Demographic Group

<table>
<thead>
<tr>
<th>Demographic Categories</th>
<th>Language Arts % Prof</th>
<th>Mathematics % Prof</th>
<th>Science % Prof</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Students</td>
<td>47.4%</td>
<td>51.2%</td>
<td>55.6%</td>
</tr>
<tr>
<td>African American</td>
<td>0.0%</td>
<td>0.0%</td>
<td>16.7%</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.0%</td>
<td>50.0%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Asian</td>
<td>76.0%</td>
<td>50.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Caucasian</td>
<td>49.2%</td>
<td>54.1%</td>
<td>59.7%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>36.7%</td>
<td>35.8%</td>
<td>33.6%</td>
</tr>
<tr>
<td>Multiple Races</td>
<td>51.6%</td>
<td>40.0%</td>
<td>52.1%</td>
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<tr>
<td>Pacific Islander</td>
<td>25.0%</td>
<td>12.5%</td>
<td>41.7%</td>
</tr>
<tr>
<td>Female</td>
<td>55.6%</td>
<td>50.5%</td>
<td>54.5%</td>
</tr>
<tr>
<td>Male</td>
<td>40.3%</td>
<td>51.7%</td>
<td>58.3%</td>
</tr>
<tr>
<td>Economically Disadvantaged</td>
<td>37.6%</td>
<td>44.5%</td>
<td>48.0%</td>
</tr>
<tr>
<td>Limited English Proficiency</td>
<td>6.7%</td>
<td>7.1%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Students with Disabilities</td>
<td>9.9%</td>
<td>7.3%</td>
<td>13.0%</td>
</tr>
<tr>
<td>Mobile</td>
<td>24.2%</td>
<td>29.4%</td>
<td>28.9%</td>
</tr>
</tbody>
</table>
Description of school climate [who attends, leadership style, parent/community involvement, school-wide discipline plan (if any), physical environment, academic environment]:

Westlake High School is located in Saratoga Springs, Utah. Westlake also serves the eagle mountain community. Saratoga Springs and Eagle Mountain are fairly young cities with lots of new development. The population is primarily made up of young families that have multiple children. This has resulted in overcrowding of many schools in the area. A new high school is currently being constructed in Eagle Mountain but until the completion of that school (it should be ready for the 2019-20 school year), Westlake will be dealing with overcrowding issues. To cope with the overcrowding, the school has been forced to overfill certain classes and bring in several portable classroom units. Multiple teachers have been required to share classrooms as well.

Westlake High School opened in 2009. It split off from Lehi High School (I graduated from Lehi High School in 2007 so I was quite familiar with the splitting process). At that point, houses in the area were quite cheap and this attracted many lower income families. In recent years, new roads and development have increased the popularity of the communities around Westlake and this has causes home values to increase. This increase in home values and amenities in the area has also increased the socio-economic level of the community. Despite the large increase in population over the last several years, the area has maintained a small-town feel and the high school is at the center of the community so it continues to receive good community/parent support.

When Westlake opened, the school was run using a “Mastery-based” system. Students were required to prove mastery in a subject by scoring at least 70% in their classes before they were allowed to continue into a new class or even into a new unit. The idea sounds great, but it did not work as well as could be hoped. Students soon realized that they did not have to try on their first attempts when taking tests. The system mandated “test-retakes” for full points so the students soon realized that they could just take the tests over and over again until they managed to pass. The school suffered from low to mediocre ACT and Sage scores during this time. Westlake soon developed a reputation for mediocrity. This reputation extended all the way from academics to sports and everywhere in between.

Just over two years ago, the school got a new principal. He did away with the “mastery-based” system and encouraged a more traditional approach in the classroom. He encouraged teachers to do away with the unlimited retake policy that had pervaded the school. This was a difficult transition for many students who were used to the old system. These changes have caused the focus of the school to shift towards standardized test scores. This has resulted in some increases in SAGE scores from the school. The ACT scores are still on the low side however.

Despite increases in scores over the last few years, the school still suffers from a culture of mediocrity. At the beginning of the year, the school conducted and assembly. At this assembly, one of the assistant principals was giving a speech about greatness and the unlimited potential of the students here at Westlake. At one point in his speech, he said to the students “Are we mediocre here at Westlake?” His hope, I would assume, was
that they would respond with a resounding “NO!” However, they all responded with a very loud and very clear “YES!” He backpedaled and tried telling them more about their potential. He then asked them a second time “Are we mediocre?” and they again responded with a very clear “YES!” Many of the students believe that they are mediocre and frankly, they are happy with it. In reality, the students are Westlake are not as mediocre as they seem to believe. For example, last year Westlake High School was 6th in the state (among public high schools) on the SAGE science test. We try to announce these types of things to the students and parents in an effort to dispel the reputation of mediocrity.

There is a new assistant principal at the school this year who has been promoting positive behavior intervention strategies (PBIS). We are trying out a PBIS program this year called “NOBILIS”. It involves an app through which teachers can award points to students when they do positive things. Students gain points by exemplifying various positive behaviors. As they get points, they can “Level-Up” and earn prizes. The goal is for all students to have attained the fourth (the highest) level of NOBILIS by the end of the year.

Grade level:

I primarily teach 10th and 11th grade students. Occasionally I will get seniors in my classes but that is not a particularly common occurrence.

Learning environment: [attendance, classroom management plan, seating arrangement, level of student engagement in learning, level of safety for learning]

Our chemistry curriculum at Westlake is centered on active learning. We try to engage the students in meaningful labs and activities whenever possible. This has made our class successful and popular among the students and has resulted in high enrollment in chemistry at the school (there are over 800 students taking chemistry this year). Attendance has been an issue throughout the school as a whole, however it has not been a real issue among the chemistry students. As a group, they tend to take their grades seriously and they know that if they are late then they will miss the bell-ringer quizzes that are frequent in my class. I am also very strict in my marking of the role so students who have a tendency to show up late quickly end up with “NC’s”. This, along with the bell-ringers and high level of activity in my class usually discourage students from being tardy or skipping class.

Group work is very important and frequent in my class. Students regularly work in groups while completing labs and other activities/assignments. I highly encourage participation in groups and expect all students to be contributors. I do not allow mean or hurtful comments in my class as they discourage participation and damage the learning environment. My room is equipped with tables, which make it very easy for students to group up around a table. While participating in a lecture, students sit facing forward but
movement and swiveling to join up in groups is common and frequent. My class is set up according to the following arrangement:

Subject matter of lessons:

Chemistry (first year)

Total number of students:

There are ~250 students in my classes. They are split between seven different periods.

Students with special needs and short explanation of the needs:

**504 plans:** 4 students

These students receive some or all of the following accommodations:

1. Allow to take tests in smaller chunks or allow to use a blank cover sheet.
2. Preferential seating
3. Check with on instructions and rephrase if needed
4. Check in with to help refocus when needed
5. Help to break large assignments into smaller pieces with individual deadlines
6. Preferred seating
7. Amplification system
8. Allow one week after due date to turn in assignments (includes in-class assignments).
9. Allow to take written assignments home to be typed.
10. Allow extended time to complete tests/quizzes.

**With IEPs:** 4 students

These students are very high functioning. I did not even realize that they had special education needs until I looked them up in the school system. They have never approached me about any special needs that they may have. I try to provide them some accommodations without being too overt about it since they have kept their situations private. Their IEP’s provide them with many of the same accommodation as the 504 students (see above).

**English language learners:** 1 student

This student is quiet and shy. He does not seem very confident about speaking in front of others. It is helpful for him when I take time to explain the meaning of science specific words that he may not be familiar with. Generally, my definitions are helpful for many students besides him as well.

**Gifted and talented:** 51 Students

**Students’ prior knowledge for these lessons:**

The students who enroll in chemistry have generally taken classes in biology and/or earth science. Usually, the 11th graders who take my class will have taken both biology and earth science while the 10th graders in my class tend to be the students who skipped earth science in junior high and went directly into biology. The lack of earth science does not generally hurt these students. Most students entering the class have little or no background in chemistry. This class is intended as an introduction to chemistry that will prepare students for success in future chemistry/science classes, so the lack of chemistry background is not a problem. It is expected that students who take chemistry will have a solid understanding of basic algebra. We rely heavily on algebraic equations in this chemistry class so students without a solid understanding of basic algebra tend to have a hard time with the math-based work that we do.

**Students’ background and interest for these lessons:**

This class is required for students who wish to receive the Utah Regents Scholarship. Many of my students wish to obtain that scholarship and are therefore pushed towards taking my class. Chemistry is also a class that many colleges like to see
on a student’s transcript so students who plan to attend college, especially if they want to go into STEM fields, often decide to take this class. The class also has a good reputation in the school so many students recommend the course to their friends and siblings.

Students generally enjoy the class and are interested in the content. We try to incorporate labs and activities into many of our lessons. The students like the active, inquiry style learning that we provide. Other students tend to prefer the more traditional lecture style learning and we provide some of that as well. We try to cater our lessons to both styles of learning. Our program has consistently grown since the school opened. We currently have over 800 students enrolled in chemistry classes here at Westlake High School.

**How did your knowledge of these students and assessment of their prior knowledge inform your lesson planning?**

As mentioned in the previous section, one of the biggest prerequisites for this class is basic algebra skills. Because of this, we spend a good portion of our first unit reviewing previous math skills that will be useful in this class. We also teach them new ways to solve problems that will help them as they go through the course. From there, we head into more traditional chemistry content. We start with the basics (atoms, molecules, chemical bonds, etc.) because these students have generally not been exposed to chemistry. Our class also builds on itself a lot, so it is important that students remember the content from lesson to lesson. We frequently refer back to what was learned in previous units and lessons.
1. Focus Students:

Description of student 1

Prior learning:
This student is an 11\textsuperscript{th} grader. She does not have a particularly strong science background. She has never taken higher level or honors science courses. This class is her first time participating in a difficult science class.

Academic ability
She has generally done well in her classes and has earned good grades historically (mostly A’s and B’s). Her classes up until now have not been particular strenuous so it is difficult to know if she has ever really stretched herself academically. She has a great desire to do well in class and puts in a lot of extra time outside of class doing things such as getting help from me.

Personal background
She comes from typical family for this area. She lives in the less affluent portion of our school boundaries. She has two siblings and her parents are married. As far as I know, her home life is good. She is a twin and has a particularly close relationship with her twin who often accompanies her to me class when she comes by for help. Her twin in not in my class. She is Hispanic but English is her primary language so language is not a barrier for her.

Other relevant characteristics
She is not a particularly quick learner but she is quite persistent. She really wants to succeed and she puts a lot of work into her academic efforts. She is shy in class but is quite talkative when she comes in to get help in small group settings.

Influence of all of these characteristics on your teaching
I spend a lot of time outside of class with her. She does not learn well in large groups. Individual teaching works best for her as she tends to have many questions but is hesitant to ask them in class. She tries to get what she can out of our in-class time and then we take care of the rest outside of class.

Description of student 2

Prior learning
This student is a 10\textsuperscript{th} grader. She has historically done well in school. She has a decent science background and has taken higher level/honors classes in the past. She is new to high school and has not taken many science classes yet but she seems to have done well in the classes that she has taken.

Academic ability
She has done well in school and earned good grades (mostly A’s). She tends to take honors level courses when possible and seems to enjoy challenging herself academically. She is a very good student.

Personal background
She is an only child. She lives in one of the more affluent areas of our school boundaries. Her parents are married and her home life seems to be good. She is white and English is her primary language.

**Other relevant characteristics**
She is very outgoing and is always very willing to participate in class. She seems to have many friends and enjoys working in groups. She occasionally comes in for help but tends to be quite self-sufficient in completing her assignments.

**Influence of all of these characteristics on your teaching**
She does well in the typical class environment. She enjoys participating in class and is always happy to answer questions when called on in class. She does not require much extra support outside of class.
Lesson Plan #1: Atomic Theory

*(Any methods/strategies that were used but were not explicitly stated have been put in parenthesis next to the activity where they will take place and italicized.)*

<table>
<thead>
<tr>
<th>Class: High School General Chemistry (10th-12th grades)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit: Unit 2</td>
</tr>
<tr>
<td>Duration: 90 minutes</td>
</tr>
</tbody>
</table>

**Objectives:**

Students will be able to:

- Be familiar with and be able to compare various major experiments that led to our current understanding of the atom (Standard 1, Objective 2, Part a).
- Evaluate and compare the limitations of the various atomic models (Standard 1, Objective 2, Part b).
- Describe the relative size, charge, and position of protons, neutrons, and electrons in an atom (Standard 1, Objective 2, Part c).
- Create a realistic model of an atom (Standard 1, Objective 2).
- Identify an element based upon that element's atomic number (Standard 1, Objective 2, Part c).

**Vocabulary Objectives:**

- Language Skills:
  - Identify, evaluate, analyze, create
- Vocabulary:
  - Proton, neutron, electron, molar mass, atomic mass, charge

These language skills will be used throughout the lesson. We will begin by creating and explaining pictures of atoms. The students are generally acquainted with many of the vocabulary words that we cover in this lesson, but this will give them a chance to use them in context. We will use and define our vocabulary words during the lecture piece of this lesson. The students will then have to evaluate some rules for our Lego activity. These rules will once again define the vocabulary words, just in a different manner. Students will be creating models of the atoms and using the periodic table throughout the lesson. They will be doing a lot of this work in groups or with partners. This should give them ample time to practice using these words.

**State Standards:** Utah Core Standards for Science

- Standard 1: Students will understand that all matter in the universe has a common origin and is made of atoms, which have structure and can be systematically arranged on the periodic table.
  - Objective 2: Relate the structure, behavior, and scale of an atom to the particles that compose it.
    - a. Summarize the major experimental evidence that led to the development of various atomic models, both historical and current.
    - b. Evaluate the limitations of using models to describe atoms.
c. Discriminate between the relative size, charge, and position of protons, neutrons, and electrons in the atom.

**Prior Knowledge:**
- Little to no prior knowledge is required for this lesson, it is meant to cover the basics of atomic theory.

**Required Materials/Resources:**
- Access to computers
  - PHET simulation
- Legos
- Phet activity worksheet
- Lego activity worksheet

**Rationale:**
This lesson is intended to be exploratory in nature. It provides the students with an opportunity to build their own understanding of the atom/its structure. I have tried to incorporate multiple mediums of instruction into this lesson in order to accommodate the various learners that I will be teaching. There are opportunities to draw for those who are artistic, there is standard lecture for the traditional learners, the PHET activity incorporates technology, and the Legos provide a hands-on activity for those who prefer to learn in that manner.

**Accommodations:**
This lesson is so well differentiated that I have never had to provide specific accommodations for students during the lesson. Those who are learning English tend to do well with the repetition that the lesson provides. They get many chances to see, hear, and use the vocabulary words. Those with other accommodations tend to thrive as well thanks to the interactive, hands-on nature of this lesson.
Lesson:

- **Anticipatory Set** *(Activate and use funds of knowledge, NLR, writing):* A writing assignment followed by a discussion of the answers.
  - The students will draw a picture of what they think an atom looks like.
  - They should write a short explanation of their drawing and explain why it is a valuable representation of an atom.

- **Teacher Input:**
  - Provide advanced organizer for the students with the lesson objectives.
  - Explain the important atomic models from history and how they have led to our current understand of the atom *(scaffolding):*
    - Pair and share *(writing, higher levels of Blooms Taxonomy):*
      - Take 2 minutes to explain which historical model most resembles your model from earlier.
      - Explain what we learned about the atom from this model.
  - Come back together as a class and discuss the “pair and share” and then transition to the next activity.

- **Modeling/Check for Understanding** *(constructivist activity, NLR, cooperative learning):*
  - Lego Activity: students will use Legos to construct multiple atomic models and they will sort these atomic models into an order that makes sense (this will imitate the organization of the periodic table).
  - This activity will be done in conjunction with class discussions about the structure of the atom and the organization of the periodic table.
  - Students will fill out the “Lego Activity” portion of their packets.

- **Assessment/Independent Practice** *(scaffolding, frequent assessment, technology):*
  - The students will go to the following website on their phones or other devices: [https://phet.colorado.edu/en/simulation/build-an-atom](https://phet.colorado.edu/en/simulation/build-an-atom)
  - They will use the program to build an atom.
  - I will be using this time to go around and visually assess the progress of the students.
  - Students will fill out the Build an Atom Phet activity portion of their activity packet which requires them to write down certain key pieces of information from the website as they build these atoms.
  - The students will complete three games at the end of the PHET as an assessment of their understanding. Students need to know the content quite well in order to pass these games in the required time limit.
  - Both packets (the Lego and the PHET) will be turned in before leaving.

**Sources:**

- Computer modeling provided by: [https://phet.colorado.edu/](https://phet.colorado.edu/)
- I got the idea for the “lego activity” from a fellow teacher named Don Bastian.
- The Madeline Hunter lesson plan format was generally followed when creating this lesson plan.
Lesson Plan #2: Isotopes and Atomic Mass

*(Any methods/strategies that were used but were not explicitly stated have been put in parenthesis next to the activity where they will take place and italicized.)*

<table>
<thead>
<tr>
<th>Class:</th>
<th>High School General Chemistry <em>(10th-12th grades)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Unit 2</td>
</tr>
<tr>
<td>Duration:</td>
<td>90 minutes</td>
</tr>
</tbody>
</table>

Objectives:

Students will be able to:

- Relate the values of molar mass and atomic mass *(Standard 1, Objective 2, Part e)*.
- Determine the net charge of an atom *(Standard 1, Objective 2)*.
- Explain what an isotope is and identify isotopes *(Standard 1, Objective 2, Part d)*.
- Perform dimensional analysis to answer math-based problems related to the atom *(Standard 1, Objective 2, Part e)*.

Vocabulary Objectives:

- **Language Skills:**
  - Analyze, apply, assess, explain
- **Vocabulary:**
  - Proton, neutron, electron, isotope, angstrom, amu, % abundance, weighted average

This lesson's vocabulary has a lot of crossover with the vocabulary from the previous lesson. To a certain extent, this lesson is a continuation of that lesson. We will rely heavily on the vocabulary that was learned during the Atomic theory lecture. Much of the new vocabulary for this lesson is math-based. Students will be learning the names of some new units and they will likely not be familiar with these units. They will also be learning about weighted averages and how they consider abundance when averaging values. We will be using a lot of repetition to help them learn and remember these new words.

State Standards: Utah Core Standards for Science

- **Standard 1:** Students will understand that all matter in the universe has a common origin and is made of atoms, which have structure and can be systematically arranged on the periodic table.
  - **Objective 2:** Relate the structure, behavior, and scale of an atom to the particles that compose it.
    - d. Generalize the relationship of proton number to the element’s identity.
    - e. Relate the mass and number of atoms to the gram-sized quantities of matter in a mole.

Prior Knowledge:

- Periodic table
- Atomic theory
### Required Materials/Resources:
- Access to computers/phones
- Regular aluminum foil
- Heavy duty aluminum foil
- Rulers
- Balances
- Activity packet (Phet activity and thickness for a thin layer lab)

### Rationale:
This lesson has a lot of math and much of it is new for the students. To help them understand and internalize the math, we will spend a lot of time practicing the math and applying it to realistic problems. Many students struggle to remember that we are using a new method to determine averages and it takes some time before they remember to use the new method rather than the old one that they are used to. Another main goal of this lesson is to help the students understand the size of atoms. We will be measuring the thickness of two pieces of aluminum foil (heavy duty and regular) and then determining how many atoms thick these foils are. This is always amazing to the students when they realize that they can actually calculate the number of atoms in something like aluminum foil.

### Accommodations:
The math involved in the aluminum foil lab can be tricky for students. Many students, whether or not they have official accommodations) struggle with this math. It is just so new and novel to them. To alleviate this issue I lead into the lab with multiple hints that help many students overcome the difficulties that they experience. For students who are still unable to solve these problems, I walk them through the steps and the logic involved in each step. This math is honestly beyond what I will test them on but it is really cool for the students who get it!
Lesson:

- **Anticipatory Set** *(Activate and use funds of knowledge, NRL)*: A quiz followed by a discussion of the answers.
  - A couple of historical atomic models will be shown on the board and they will identify them.
  - Some elements will be identified based upon proton number.

- **Teacher Input**:
  - An advanced organizer will be provided with the lesson objectives for the day.
  - Lecture on charges, isotopes, and the math based problems that are common to this subject.
  - Class will spend time working through example and practice problems.
    - “pair and compare” answers as we do the practice problems

- **Modeling/Check for Understanding** *(Technology)*:
  - The students will go to the following website: [https://phet.colorado.edu/en/simulation/isotopes-and-atomic-mass](https://phet.colorado.edu/en/simulation/isotopes-and-atomic-mass)
  - They will use the program to build different isotopes of an atom and assess their stability.
  - I will be using this time to go around and visually assess the progress of the students.
    - Students will fill out the Phet activity portion of their packet which requires them to write down certain key pieces of information from the website as they compare these isotopes.

- **Assessment/Independent Practice** *(constructivist activity, NLR, cooperative learning)*:
  - Thickness of a thin layer activity: Students will compare the thicknesses of two different pieces of aluminum foil. They will use dimensional analysis to determine roughly how many atoms across are in each piece of foil.
  - Final portion of the activity packet will be filled out during this activity.

Sources:

- Computer modeling provided by: [https://phet.colorado.edu/](https://phet.colorado.edu/)
- I got the idea for the “Thickness of a thin layer” from a fellow teacher named Don Bastian.
- The Madeline Hunter lesson plan format was generally followed when creating this lesson plan.
Lesson Plan #3: Radioactivity

(Any methods/strategies that were used but were not explicitly stated have been put in parenthesis next to the activity where they will take place and italicized.)

<table>
<thead>
<tr>
<th>Class: High School General Chemistry (10th-12th grades)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit: Unit 2</td>
</tr>
<tr>
<td>Duration: 90 minutes</td>
</tr>
</tbody>
</table>

**Objectives:** Students will be able to:
- Describe the origin and nature of radioactive particles (Standard 2, Objective 2, Part a).
- Compare the mass, energy, and penetrating power of alpha, beta, and gamma particles (Standard 2, Objective 2, Part c).
- Compare and contrast the energy from the strong nuclear force/nuclear reactions with that of chemical reactions (Standard 2, Objective 2, Part d).
- Compare fission reactions with fusion reactions (Standard 2, Objective 2, Part d).
- Write and balance nuclear equations (Standard 2, Objective 2, Part b).
- Research and describe effects of radiation on the body (Standard 2, Objective 2, Part e).

**Vocabulary Objectives:**
- Language Skills:
  - Identify, compare, research, evaluate
- Vocabulary:
  - Radiation, alpha, beta, gamma, strong nuclear force, fission, fusion, nucleons, isotope

The vocabulary in this lesson is often new or unfamiliar for many of the students. They may have heard some of these words before but they rarely understand their meaning. This lesson requires lots of defining and opportunities for the students to familiarize themselves with their words. Luckily, this subject also interests many students so they tend to be quite willing to learn these vocabulary words. It is important that students are given ample time to understand and use each of these words in context.

**State Standards:** Utah Core Standards for Science
- Standard 2: Students will understand the relationship between energy changes in the atom specific to the movement of electrons between energy levels in an atom resulting in the emission or absorption of quantum energy. They will also understand that the emission of high-energy particles results from nuclear changes and that matter can be converted to energy during nuclear reactions.
  - Objective 2: Evaluate how changes in the nucleus of an atom result in emission of radioactivity.
    - a) Recognize that radioactive particles and wavelike radiations are products of the decay of an unstable nucleus.
b) Interpret graphical data relating half-life and age of a radioactive substance.

c) Compare the mass, energy, and penetrating power of alpha, beta, and gamma radiation.

d) Compare the strong nuclear force to the amount of energy released in a nuclear reaction and contrast it to the amount of energy released in a chemical reaction.

e) After researching, evaluate and report the effects of nuclear radiation on humans or other organisms.

**Prior Knowledge:**

- Atomic theory
- Isotopes
- Atomic mass

**Required Materials/Resources:**

- Access to computers/phones (the internet)
- Radioactive samples
- Radioactivity detector

**Rationale:**

Student tend to be very intrigued by the topic of this lesson. I have several main goals with the lesson. I want to dispel common misconceptions around radioactivity and minimize the mystery around the subject. I want to show them physical sample of radioactive substances. Finally, I want to answer all of their questions. They tend to have many questions about this topic. This lesson is set up in a manner that will pique their interest and facilitate conversation. Lots of conversation makes this lesson fun and productive.

**Accommodations:**

English language learners are often unfamiliar with many of the terms that we learn in this lesson. Unfamiliarity with the terms is not unique to that group though. Most of the students are unfamiliar with the terminology or they at least have flawed understandings of the words. This lesson is set up well for ELL students as there are lots of definitions and discussion around the new words being introduced. I have never had to offer any other accommodations aside from spending a lot of time on vocabulary.
Lesson:

- **Anticipatory Set** *(Activate and use funds of knowledge, NRL, Attention grabber):*
  - Work through a couple of homework problems as a class.
  - Review key concepts from the last couple of lessons that pertain to today’s lesson.
  - Watch radiation video to increase interest in the subject.
    - [https://www.youtube.com/watch?v=TRL7o2kPqw0](https://www.youtube.com/watch?v=TRL7o2kPqw0)
  - Show the students some radioactive samples.

- **Teacher Input:**
  - An advanced organizer will be provided with the lesson objectives for the day.
  - Radiation lecture
    - What is radiation
    - Types of radiation
      - Show samples of each type of radiation.
    - Nuclear equations
    - Strong nuclear force
    - Fission vs. fusion

- **Modeling/Check for Understanding** *(Cooperative learning):*
  - Example nuclear problems
  - Practice nuclear problems
    - Pair and share answers to the practice problems
    - Go over answers and how to work the problems as a class

- **Independent Practice** *(constructivist activity, technology, higher levels of Blooms taxonomy):*
  - Students will individually research the effects of radiation on the body.
  - They will compile a list of these effects.
  - We will compile a list as a class.
  - The students will choose one of these and they will be further researching that effect as part of their homework.

**Sources:**

- [Veritasium](https://www.youtube.com/watch?v=TRL7o2kPqw0) *(the video)*
- The Madeline Hunter lesson plan format was generally followed when creating this lesson plan.
Lesson Plan #4: Half-Life

(Any methods/strategies that were used but were not explicitly stated have been put in parenthesis next to the activity where they will take place and italicized.)

<table>
<thead>
<tr>
<th>Class:</th>
<th>High School General Chemistry (10th-12th grades)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit:</td>
<td>Unit 2</td>
</tr>
<tr>
<td>Duration:</td>
<td>90 minutes</td>
</tr>
</tbody>
</table>

**Objectives:**
Students will be able to:
- Explain the concept of a half-life (Standard 2, Objective 2, Part b).
- Read and analyze a half-life graph (Standard 2, Objective 2, Part b).
- Solve for the following variables when presented with half-life problems or graphs (Standard 2, Objective 2, Part b).
  - How long is the half-life?
  - How long has the sample been in storage?
  - How much sample is left?
  - How much sample was originally put into storage?
- Create a graph when provided with half-life data (Standard 2, Objective 2, Part b).

**Vocabulary Objectives:**
- Language Skills:
  - Interpret, analyze, explain
- Vocabulary:
  - half-life, isotope, radioactivity, atomic mass, nuclei

This lesson is primarily centered on helping students understand and be able to explain the concepts of half-lives and graphs relating to half-lives. We will spend time both analyzing and creating half-life problems and graphs. This lesson will involve group work as well as individual work. This should allow the students to both internalize and understand the concept and well as discuss and explain it to their peers. After both individual and group work, they ought to have decent vocabularies in regards to the concept of half-lives.

**State Standards:** Utah Core Standards for Science
- Standard 2: Students will understand the relationship between energy changes in the atom specific to the movement of electrons between energy levels in an atom resulting in the emission or absorption of quantum energy. They will also understand that the emission of high-energy particles results from nuclear changes and that matter can be converted to energy during nuclear reactions
  - Objective 2: Evaluate how changes in the nucleus of an atom result in emission of radioactivity.
    - a. Recognize that radioactive particles and wavelike radiations are products of the decay of an unstable nucleus.
    - b. Interpret graphical data relating half-life and age of a radioactive substance.
### Prior Knowledge:
- Atomic theory
- Radioactivity
- Types of radioactivity
- Isotopes
- Atomic mass

### Required Materials/Resources:
- 12 shoe box sized Rubbermaid containers
- 1210 pennies
- Graph paper

### Rationale:
Half-life related graphs are a highly emphasized piece of the state core. I want to give the students a chance to see these graphs, analyze them, and create them. I’ll begin by simply explaining the concept but we will quickly move on to multiple problems and graphs that the students themselves will analyze and discuss with their neighbors. The “Pennium” activity that we will complete gives students a chance to actually handle physical objects that demonstrate this concept and will hopefully help those students who are struggling to really internalize the subject.

### Accommodations:
This lesson is built to accommodate various learners. It provides students with multiple opportunities to learn the content, lots of repetition, and physical objects to manipulate. I have not had to provide special accommodations beyond the lesson for students when teaching this lesson.
Lesson:

- **Anticipatory Set** *(Activate and use funds of knowledge, similarities and differences, writing)*: A quiz followed by a discussion of the answers (to review from last time).
  - What is radioactivity?
  - What is the atomic mass of Uranium
  - How many neutrons, protons, and electrons does a Uranium atom contain?
  - What does Uranium become when it undergoes alpha decay?
  - Which of the following is an example of an isotope of carbon-12?

- **Teacher Input:**
  - Provide advanced organizer for them with lesson objectives for the day.
  - Half-life lecture which contains *(scaffolding)*:
    - Description of half-lives
    - Examples of real world application for the concept
    - Example/practice half-life graphs *(higher levels of Blooms Taxonomy)*
    - Example/practice half-life problems *(higher levels of Blooms Taxonomy)*

- **Modeling** *(scaffolding)*:
  - I will have ten pennies in a cup at the front of the room. I will use these pennies to model the concept of half-lives. I will do this shaking the pennies up in the cup and then dumping them out on the front counter. Any pennies that are tails will represent decayed nuclei and will be removed. This will continue until all of the pennies are gone.

- **Check for Understanding:**
  - Verbal assessment of the class with the following questions:
    - Why did I take away the pennies that landed on tails? What did they represent?
    - What happened to the pennies when they “decayed”? What happened to nuclei when they decay?
    - How many half-lives did it take for all of the pennies to “decay”?
    - If the half-life of a penny is 500 years, how long did the decaying process take in this example? (This problem will be worked out by the entire class on paper)

- **Assessment/Independent Practice** *(constructivist activity, NLR, cooperative learning)*:
  - Pennium Lab: This is basically a larger scale version of the example that I used in the modeling section of this lesson plan. Their lab sheets and graphs will be turned in before leaving class for the day. The lab sheet can be found at the end of this lesson plan.
    - The following are ideas of assigned roles within the lab groups:
      - Scribe
      - Collect the heads and put them back in the bucket
      - Collect the tails and set them aside
      - Count up the tails as they are being collected
Sources:

- I got the idea for the “Pennium Lab” activity from a fellow teacher named Don Bastian.
- The Madeline Hunter lesson plan format was generally followed when creating this lesson plan.
Reflection and evaluation of lessons, including analysis of assessment data.

Analyze student learning:

Performance of student 1

Student 1 worked very hard during this unit. I saw her putting in more time before and after school than any of the other students. She completed all of her assignments for the unit and did quite well on the quizzes as well. She generally came in for extra help at least once for every time that we met as a class. She often requested help with the math based problems. When I would ask her questions in an attempt to probe for understanding of the more conceptual content she often seemed confused by that as well and would require extra explanation. The homework was math based which is why I believe that her questions usually centered on the math.

She made several minor errors in some of our labs and in-class activities. These have been noted on the attached student work samples. She particularly struggled on the math in the “Thickness of a Thin Layer” lab. She however did quite well on the Isotopes and the Half-life assignments. Her real struggle was with the test. She only scored a 68% on the Unit test. This was a lower scoring test for many students as the material is significantly harder than the content from our previous unit but her score was still among the lower scores in the class.

This student wants to succeed so badly. She puts in a ton of time outside of class and she has impressed me with her resilience. This content does not come easily to her but she has stuck with it. Her hard work and efforts on the assignments and labs in the course have helped her to do well in the class despite her difficulty on the tests. Currently, her biggest hindrance to success is her lack of preparation for this class. Her background knowledge and skills are quite a bit behind the other students so she constantly has to play catch up in an already difficult class. I work with her quite often both before and after school to help her keep up with the pace of the class. We end up spending a lot of time working on remedial content that she ought to have learned during previous courses. If she is willing to continue spending the extra time outside of class than she should be able to keep up with the pace of the course and do well in the class.

Performance of student 2

Student 2 did very well this unit. She completed all of her assignments, did well on quizzes (aside from one poor quiz score), and did well on the unit test (90%). She is an independent learner and does not request much help outside of class. I believe that she would still benefit from occasional help outside of class but she has not seemed interesting in coming in for help outside of class time. She also contributes to our class discussions on a regular basis. She made a few errors on her assignments and labs. One of these was on a post lab question from the “Thickness of a Thin Layer” lab and the other was in a graph on the “Half-Life” assignment. These were small errors though and they did not indicate a real lack of understanding of these assignments. These assignments can be seen in the attached students work samples.
In reviewing the questions missed by this student on the Unit test, it appears that she had some misconceptions in regards to nuclear decay and isotopes. She missed several questions about nuclear decay and just one about isotopes so would say that nuclear decay was the most problematic topic of the unit for her. I would like to see her coming in for help when she does have questions about the content. She has not done this yet, largely because she seems to understand the contest on her own, but I also suspect that she does not like admitting that she needs help. I want to make sure that she feels comfortable asking for help when she does need it.

**Analyze teaching effectiveness:**

**What did you do differently than what you originally planned? Why?**

The teachers at my school have historically taught this unit by explaining the content in lecture form during a couple of lessons at the beginning of the unit and then following this up with a couple days of labs and activities in which the students solidify their understanding of the concepts. The idea being that we want to provide the students with significant scaffolding prior to the labs. This has worked decently in the past but I wanted to switch things up this year and provide the students with more of an exploratory learning experience. The lessons plans that I outlined earlier in this assignment placed activities such as the “Lego” lab and the “Phet: Build an Atom” activity near the beginning of the unit and followed up with class discussion of these topics. Some supply issues along with some attempts by me to keep my classes more in line with the other chemistry teachers ended up foiling my plans to make this unit more exploratory in nature and I ended up following much nearer to the old system than I had planned. This worked well but I was none-the-less disappointed to miss a chance to try a new format for the unit.

As might be expected, my students performed similarly this year to my students from previous years on the unit test. They also performed similarly to the students from the other chemistry classes in the school. Unfortunately, this unit has historically been a difficult one for the students and scores have often been somewhat low on the test for this unit. As such, I would like to see a change from previous years rather than stagnating. These low scores may be due to the manner in which we present the material for the unit but it also may be due to the difficulty of the test. It tends to catch some students off guard. I suspect that both of these factors are to blame for the lower scores on this test. Next year I would like to follow through on my plans for switch up with order of this unit. I have suggested this switch to the other teachers on the chemistry team and they will likely be joining me next year in making the unit more exploratory.

**What worked and what didn’t work?**

The amount of lab work in the unit is great! It gives the students lots of opportunity to interact with the concepts. There are labs in this unit for every concept that we cover. Historically the labs have filled a supportive role. They provide opportunities for students to
reinforce their learning. The lectures have historically been the place where new content in shared. This does provide the students with plenty of scaffolding and opportunity to succeed on the labs. My main fear is that the content may not be sticking with them long term when we use this method. I would like to turn this into an exploratory unit instead. I would like to see the labs filling the role of delivering new content and the lectures can become the supporting activity. This would cause the students to think more about the content and develop their own understanding rather than simply parroting back what we have told them. I believe that this change will result in better long-term learning.

The content is also very interesting for many students. They find the ideas of nuclear decay, radiation, etc. to be intriguing. We often get lots of good questions and discussion while teaching these concepts. I have found several great demonstrations to use during this unit. For instance, I have some radioactive isotopes that I can bring out to show them. I am able to hold up a radiation detector and it starts beeping rapidly when near those materials. They really like seeing those! I would like to find more things like that to show the students when teaching them about this intriguing topic.

**How would you modify the unit based on the focus students’ performance?**

For some students, our current method of teaching this unit works great. For others, it just is not cutting it. Historically, there have often been quite a few low scores on this unit test. I attribute this to both the manner in which we teach the content as well as to the fact that this unit test is much more difficult than the first test of the year. Focus student 2 was able to find success on the unit test despite the increase in difficulty. Students like her tend to do well in the class no matter what we throw at them. Focus student 1, along with many other students, had more difficulty. These are the students that really stand to benefit from a change in the structure of this unit.

I also think that it would greatly benefit the students if we were to provide them with more/better formative assessments throughout the unit. I gave the students frequent, small quizzes throughout the unit in an attempt to provide them with some good self-assessment. Unfortunately, I think that I may have made the quizzes too easy. If I were to provide them with at least one longer and more difficult quiz along with the shorter assessments that ought to provide them with a better reminder that they need to take this unit more seriously than they did the last unit.

**In what other ways would you modify the unit in the future? Why? What would you do differently in the future?**

There is a lot that I like about this unit. It is interesting, it covers fun content, and it contains a lot of labs and activities. Overall, it is an enjoyable unit for both teacher and students. I just need to find a way to help the students retain the information better. They struggle to show
mastery of the content when tested at the end of the unit. This seems to be due to a lack of longevity in their understanding. I really think that shifting the focus from scaffolding to exploration will help with this problem. Exploratory learning is so much more memorable and meaningful than lecture. I believe that switching my schedule and providing students with the labs and activities first will improve their mastery of the content. I also plan to provide them with quizzes that are better at assessing depth of knowledge/understanding. These will provide them with a better approximation of the test questions that they will face at the end of the unit. I believe that these changes will make this unit more enjoyable and more successful for the students.
Thickness of a thin layer lab

**Purpose**
Can we determine the thickness of a very thin object with the skills we have learned this year?

**Equipment**
- Regular aluminum foil
- Heavy duty aluminum foil
- Ruler
- Scale

**Procedure**
1. Obtain a piece of regular and heavy duty foil
2. Determine the area of each piece of foil
3. Determine the mass of each piece of foil
4. Calculate the thickness of the foil
5. Clean-up your lab station

**Data**

<table>
<thead>
<tr>
<th></th>
<th>Regular Foil</th>
<th>Heavy duty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass (g)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Calculations** - Hint the density of Aluminum is 2.7 g/cm^3

1. Area of regular foil

2. Area of heavy duty foil

3. Thickness of regular foil

4. Thickness of heavy duty foil
Questions

1. Sketch a side view of the foil including atoms.

2. What is the maximum size (diameter) of an aluminum atom?

3. Given the fact that the accepted value for the diameter of an aluminum atom is $2.9 \times 10^{-8}$ cm, how many atoms thick is the regular and heavy duty foil?

Conclusion
Lego Activity

**Goal**
Build as many combinations of Legos with as much variety as possible using only the Legos supplied in your cup. After building a combination sketch it in the box. Then recycle its pieces to make a new combination.

![Legos](image)

| 1 White | 1 Green | 1 Black |

You can only build combinations that obey the three rules.

**Rules**
1. The # of white pieces = # of green pieces

2. To build a structure with more than one green then the # of black pieces ≥ # green

3. The # of blacks can not be greater than twice the # of greens

**DO NOT PRESS PIECES TOO FIRMLY TOGETHER**

You should be able to make 10 combinations or more.

Sketch your finished products &
Label the # of each colored used in each structure

When done:
Separate all Legos in cup
Place lid back on tightly
What does the green Lego represent?  
What does the white Lego represent?  
What does the black Lego represent?

Place your combinations in a logical order

Summarize what you learned

Explain your logical order
## Homework Coversheet

**Unit 2**

### Homework Grading

<table>
<thead>
<tr>
<th>Day</th>
<th>Notes</th>
<th>On Time = 10 points</th>
<th>Late = 5 points</th>
<th>Not Finished = 0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Atomic Theory</td>
<td>0 /10 pts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>Atomic Theory</td>
<td>0 /10 pts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td>Atomic Theory</td>
<td>0 /10 pts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 4</td>
<td>Radioactivity</td>
<td>10 /10 pts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 5</td>
<td>Radioactivity</td>
<td>0 /10 pts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Homework

<table>
<thead>
<tr>
<th>Notes</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern Atomic Theory (blue)</td>
<td>0/10 pts</td>
</tr>
<tr>
<td>Average Atomic Mass (yellow)</td>
<td>0/10 pts</td>
</tr>
<tr>
<td>Atoms Across (blue)</td>
<td>0/10 pts</td>
</tr>
<tr>
<td>Nuclear Equations (yellow)</td>
<td>0/10 pts</td>
</tr>
<tr>
<td>Half life (blue)</td>
<td>0/10 pts</td>
</tr>
<tr>
<td>Review: Atomic theory &amp; Radioactivity (green)</td>
<td>0/10 pts</td>
</tr>
</tbody>
</table>

### Quiz Scores

<table>
<thead>
<tr>
<th>Quiz</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiz 1</td>
<td>5/5</td>
</tr>
<tr>
<td>Quiz 2</td>
<td>4/5</td>
</tr>
<tr>
<td>Quiz 3</td>
<td>5/5</td>
</tr>
</tbody>
</table>

**Total Points:** 124 / 125 points

**Test:** 68%
Build an Atom Activity

Google PHET Chemistry
https://phet.colorado.edu/en/simulations/category/chemistry

Select "Build an Atom"

Click Play

When open, press "Atom"

Now build a standard Carbon and write down how many protons, neutrons, and electrons are present.

P = 6
N = 6
e⁻¹ = 6
Make sure the box “Stable/Unstable” is checked

Now take the Carbon atom you have made and start adding or taking away neutrons. Record whether the atom is marked as stable or unstable.

<table>
<thead>
<tr>
<th>Mass Number</th>
<th>Stable or Unstable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Unstable</td>
</tr>
<tr>
<td>11</td>
<td>Unstable</td>
</tr>
<tr>
<td>12</td>
<td>Stable</td>
</tr>
<tr>
<td>13</td>
<td>Stable</td>
</tr>
<tr>
<td>14</td>
<td>Unstable</td>
</tr>
</tbody>
</table>

Why do you think the atom becomes unstable?

Now click the game button on the bottom of the webpage

Play each game. To pass this activity, you must score a perfect ten on each game in under 30 seconds. Show your teacher when you have completed a game and they will sign you off in the boxes below.
Goal
Build as many combinations of Legos with as much variety as possible using only the Legos supplied in your cup. After building a combination sketch it in the box. Then recycle its pieces to make a new combination.

<table>
<thead>
<tr>
<th>1 White</th>
<th>1 Green</th>
<th>1 Black</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="White Lego" /></td>
<td><img src="image2" alt="Green Lego" /></td>
<td><img src="image3" alt="Black Lego" /></td>
</tr>
</tbody>
</table>

You can only build combinations that obey the three rules.

Rules
1. The # of white pieces = # of green pieces
2. To build a structure with more than one green then the # of black pieces ≥ # green
3. The # of blacks can not be greater than twice the # of greens

DO NOT PRESS PIECES TOO FIRMLY TOGETHER

You should be able to make 10 combinations or more.

Sketch your finished products & Label the # of each colored used in each structure

When done:
Separate all Legos in cup
Place lid back on tightly
What does the green Lego represent?

- electron

What does the white Lego represent?

- proton

What does the black Lego represent?

- neutron

Summarize what you learned

Elements can have different amounts of isotopes.

Place your combinations in a logical order

<table>
<thead>
<tr>
<th>Hydrogen</th>
<th>Helium</th>
<th>Lithium</th>
<th>Beryllium</th>
<th>Boron</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Green</td>
<td>2 Black</td>
<td>3 White</td>
<td>4 Green/ Black/ White</td>
<td>5 Green/ Black/ White/ And White</td>
</tr>
</tbody>
</table>

Explain your logical order

I did it by the number of protons and electrons and I started at one and went in order. I did it from least to greatest.

--- I did from least to greatest with the black legos.
Isotopes & Atomic Mass

Google PHET Chemistry
(https://phet.colorado.edu/en/simulations/category/chemistry)
Select "Isotopes & Atomic Mass"

<table>
<thead>
<tr>
<th>Isotopes and Atomic Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select &quot;Run Now&quot;</td>
</tr>
</tbody>
</table>

Procedure:
1. Open the program and start out at the "Make Isotopes" tab.
2. Choose an element other than H. Beneath the scale in the center of the screen click "Atomic Mass (amu)".
3. Open the "Symbol" and "Abundance in Nature" tabs.

### Example:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron-45</td>
<td>0 (unstable)</td>
<td>45.01458</td>
</tr>
<tr>
<td>Iron-54</td>
<td>5.845</td>
<td>55.93961</td>
</tr>
<tr>
<td>Iron-57</td>
<td>2.119</td>
<td>56.93539</td>
</tr>
<tr>
<td>Iron-58</td>
<td>0.282</td>
<td>57.93327</td>
</tr>
<tr>
<td>Iron-59</td>
<td>91.754</td>
<td>58.93493</td>
</tr>
</tbody>
</table>

Average atomic mass: 55.84520 amu (we ignore Fe because it is not abundant in nature).

#### Element 1

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen-17</td>
<td>0.038%</td>
<td>16.9813</td>
</tr>
<tr>
<td>Oxygen-18</td>
<td>0.205%</td>
<td>17.9986</td>
</tr>
<tr>
<td>Oxygen-19</td>
<td>0% unstable</td>
<td></td>
</tr>
<tr>
<td>Oxygen-20</td>
<td>99.75%</td>
<td>15.9991</td>
</tr>
</tbody>
</table>

Average atomic mass: 15.99 amu

#### Element 2

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium-7</td>
<td>92.41%</td>
<td>7.06906</td>
</tr>
<tr>
<td>Lithium-6</td>
<td>7.38%</td>
<td>6.93412</td>
</tr>
<tr>
<td>Lithium-9</td>
<td>Unstable</td>
<td></td>
</tr>
<tr>
<td>Lithium-10</td>
<td>Unstable</td>
<td></td>
</tr>
</tbody>
</table>

Average atomic mass: 6.94 amu

#### Element 3

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beryllium-9</td>
<td>100%</td>
<td>9.00918</td>
</tr>
<tr>
<td>Beryllium-10</td>
<td>Unstable</td>
<td></td>
</tr>
<tr>
<td>Beryllium-11</td>
<td>Unstable</td>
<td></td>
</tr>
<tr>
<td>Beryllium-12</td>
<td>Unstable</td>
<td></td>
</tr>
</tbody>
</table>

Average atomic mass: 9.01 amu

Symbol: +
Abundance in Nature: %

2. Choose an element and perform the following procedure:
a. Add neutrons one at a time; record the symbol as shown. For each neutron added, they also indicate the percent abundance.
b. Remove neutrons from the original elements, record the symbol and percent abundance.
c. From the percent abundance and the atomic masses calculate the average atomic mass for the elements.
d. Repeat this for 2 more elements.
e. What changed as you added or removed neutrons?

When I always removed a neutron the element would become unstable.

f. What did not change?

The amount of protons

g. Why do you think that each isotope has a different % abundance?

Some may be heavier than others.

3. Go to the "Mix Isotopes" tab.

Mix Isotopes

a. Choose "Nature's mix of isotopes".

○ My mix of isotopes
○ Nature's mix of isotopes

b. For one of the elements you used in part 1 look at the colored spheres on the left side of the screen. What do you think the spheres represent?

I think the spheres represent the protons, neutrons, and electrons.

c. Now, look at the percent abundances and average atomic mass for each element you previously chose. How closely do your calculated values come to matching the value listed?

<table>
<thead>
<tr>
<th>Element</th>
<th>Calculated ave. atomic mass</th>
<th>Listed ave. atomic mass</th>
<th>Difference between calculated and listed masses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Oxygen</td>
<td>15.9991</td>
<td>15.9940</td>
<td>0.00449 amu</td>
</tr>
<tr>
<td>2) Lithium</td>
<td>7.01600</td>
<td>6.94100</td>
<td>0.075 amu</td>
</tr>
<tr>
<td>3) Beryllium</td>
<td>9.01218</td>
<td>9.01218</td>
<td>0.000 amu</td>
</tr>
</tbody>
</table>

Why might there be a difference between your calculated mass and the listed mass?

The listed mass identifies the closest average number to the mass and the calculated mass was identified.

Learning Goals:
1. Understand that different elements have different percent compositions of isotopes in nature.

2. Calculate the average atomic mass using the masses of the isotopes of an element.
Thickness of a thin layer

Purpose
Can we determine the thickness of a very thin object with the skills we have learned this year?

Equipment
- Regular aluminum foil
- Heavy duty aluminum foil
- Ruler
- Scale

Procedure
1. Obtain a piece of regular and heavy duty foil
2. Determine the area of each piece of foil
3. Determine the mass of each piece of foil
4. Calculate the thickness of the foil
   - Hint the density of Aluminum is 2.7 g/cm³
5. Clean-up your lab station

Data

<table>
<thead>
<tr>
<th></th>
<th>Regular Foil</th>
<th>Heavy duty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (cm)</td>
<td>9.3</td>
<td>9.1</td>
</tr>
<tr>
<td>Width (cm)</td>
<td>9.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Area (cm²)</td>
<td>91.14</td>
<td>87.36</td>
</tr>
<tr>
<td>Mass (g)</td>
<td>0.42</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Calculations
1. Area of regular foil
   \[ \text{Area}_{\text{regular}} = 91.14 \text{ cm}^2 \]
2. Area of heavy duty foil
   \[ \text{Area}_{\text{heavy duty}} = 87.36 \text{ cm}^2 \]
3. Thickness of regular foil
   \[ \text{Thickness} = \frac{0.42 \text{ g}}{2.7 \text{ g/cm}^3} = 0.015 \text{ cm} \]
4. Thickness of heavy duty foil
   \[ \text{Thickness} = \frac{0.52 \text{ g}}{2.7 \text{ g/cm}^3} = 0.019 \text{ cm} \]
Questions

1. What is the maximum size (diameter) of an aluminum atom?
   Heavy = 0.192192  Regular = 0.145824

2. Sketch a side view of the foil including atoms.

3. Given the fact that the accepted value for the diameter of an aluminum atom is $2.9 \times 10^{-8}$ cm, how many atoms thick is the regular and heavy duty foil?
   Heavy = $6.38 \times 10^{-12}$  Regular = $4.6 \times 10^{-11}$

Conclusion

We can determine the thickness by doing a railroad track or converting the units from foil to cm$^3$. 
Pennium Lab
Half-life and Average Atomic Mass

In this lab we are assuming that we have found a new element called pennium. Each penny represents an atom of this new element. In this lab we are going to help describe this element. Below are the instructions to determine the half-life of this radioactive element and its average atomic mass.

Half-life
Discussion
Every atom of pennium is radioactive. We are going to assume that when a coin is tails it has decayed.

Procedure
1. Double check that there are 100 pennies in your plastic container.
2. Place all of the pennies heads up in the container.
3. Shake the plastic container 5 times. Each shake is one year.
4. Count and remove all of the tails.
5. Record your data.
6. Repeat steps 3-5 until no pennies remain.
7. Graph your data.

Data Table

<table>
<thead>
<tr>
<th>Heads Pennium Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>46</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>33</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

*Graph on back*
**Average atomic mass**

**Discussion**

We know that there are two isotopes of pennium. For our purposes it is important to realize that before 1982 pennies were solid copper. Now pennies have a zinc center coated with copper. This causes the two types of pennies to have different masses. To determine the average atomic mass of pennium we need to find the percent abundance of these two isotopes and the average mass of each isotope.

**Procedure**

1. Mass each atom of pennium and record the measurement in the data table. Be sure to put the data in the correct column.
2. Average the masses in each column.
3. Calculate the percent abundance of each isotope.
4. Calculate the average atomic mass of pennium.

**Data**

<table>
<thead>
<tr>
<th>Mass of Pre 82 pennies (grams)</th>
<th>Mass of Post 82 pennies (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.09</td>
<td>2.51</td>
</tr>
<tr>
<td>3.10</td>
<td>2.49</td>
</tr>
<tr>
<td>3.01</td>
<td>2.49</td>
</tr>
<tr>
<td>3.12</td>
<td>2.50</td>
</tr>
<tr>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>2.48</td>
<td>2.50</td>
</tr>
<tr>
<td>2.50</td>
<td>2.48</td>
</tr>
<tr>
<td>2.53</td>
<td>2.50</td>
</tr>
<tr>
<td>2.47</td>
<td>2.47</td>
</tr>
<tr>
<td>2.49</td>
<td>2.49</td>
</tr>
<tr>
<td>2.52</td>
<td></td>
</tr>
</tbody>
</table>

Average Mass = 3.08

Percent Abundance = 20%

Average Mass = 2.49

Percent Abundance = 80%

**Calculations**

What is the value should be reported for the average atomic mass of pennium?

\[
(3.08 \times 20\%) + (2.49 \times 80\%) = 2.608 \text{ amu.}
\]
Make a graph
Label axes: X-axis time in years and Y-axis atoms of pennium (heads)

Title: Pennium

Remember to use the whole graph (make an appropriate scale)
Connect the dots in a curve.
Read the half-life from the graph
Years required to go from 100 to 50 atoms \( 2 \) years
Years required to go from 50 to 25 atoms \( 3.4 \) years
Years required to go from 25 to 12.5 atoms \( 4.1 \) years

What is the average half-life of pennium?
\( 3.167 \) years
# Homework Coversheet

**Unit 2**

## Homework Grading

<table>
<thead>
<tr>
<th>Notes</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1 Atomic Theory</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Day 2 Atomic Theory</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Day 3 Atomic Theory</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Day 4 Radioactivity</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Day 5 Radioactivity</td>
<td>10 /10 pts</td>
</tr>
</tbody>
</table>

## Homework

<table>
<thead>
<tr>
<th>Notes</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern Atomic Theory (blue)</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Average Atomic Mass (yellow)</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Atoms Across (blue)</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Nuclear Equations (yellow)</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Half Life (blue)</td>
<td>10 /10 pts</td>
</tr>
<tr>
<td>Review: Atomic theory &amp; Radioactivity (green)</td>
<td>10 /10 pts</td>
</tr>
</tbody>
</table>

### Total Points:

123 / 125 points

Test = 90%
Build an Atom Activity

Google PHET Chemistry
https://phet.colorado.edu/en/simulations/category/chemistry

Select "Build an Atom"

Click Play

When open, press "Atom"

Now build a standard Carbon and write down how many protons, neutrons, and electrons are present.

P = 6
N = 6
e- = 6
Make sure the box "Stable/Unstable" is checked

Show

☑️ Element Name
☑️ Neutral/Ion
☑️ Stable/Unstable

Now take the Carbon atom you have made and start adding or taking away neutrons. Record whether the atom is marked as stable or unstable.

<table>
<thead>
<tr>
<th>Mass Number</th>
<th>Stable or Unstable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Unstable</td>
</tr>
<tr>
<td>11</td>
<td>Unstable</td>
</tr>
<tr>
<td>12</td>
<td>Stable</td>
</tr>
<tr>
<td>13</td>
<td>Stable</td>
</tr>
<tr>
<td>14</td>
<td>Unstable</td>
</tr>
</tbody>
</table>

Why do you think the atom becomes unstable?

Because it can't support the difference in weight.

Now click the game button on the bottom of the webpage

Play each game. To pass this activity, you must score a perfect ten on each game in under 30 seconds. Show your teacher when you have completed a game and they will sign you off in the boxes below.
Lego Activity

Goal
Build as many combinations of Legos with as much variety as possible using only the Legos supplied in your cup. After building a combination sketch it in the box. Then recycle its pieces to make a new combination.

Rules
1. The # of white pieces = # of green pieces
2. To build a structure with more than one green then the # of black pieces ≥ # green
3. The # of blacks can not be greater than twice the # of greens

You can only build combinations that obey the three rules.

When done:
Separate all Legos in cup
Place lid back on tightly
What does the green Lego represent?
- proton

What does the white Lego represent?
- electron

What does the black Lego represent?
- neutron

Place your combinations in a logical order

Summarize what you learned
- you can make a ton of different things + combinations even following the 3 rules.

Explain your logical order
- I went from simple to complex
Isotopes & Atomic Mass

Google PHET Chemistry
(https://phet.colorado.edu/en/simulations/category/chemistry)
Select "Isotopes & Atomic Mass"

Procedure:
1. Open the program and start out at the "Make Isotopes" tab.
   - Select an element other than H. Beneath the scale in the center of the screen
     click "Atomic Mass (amu)".
   - Open the "Symbol" and "Abundance in Nature" tabs.

2. Choose an element and perform the following procedure:
   a. Add neutrons one at a time; record the symbol as shown. For each
      neutron added, they also indicate the percent abundance.
   b. Remove neutrons from the original elements, record the symbol and
      percent abundance.
   c. From the percent abundance and the atomic masses calculate the
      average atomic mass for the elements.
   d. Repeat this for 2 more elements.

Example:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron-45</td>
<td>0 (unstable)</td>
<td>45.01458 (it may not report the mass if it is unstable. If so, make a hash ---)</td>
</tr>
<tr>
<td>Iron-54</td>
<td>5.845</td>
<td>53.93961</td>
</tr>
<tr>
<td>Iron-57</td>
<td>2.119</td>
<td>56.93539</td>
</tr>
<tr>
<td>Iron-58</td>
<td>0.262</td>
<td>57.93327</td>
</tr>
<tr>
<td>Iron-56</td>
<td>91.754</td>
<td>55.93432</td>
</tr>
</tbody>
</table>

Average atomic mass: 55.84520 amu (we ignore Fe because it is not abundant in nature).

Element 1

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orogen 12</td>
<td>76.93</td>
<td>16.00</td>
</tr>
<tr>
<td>Orogen 13</td>
<td>23.07</td>
<td>16.00</td>
</tr>
<tr>
<td>(Carbon 15)</td>
<td>variable</td>
<td></td>
</tr>
<tr>
<td>(Carbon 14)</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Average atomic mass: 12.01

Element 2

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron 11</td>
<td>80.19</td>
<td>11.00</td>
</tr>
<tr>
<td>Boron 10</td>
<td>19.81</td>
<td>11.00</td>
</tr>
<tr>
<td>(Boron 15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Boron 14)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average atomic mass: 8.93

Element 3

<table>
<thead>
<tr>
<th>Isotope</th>
<th>% Abundance</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen 18</td>
<td>98.57</td>
<td>15.9994</td>
</tr>
<tr>
<td>Oxygen 17</td>
<td>1.43</td>
<td></td>
</tr>
<tr>
<td>Oxygen 16</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

Average atomic mass: 15.994
e. What changed as you added or removed neutrons?

f. What did not change?

The element itself

3. Go to the "Mix Isotopes" tab.

Mix Isotopes

a. Choose "Nature's mix of isotopes".

○ My mix of isotopes
○ Nature's mix of isotopes

b. For one of the elements you used in part 1 look at the colored spheres on the left side of the screen. What do you think the spheres represent?

\[ \text{percent composition? Does this show abundance?} \]

\[ \text{Percent composition?} \]

\[ \text{show abundance?} \]

c. Now, look at the percent abundances and average atomic mass for each element you previously chose. How closely do your calculated values come to matching the value listed?

<table>
<thead>
<tr>
<th>Element</th>
<th>Calculated ave. atomic mass</th>
<th>Listed ave. atomic mass</th>
<th>Difference between calculated and listed masses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Carbon</td>
<td>12.01</td>
<td>12.01070</td>
<td>0.0007</td>
</tr>
<tr>
<td>2) Boron</td>
<td>8.43</td>
<td>10.911</td>
<td>1.481</td>
</tr>
<tr>
<td>3) Oxygen</td>
<td>15.9945</td>
<td>15.9994</td>
<td>0</td>
</tr>
</tbody>
</table>

Why might there be a difference between your calculated mass and the listed mass?

I didn't wanna write out all decimals, so I just rounded.

Learning Goals:

1. Understand that different elements have different percent compositions of isotopes in nature.

2. Calculate the average atomic mass using the masses of the isotopes of an element.
\[ (12 \times 99.93) + (0.0107 \times 13.00235) + (0 \times 14.00324) = 12.01 \text{ (0)} \]

\[ (11.00931 \times 8.01) + (10.01204 \times 0.0107) = 90.93 \]

\[ (15.99491 \times 9.9757) + (14.9913 \times 0.0038) + (17.9916 \times 0.00205) = 15.9994 \]
Thickness of a thin layer

Purpose
Can we determine the thickness of a very thin object with the skills we have learned this year?

Equipment
- Regular aluminum foil
- Heavy duty aluminum foil
- Ruler
- Scale

Procedure
1. Obtain a piece of regular and heavy duty foil
2. Determine the area of each piece of foil
3. Determine the mass of each piece of foil
4. Calculate the thickness of the foil
   - Hint: the density of Aluminum is 2.7 g/cm³
5. Clean-up your lab station

Data

<table>
<thead>
<tr>
<th></th>
<th>Regular Foil</th>
<th>Heavy duty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (cm)</td>
<td>9.6</td>
<td>8.5</td>
</tr>
<tr>
<td>Width (cm)</td>
<td>10</td>
<td>10.9</td>
</tr>
<tr>
<td>Area (cm²)</td>
<td>95</td>
<td>92.65</td>
</tr>
<tr>
<td>Mass (g)</td>
<td>0.41</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Calculations
1. Area of regular foil
   \[ 95 \text{ cm}^2 \]
2. Area of heavy duty foil
   \[ 92.65 \text{ cm}^2 \]
3. Thickness of regular foil
   \[ 0.0015918441 \]
4. Thickness of heavy duty foil
   \[ 0.002198637 \]
Questions
1. What is the maximum size (diameter) of an aluminum atom?  
   \[ \text{192 pm} \]
2. Sketch a side view of the foil including atoms.
3. Given the fact that the accepted value for the diameter of an aluminum atom is \(2.9 \times 10^{-8}\) cm, how many atoms thick is the regular and heavy duty foil?

\[
\text{Regular: } \frac{0.01598991}{2.9 \times 10^{-8}} = 535.18458 \\
\text{Heavy Duty: } \frac{0.02198637}{2.9 \times 10^{-8}} = 758.15406397
\]

Conclusion
It takes a lot of steps to find out the amount of atoms in things.
Pennium Lab
Half-life and Average Atomic Mass

In this lab we are assuming that we have found a new element called pennium. Each penny represents an atom of this new element. In this lab we are going to help describe this element. Below are the instructions to determine the half-life of this radioactive element and its average atomic mass.

**Half-life**

**Discussion**
Every atom of pennium is radioactive. We are going to assume that when a coin is tails it has decayed.

**Procedure**
1. Double check that there are 100 pennies in your plastic container.
2. Place all of the pennies heads up in the container.
3. Shake the plastic container 5 times. Each shake is one year.
4. Count and remove all of the tails.
5. Record your data.
6. Repeat steps 3-5 until no pennies remain.
7. Graph your data.

**Data Table**

<table>
<thead>
<tr>
<th>Heads Pennium Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>96</td>
</tr>
<tr>
<td>91</td>
</tr>
<tr>
<td>87</td>
</tr>
<tr>
<td>82</td>
</tr>
<tr>
<td>79</td>
</tr>
<tr>
<td>76</td>
</tr>
<tr>
<td>72</td>
</tr>
<tr>
<td>69</td>
</tr>
<tr>
<td>66</td>
</tr>
<tr>
<td>63</td>
</tr>
<tr>
<td>60</td>
</tr>
</tbody>
</table>

*Graph on back*
**Average atomic mass**

**Discussion**

We know that there are two isotopes of pennium. For our purposes it is important to realize that before 1982 pennies were solid copper. Now pennies have a zinc center coated with copper. This causes the two types of pennies to have different masses. To determine the average atomic mass of pennium we need to find the percent abundance of these two isotopes and the average mass of each isotope.

**Procedure**

1. **Mass** each atom of pennium and record the measurement in the data table. Be sure to put the data in the correct column.
2. **Average** the masses in each column.
3. **Calculate** the percent abundance of each isotope.
4. **Calculate** the average atomic mass of pennium.

**Data**

<table>
<thead>
<tr>
<th>Mass of Pre 82 pennies (grams)</th>
<th>Mass of Post 82 pennies (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.07</td>
<td>2.49</td>
</tr>
<tr>
<td>2.49</td>
<td></td>
</tr>
<tr>
<td>2.51</td>
<td></td>
</tr>
<tr>
<td>2.51</td>
<td></td>
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<td>2.51</td>
<td></td>
</tr>
<tr>
<td>2.51</td>
<td></td>
</tr>
<tr>
<td>2.51</td>
<td></td>
</tr>
</tbody>
</table>

**Calculations**

What is the value should be reported for the average atomic mass of pennium?

\[
(3.07 \times 2) + (2.49 \times 8) = 2.606
\]
Make a graph
Label axies: X-axis time in years and Y-axis atoms of pennium (heads)

Title: Pennium Decay

Remember to use the whole graph (make an appropriate scale)
Connect the dots in a curve.
Read the half-life from the graph

- Years required to go from 100 to 50 atoms: 5 years
- Years required to go from 50 to 25 atoms: 5 years
- Years required to go from 25 to 12.5 atoms: 5 years

What is the average half-life of pennium?

5 years