Chemistry

Sample Science Learning Plan

Big Idea/ Topic

Atomic theory and characteristics of atoms and elements

Standard Alignment

SC1. Obtain, evaluate, and communicate information about the use of the modern atomic theory and periodic law to explain the characteristics of atoms and elements.

a. Evaluate merits and limitations of different models of the atom in relation to relative size, charge, and position of protons, neutrons, and electrons in the atom.
b. Construct an argument to support the claim that the proton (and not the neutron or electron) defines the element's identity.
c. Construct an explanation based on scientific evidence of the production of elements heavier than hydrogen by nuclear fusion.
d. Construct an explanation that relates the relative abundance of isotopes of a particular element to the atomic mass of the element.

Connection to other content areas:

ELAGSE11-12RI1: Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

ELAGSE11-12RI7: Integrate and evaluate multiple sources of information presented indifferent media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.

ELAGSE11-12W1: Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

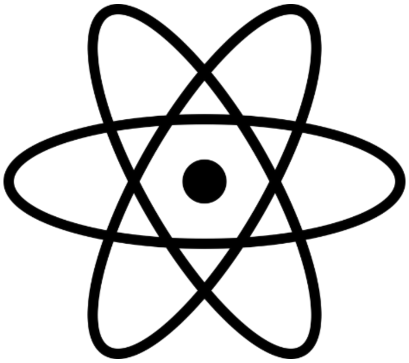
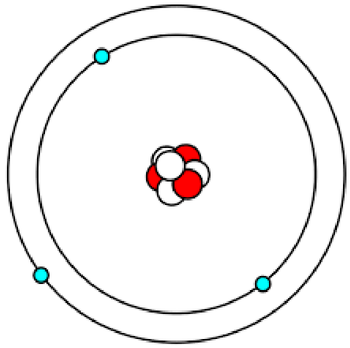
Instructional Design

Engage:

Phenomenon: How do we know so much about atoms when we cannot see them directly?

Students have explored atomic structure in either eighth grade science or physical science and were introduced to subatomic particles also; in chemistry we go in depth about different atomic models and explore new topics too. In this learning segment, students will construct atomic models, explore different models of the atom, learn about atomic structure and element production.

When we think about atoms, these pictures might come to mind:

But how do we know this is what atoms look like when we cannot see them? Before exploring the history of atomic models, students will build a model to see the scale.

Build a model:

A scale model of an atom can be made by students in their homes. This will give students an idea of how the subatomic particles are arranged. A scale of the hydrogen atom could be approximated to be as follows: the nucleus being 1 mm wide and the atomic diameter as 6 m wide. The model could be proposed as a question/challenge to students:

If you made a model of a single hydrogen atom—what would it look like? On a piece of paper, draw a single dot the width of the pencil lead. If this was the center of the atom, where would the rest of it be? Remind students (or they may remember) that hydrogen has only one proton and one electron.

Allow students to complete an initial model or engage in discussion with others about what it might look like. If this was a scale model, the nucleus would be about 1 mm and the entire diameter would be about 6 m. As students measured this out at home, they might be surprised to see so much empty space. This could lead to a great class discussion.

Potential questions for this part of the segment:

- When you made your model, how big did you make the entire atom?
- How do we know there is so much empty space in the atom?
- Do atoms other than hydrogen have as much empty space?

Unplugged: students can still construct their atomic models and respond asynchronously to the discussion questions. An option is for students to maintain a science journal during distance learning to include responses to phenomenon prompts and other work from learning segments.

Explore:

To learn more about models of the atom, have students use the following simulation:

Rutherford Scattering; PhET Interactive Simulations University of Colorado Boulder
https://phet.colorado.edu

Using the simulation, students complete Atomic Model Simulation Student Sheet. As students complete work, there are multiple points where class discussions would be useful.

Unplugged: students could read about the various models and create diagrams of each showing the proposed atomic structures. Optional sources for content material include Georgia Virtual School and GPB: Chemistry Matters. Selections from online textbooks could also be used to provide a print resource or remain digital, such as OpenStax Chemistry.

Explain:

In this part of the segment, students learn more about the various atomic models, the content can be delivered asynchronously or together using technology to discuss as a group. One option for distance is to use a video, such as Crash Course Chemistry: The History of Atomic Chemistry and to utilize guided notes for students to use also.

Atomic models guided notes with blanks

Atomic models guided notes complete

Another option is to use an organizer that compares the different atomic models, such as: A History of the Atom: Theories and Models

Unplugged: students could have access to completed notes, articles, or other sources and discussion questions in printed form.

Elaborate:

In this section, students build on their understandings of atomic structure using the PhET Simulation: Build an Atom; PhET Interactive Simulations University of Colorado Boulder https://phet.colorado.edu

Students will be searching for patterns in atomic structure as they construct arguments about proton number and element identity. The simulation also includes a game that can be used as a formative assessment of understanding.

Build and Atom Student Sheet

At the end of the simulation task students will construct an argument for what particle determines the element's identity. A focus should be placed on using evidence from models, research, and other class materials when students are writing arguments.

After completing the atom simulation, students construct explanations about isotope abundance and average atomic mass. In the simulation, students should have noticed that the mass number for the element did not match the mass of the element on the periodic table; this leads into a discussion of isotope abundance. Students can complete the Isotope Questions.

Students elaborate on atomic theory and models to construct an argument about element formation by fusion. An optional resource to use: NASA Educator's Corner or NOVA video.

The Fusion Student Sheet provides data and questions for students to guide their argument writing about element formation.

Unplugged: Students could use the same Build an Atom Student Sheet without the simulation. They could use other materials to model and diagram the atoms. Students would need support in using the periodic table to identify elements and their properties, as well as subatomic particle arrangement.

Evaluate:

The following sorting activities can be used to assess understanding. This could be done electronically with a quiz website, as a whole group, or unplugged for each student individually.

Five Minute Sort: Atomic Models/Atomic Numbers

Students should demonstrate their understanding as they communicate verbally and through written work about atomic models and structure.

Lesson Goals Checklist

SC1. Obtain, evaluate, and communicate information about the use of the modern atomic theory and periodic law to explain the characteristics of atoms and elements.

- ☐ Evaluate the merits and limitations of different models of the atom in relation to
  - ☐ Relative size of protons, neutrons, and electrons
  - ☐ Charge of protons, neutrons, and electrons
  - ☐ Position of protons, neutrons, and electrons
- ☐ Construct an argument to support the claim that the proton defines the element's identity.
- ☐ Construct an explanation based on scientific evidence of the production of elements heavier than hydrogen by nuclear fusion.
- ☐ Construct an explanation that relates the relative abundance of isotopes of a particular element to the atomic mass of the element.

Evidence of Student Success
Student mastery is assessed throughout this unit using formative and summative components. Student discussion, explanations and products should reflect the understanding indicated in the Evaluate section above. Each activity in the segment functions as an assessment opportunity as well to plan targeted supports or provide extension items. Formative options using the self-evaluation checklist and the sorting activity at various points during the segment.

Student Learning Supports
The goal for science education in the state of Georgia is as follows: All Students, over multiple years of school, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields. The learning experiences provided for students should engage them with fundamental questions about the world and with how scientists have investigated and found answers to those questions.

This lesson includes the disciplinary core ideas, science and engineering practices and crosscutting concepts to actively engage students in exploring science concepts with real world topics. As part of the vision we must support the inclusion of all students in science learning. Some **general** ideas to assist in supporting students that struggle are as follows:

- Be sure that students can access the information that you they are learning. Make sure that you can answer the following questions:
    - Do students have what they need to get the information? This is about them having the book or internet access to get to the information.
    - Once students obtain the information, are students able to determine what information is important? This is about the students having materials on the appropriate grade level and that is in a format that students can understand.
    - Is the material presented in multiple ways that allows all students to interact with information in a way that works for them? Such as video, audio, and articles.
    - Consider read aloud as a potential option for students that have reading deficits as a option to assist students in accessing the material. This could be done using video or via phone.
- Students may need ideas about where to find information. Providing students with information about what a reliable source is and even where to find reliable sources may be beneficial for students.
- Some students may find it difficult to complete the entire lesson workload. Some students may benefit from a reduced workload (note: this should be used only when absolutely necessary). Be sure that the information that is removed will not negatively impact the student's understanding of the disciplinary core idea.
- Consider how students show their knowledge. Students need multiple ways and opportunities to show their knowledge. Things to consider:
    - Recording video or audio
    - Drawing
    - Writing
    - Typed
    - Verbal
- Provide students with a way to ask questions in a forum that does not cause anxiety. Frequently students do not want to ask questions in front of their peers because they are afraid of what their peers may think of them. So, be sure to provide students a way to ask questions that is private or anonymous.
- Consider materials that students need to complete the assignments.
    - Do students have needed materials?
    - What are some alternative materials that students may have available to them?
- Have a clear and consistent set of guidelines for providing consistent feedback to all students.
- Utilize graphic organizers such as those from the Wonderofscience.com
- Use high leverage and evidence-based practices to reach all students.

Some things to consider, **specific to this lesson**, when designing supports for students are as follows:

- When giving measurements it might be beneficial to give the measurements in meters and then in feet. Many students will not have access to a meter stick at home but will either have a tape measure or a concept of how long feet are.
- Show students what the model might look like and how much free space the students should have had in their model.
- The teacher should consider providing student with a way to read articles and text out loud. This can be done using read aloud via video chat, telephone, video, text-to-speech features or programs.

- The teacher should make sure that videos that are include in the lesson have a closed caption option.
    - Consider teaching students to turn on/off closed captions so that students can use them or not as needed. Some students will find it helpful and other students will find it distracting.
- The teacher should consider providing students with sources to use in their research.
    - The teacher should, also, consider teaching students how to identify reliable sources.
    - The teacher should, also, consider modeling for students how to identify the important information contained in the text.
- The teacher should have clear and consistent guidelines for how students should ask questions.
- The teacher should have clear and consistent guidelines for discussions.
- The teacher should consider using guiding questions to help students work through the lesson.
- The teacher should consider providing students with rubrics to help students understand the expectation and self-evaluate their work.
- The teacher should provide multiple formats for students to show their knowledge. Students should be able to choose what best suits their needs. These formats could include written, video or verbally explaining.

Engaging Families

Additional resources to support chemistry understandings in this segment include Georgia Virtual School and GPB: Chemistry Matters. Selections from online textbooks could also be used to provide a print resource or remain digital, such as OpenStax Chemistry.

Atomic Model Simulation Student Sheet

Link to simulation: [Rutherford Scattering]

Using the Plum Pudding Atom simulation, answer the following questions:

1. Describe the atomic model proposed by J.J Thomson.
2. What happens as alpha particles are shot through this model of the atom?
3. Draw what the model looks like when the particles are sent through the material.
4. How is positive charge represented in this model?

Using the Rutherford Atom simulation, answer the following questions:

5. What happens as alpha particles are shot through the gold foil?
6. Draw what models looks like when the particles are sent through the material.
7. Ernest Rutherford: what are two conclusions from the Gold Foil Experiment?
8. If you increase the mass of the atoms that are being bombarded with alpha particles—what happens? Why do you think this occurs?
9. What is an alpha particle? Explain why it would be deflected from the nucleus.

The History of Atomic Chemistry Guided Notes

Video Link

Greek Philosopher Leucippus and his student _____________ "Matter is composed of _______"

-Named them "__________"—meaning uncuttable or indivisible

- properties of each substance was due to the particles they were made of

Next major development came ______years later:

________________-Law of conservation of mass: even if matter changes shape or form, its __________stays the __________

John Dalton- elements exist as _______________

Not in Video: -Developed an atomic theory based on experiments:

- Everything is made of atoms, atoms cannot be destroyed
- Atoms of the same element are identical
- Atoms of different elements have different sizes and masses
- Compounds are formed when atoms combine in whole-number amounts
- A chemical reaction occurs when atoms rearrange

In the 1870s, scientists experimented with discharge tubes (gas filled tubes with electrodes at each end and light is emitted from positive and negative electrodes)

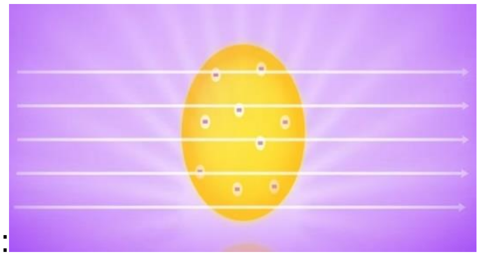
J.J. Thomson: able to estimate the ________ of the rays in the cathode ray; he found it to be 1000 times lighter than _________; he concluded that the rays were made of small, negatively-charged particles; he called them "________________" (electrons)

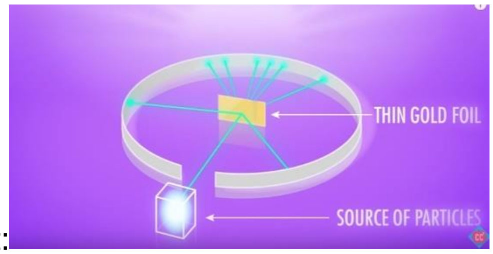
How were the particles arranged in the atom?

Describe the model proposed by Thomson:

The nickname given this model:

Ernest Rutherford: in 1909; did an experiment with a thin sheet of ___________ and a screen. He bombarded the foil with _______________.

The expectation: 

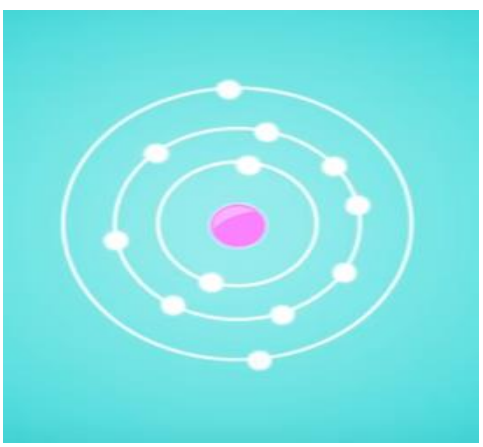
The result: 

Describe the significance of the experimental result:

The entire positive charge in an atom must be concentrated in a very small area→ the nucleus

Most of the atom is ____________.

___________: in 1911 through calculation and experiment, predict the most likely ________ of the electrons in the atom. Called the planetary model (Label the picture):



<u>**Werner Heisenberg:**</u> it is impossible to know with certainty both the ________ of an electron and its exact __________; this led to:

_______________- electrons have properties of waves and particles; the arrangement of electrons can only be described in terms of __________. There are certain regions where an electron is most likely to be found.

These regions are called _____________

-s,p,d,f

The History of Atomic Chemistry—Guided Notes--Completed

Video Link

Greek Philosopher Leucippus and his student Democritus "Matter is composed of tiny particles"

-Named them "a tomos"—meaning uncuttable or indivisible

- properties of each substance was due to the particles they were made of

Next major development came 2300 years later:

Antoine Lavosier-Law of conservation of mass: even if matter changes shape or form, its mass stays the same

John Dalton- elements exist as discreet packets of matter

Not in Video: -Developed an atomic theory based on experiments:

- Everything is made of atoms, atoms cannot be destroyed
- Atoms of the same element are identical
- Atoms of different elements have different sizes and masses
- Compounds are formed when atoms combine in whole-number amounts
- A chemical reaction occurs when atoms rearrange

In the 1870s, scientists experimented with discharge tubes (gas filled tubes with electrodes at each end and light is emitted from positive and negative electrodes)

J.J. Thomson: able to estimate the mass of the rays in the cathode ray; he found it to be 1000 times lighter than hydrogen; he concluded that the rays were made of small, negatively-charged particles; he called them "corpuscles" (electrons)

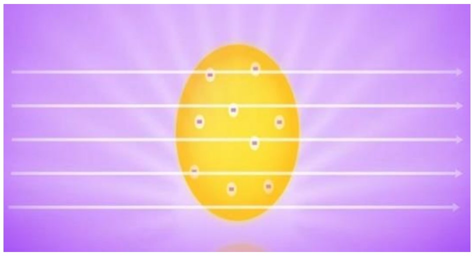
How were the particles arranged in the atom?

Describe the model proposed by Thomson:

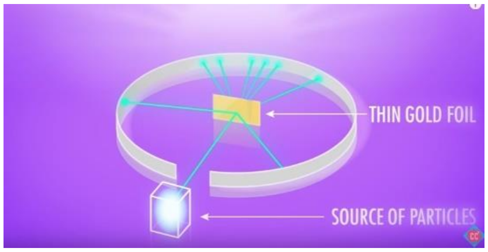
The nickname given this model:

Ernest Rutherford: in 1909; did an experiment with a thin sheet of gold foil and a screen. He bombarded the foil with alpha particles.

The expectation:



The result:

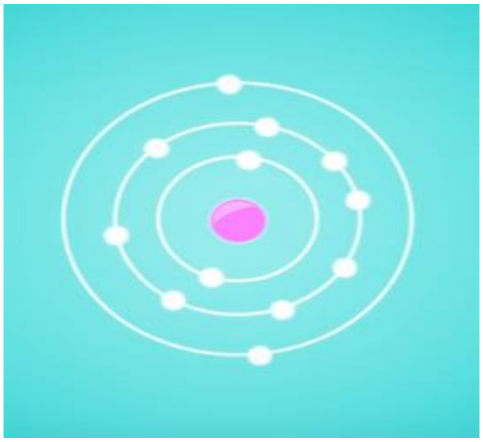


Describe the significance of the experimental result:

The entire positive charge in an atom must be concentrated in a very small area the nucleus

Most of the atom is empty space;

Niels Bohr: in 1911 through calculation and experiment, predict the most likely positions of the electrons in the atom. Called the planetary model:



Werner Heisenberg: it is impossible to know with certainty both the momentum of an electron and its exact position; this led to:

Quantum Theory- electrons have properties of waves and particles; the arrangement of electrons can only be described in terms of probability. There are certain regions where an electron is most likely to be found.

These regions are called Orbitals:

-s,p,d,f

Build an Atom Student Sheet

Simulation link: [Build an Atom]

Directions:

Open the Build an atom simulation and explore the functions and how to change particles.

Make five different atoms that have a stable nucleus and complete the following:

Atom:	1	2	3	4	5
Draw the nucleus					
Element identity					
Particles	Protons:____ Neutrons:___ Electrons: ___	Protons:____ Neutrons:___ Electrons: ___	Protons:____ Neutrons:___ Electrons: ___	Protons:____ Neutrons:___ Electrons: ___	Protons:____ Neutrons:___ Electrons: ___

1. What happens when the proton number changes? Explain.
2. What determines the mass of the atoms? Explain.
3. Why would an atom be stable or unstable?
4. What particles are heavy and light?
5. What determines if the atom is neutral, negative ion, or positive ion? Draw an example of each.
6. Draw a stable atom with a mass number of 12 that is neutral.

7. Draw a stable atom with a mass number of 16, atomic number of 8, with a -2 charge.
8. Construct an argument: what particle determines the atom's identity? How do you know? Construct an argument using evidence from the simulation to explain what determines the identity of an atom.

Isotope Questions

1. The majority of an atom's mass is due to these two particles:
2. Why do the particles above comprise most of the atom's mass?
3. What is the atomic mass unit? What is based on?
4. What is an isotope?
5. The atomic mass for Magnesium is 24.305 amu. It has three stable isotopes:
    a. Mg-24 with a mass of 23.98
    b. Mg-25 with a mass of 24.98
    c. Mg-26 with a mass of 25.98

    The isotopes are not equal in abundance; construct an explanation for what isotope should be the most abundant.

6. Determine the atomic mass of the following fictitious element:
    Isotope 1: 17.44 amu, 85.40 % abundance

    Isotope 2: 16.92 amu, 14.60% abundance

    Show your work.

7. Use the following information about a fictitious element to solve the problem:
    Isotope 1: 87.55 amu, 55.40% abundance

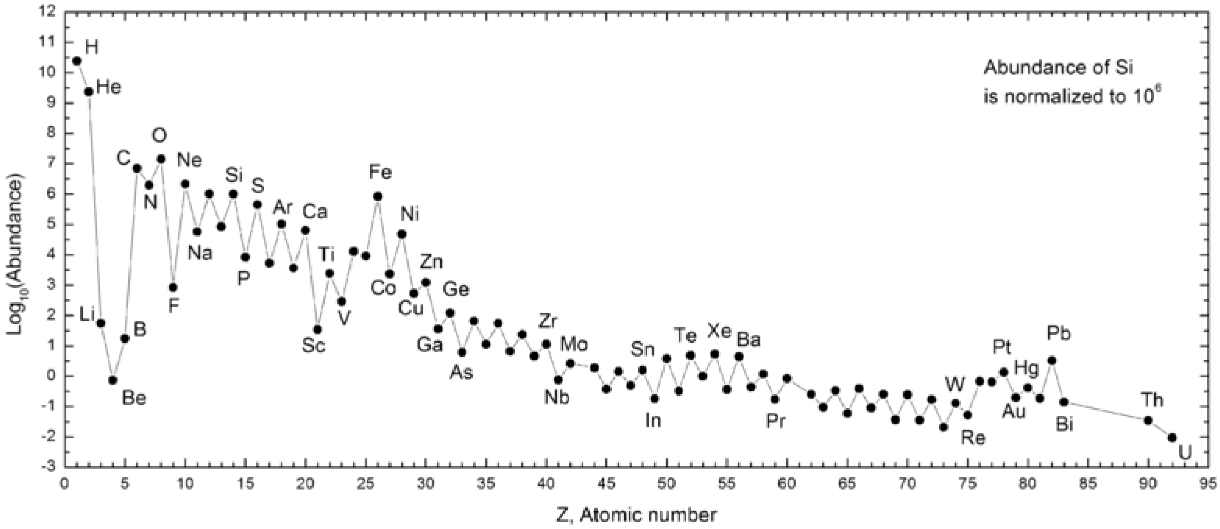
    Isotope 2: 89.35 amu, 23.50 % abundance

    Isotope 3: ______ amu, ______% abundance

    The average atomic mass of this element is 86.95 amu. Solve for the missing information about isotope 3. Show your work.

Fusion Student Sheet

The following chart shows the abundances of elements in our solar system.



1. Why do you think hydrogen and helium are the most abundant by far?
2. Why are heavier elements much less abundant?
3. Briefly describes the steps in a star's life cycle.
4. At what point in the life cycle are elements (other than helium) formed? How?
5. In a star, fusion stops with iron. Why? How are elements heavier than this formed?
6. What is cosmic microwave background radiation?
7. What evidence exists that lead scientists to make these conclusions?

Five Minute Sort: Atomic Models/Atomic Numbers

Teacher directions: Students sort the following into the correct category. This could be printed for students as an unplugged assessment, done in groups, or using a quiz website. Additional items can be added as well.

Categories: Proton Electron Neutron

Items to sort:

Magnesium has 12

Fe^{2+} has 24

Located in the nucleus

Gold has 79

Less massive than other particles

Silicon-30 has 16

P^{3-} has 15

Magnesium has 12

If this changes, the element identification changes

P has 15

Silicon-30 has 14

S^{2-} has 18

P^{3-} has 18

More massive

A change in this yields isotopes

Has net negative charge

Has a net neutral charge

Discovered with cathode ray tube

P has 15

Fe^{2+} has 26

Mg^{2+} has 10

Uranium-238 has 92

A change in this does not change the identification of the element

Uranium-238 has 146

S^{2-} has 16

Silicon-30 has 14

A loss or gain changes the charge

More massive than other particles

Located in the nucleus

Carbon-14 has 8

Has a net positive charge

P has 16

Mg^{2+} has 12

S^{2-} has 16

Magnesium has 12

Determines the type of element

Fe^{2+} has 30

An atom of lead has 125

Not in nucleus

Mg^{2+} has 12

P^{3-} has 16