Course: *Chemistry* **Unit #:** *1: The Chemical Universe*	**Year of Implementation:** 2021-2022

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Stage One - Desired Results

Link(s) to New Jersey Student Learning Standards for this course:
https://www.state.nj.us/education/cccs/2020/
https://www.nj.gov/education/cccs/2016/science/

Unit Standards:

Science and Engineering Practices
The content of this unit will strengthen student skills in the following SEPs.

- Practice 2 Developing and Using Models
- Practice 3 Planning and Carrying Out Investigations
- Practice 4 Analyzing and Interpreting Data
- Practice 5 Using Mathematics and Computational Thinking
- Practice 6 Constructing Explanations and Designing Solutions
- Practice 7 Engaging in Argument from Evidence

Performance Expectations:
The content of this unit will contribute to students ability to meet the following performance expectations:

- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms
- HS-PS2-4. Use mathematical representations of Coulomb's Law to describe and predict the electrostatic forces between objects.

- HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
- HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
- HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
- HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other
- HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter
- HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Disciplinary Core Ideas:
The content of this unit addresses partially or completely each of the following DCIs, as specified in the Knowledge and Skills statements.

PS1.A: STRUCTURE AND PROPERTIES OF MATTER
- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The repeating patterns of this table reflect patterns of outer electron states.
- The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns.
- Stable forms of matter are those in which the electric and magnetic field energy is minimized.

PS2.B: TYPES OF INTERACTIONS
- Coulomb’s law provides the mathematical models to describe and predict the effects of electrostatic forces between distant objects.
- Forces at a distance are explained by fields permeating space that can transfer energy through space.

PS3.A: DEFINITIONS OF ENERGY
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in

fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

PS3.B: CONSERVATION OF ENERGY AND ENERGY TRANSFER

- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

PS4.A: WAVE PROPERTIES

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

PS4.B: ELECTROMAGNETIC RADIATION

- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.
- Atoms of each element emit and absorb characteristic frequencies of light, and nuclear transitions have distinctive gamma ray wavelengths. These characteristics allow identification of the presence of an element, even in microscopic quantities.

ESS1.A THE UNIVERSE AND ITS STARS

- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.

NJSLS Career Readiness, Life Literacies, and Key Skills

The content of this unit will contribute to a student's ability to meet the following standards.

Creativity and Innovation

- 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas

Critical Thinking and Problem-solving

- 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving

Information and Media Literacy

- 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions

Technology Literacy

- 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

Transfer Goal: Students will be able to apply the relationship between atomic structure and the periodic table to explain a variety of real-world phenomena.

Department Goals
Students will:

- design, critique, and carry out experiments in order to investigate scientific questions and/or propose solutions.
- collect, interpret, and analyze data in order to solve a defined problem.
- apply mathematics to express relationships efficiently and accurately.
- draw evidence-based conclusions from data in order to make informed decisions.
- construct, interpret, and refine models (scientific and mathematical) to explain the physical and natural world.
- effectively communicate scientific ideas and evidence-based arguments to an appropriate audience through written and oral means.

Enduring Understandings	*Essential Questions*
Students will understand that. . .	
EU 1 continually progressing technology and scientific knowledge allow us to refine or change our understanding of atomic structure.	*EU 1* • When does a scientific model of the atom become obsolete? • Why is it important to know about the insides of atoms? • What is the significance of each subatomic particle in the atom?
EU 2 scientists use the predictable interactions of light and matter to study and identify substances.	*EU 2* • How can we be so sure of how the electrons in an atom are arranged? • How do atoms react to different types of light? • How do we know what stars are made of when they

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<td>EU 3
the organization of the periodic table results from patterns in atomic structure.</td>
<td>are so far away?
How can models predict what will happen when light and atoms interact?
EU 3
How do charged particles inside the atom affect its overall structure?
Why is the periodic table shaped that way?
How is atomic structure related to the arrangement of elements in the periodic table?
How does the arrangement of the periodic table allow us to predict how atoms will respond in different kinds of interactions?</td>
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<td><u>Knowledge</u>
Students will know . . .

EU 1
atom substructure consists of a central nucleus made of protons and neutrons that is surrounded by electrons. (PS1.A)
the arrangement of particles in a stable atom will always be one that minimizes the energy of all interacting electric and magnetic fields from each of the subatomic particles. (PS1.A)
new evidence has caused scientific knowledge of atomic structure to evolve through several models.(SEP 6)</td>
<td><u>Skills</u>
Students will be able to. . .

EU 1
create or justify a model of an atom based on available evidence. (SEP 7)
describe evidence that could be used to support a proposed atomic model. (SEP 2, 4)
identify the strengths and limitations of various historical models of the atom. (SEP 2)</td>
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• no model is perfect, but a good model is useful.(SEP 2) *EU 2* • protons and electrons can affect each other without touching because the space around any charged particle, called a field, can apply force to any other charged particle within a certain distance. (PS2.B) • energy levels in an atom are explained through a mathematical representation associated with the relative number and position of charged subatomic particles and their fields. (PS3.A) • light acts like both a particle and a wave at the same time, and some interactions are better explained by modeling only one or the other. (PS4.B) • the wavelength, frequency, and energy of a photon are all interrelated properties (PS4.A) • the effect of light on matter depends both on the energy of the photon and on the structure of the interacting atom. (PS4.B) • during the interaction of a photon with an atom the energy of the system is conserved, allowing a quantitative determination of the resulting energy changes inside the atom. (PS3.B) • atoms of each element emit and absorb characteristic frequencies of light, allowing identification of the presence of an element in a sample. (PS4.B) • the macroscopic observation of light emission is a result of energy being released by atoms. (PS3.A).	*EU 2* • identify the presence or absence of elements from atomic emission data. (SEP 3, 4) • calculate values for photons absorbed or emitted through interactions of atoms and energy. (SEP 5) • use various models, such as the Bohr model and the quantum model, to communicate different types of information about atomic structure and interactions. (SEP 2) • model the relationship between the structure of an atom and its emission spectrum.(SEP 2)

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- scientists can determine what stars are made of by observing their emission spectra and comparing them to the spectra of known elements and compounds.(ESS1.A)

EU 3

- the periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. (PS1.A)
- the repeating patterns on the periodic table reflect the patterns of outer electron states of the atoms. (PS1.A)
- atomic properties of different elements can be explained by applying Coulomb's Law to the structure of the atoms. (PS2.B)

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EU 3

- identify structural features of the atom, given only it's placement on the periodic table. (SEP 2)
- predict relative atomic properties based on an element's placement on the periodic table. (SEP2)
- justify trends in atomic properties using models that show patterns in atomic structure. (SEP 2, 6)

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Stage Two - Assessment

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<u>Other Evidence:</u>

- *Written justifications for evidence supporting a model*
- *Lab report*
- *Tests/Quizzes on:*

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- Atomic structure - changes in knowledge
    - *Atomic emission*
    - *Periodic table patterns and trends*
- *Written responses regarding application of concepts as seen in science magazine articles*

Stage Three - Instruction

<u>*Learning Plan:*</u> **Suggested Learning Activities to Include Differentiated Instruction and Interdisciplinary Connections: Each learning activity listed must be accompanied by a learning goal of A= Acquiring basic knowledge and skills, M= Making meaning and/or a T= Transfer.**

***Bolded activities are hyperlinked to a resource folder.**

Unit Phenomenon: Auroras - *Show any image or video of an aurora*

1. Brainstorm: How can you explain this phenomenon? (EU2, M)
    - Describe the phenomenon using good scientific observations.
    - What do you know about it?
    - What other things are similar to it?
        i. How are they also different from it?
        ii. What do you know about these other things?
    - Transition to realizing that we must know something about the particles and something about light
2. Teacher-directed discussion of atomic structure (EU1, A/M)
    - Think-Pair-Share: What do you know about an atom? How do we know this information about atoms?
    - Teacher-facilitated Summary of Think-Pair-Share
3. **Pudding and Clouds Activity** - new evidence advances knowledge and changes what we "know" (EU1, A/M)
    - Summarize historical evidence-based models, focus on how a model can change when new evidence is acquired.
4. **Chemistry POGIL 8 Isotopes -** Atomic/Nuclear symbols using periodic table (EU1, A)
    - Protons, neutrons, electrons

- Atomic number, atomic mass, mass number

5. Revisit the aurora phenomenon (EU2)
    - Lesson Mini-Phenomenon - Shocking! (this is meant to be a short activity, less than one period)
        i. Any video clip showing how when you shuffle your feet in socks on a carpet, you can shock someone with your finger (A/M)
            1. Nice simple explanation here, if needed: https://energized.edison.com/stories/when-we-shuffle-our-feet-on-carpet-how-does-electricity-appear#:~:text=Electric%20charges%20are%20carried%20by,the%20metal%2C%20making%20a%20spark.
        ii. Discussion: (A/M)
            1. What is that shock? What is the light?
            2. What is electricity?
            3. How did your finger get extra electrons on it?
    - Using what you now know about atoms and "shocks", propose a possible explanation for how atoms may play a role in auroras. The explanation must be both written in words and drawn as a model you create. This must include an atom and its parts as part of the explanation. (T)
        i. Students do a "gallery walk" to review and discuss the different ways these were represented, then identify specific aspects of any model (except their own) that they felt was a good way to show or explain the process. They should also discuss what made it "good" or understandable, or complete...
6. *Lesson Phenomenon* - Photograph of stars or anything in the universe that glows (EU2)
    - Discussion to determine initial ideas (record these): How do we know what stars are made of when they are so far away? (M)
    - Supernova Chemistry Lesson Plan or any emission spectra/flame tests lab (M/T)
    - **POGIL 12 Electron Energy and Light:** (A/M)
    - Discuss: Light, Energy, Wavelength, Frequency (A)
    - Practice: Calculations involving wave properties (A/M)
    - Teacher-led Discussion: Atomic Spectra vs. Flame Test colors (M)
    - NOVA Fireworks Video (in school media center) (A)

7. Application Assessment: Read ChemMatters article, October 2020, **Lighting Up the Night Sky** and complete selected student comprehension questions from Teachers Guide. (EU2, M/T)
    - Answers to these questions will assess comprehension of the processes involved in light emission in an aurora, which is similar to the process in a flame test.
8. Teacher-led discussion: Post the question "Why is the periodic table shaped that way?" (EU3)
    - Review basic PT structure from learning earlier in the unit, then do one or both of the following as appropriate:
        i. Collisions Game - Atoms: activity to show e-configurations/atomic radius trend (A/M)
            1. To use this game, you must sign up for a free teacher account through Google. Then you assign game to students in the Teacher Portal either through a class code or by connecting with Google Classroom. Site contains several student and teacher resources.
            2. Sign up here: Playmada Games
            3. Once on the game page, choose "Atoms". Play around with it before going to Teacher Portal to assign to classes.
        ii. **POGIL 13 Electron Configuration**: (A/M)
    - *Lesson Phenomenon*: Video of Li, Na, K in water (EU3, A/M)
        i. Students should record observations, determine how these are related on the PT (same group), identify the group pattern using the periodic table, and propose possible reasons for the pattern.(M)
            1. NOTE: There is also an opportunity here to ask why the resulting flames in the potassium and sodium reactions were purple and yellow, respectively (this emitted energy was previously gained in a different way than in flame tests, but it is still potassium and sodium atoms giving off energy)
            2. Small groups: Given a model or explanation to describe that these reactions occur when water attracts the valence electron away from the atom, identify differences in the 3 atoms that might explain why one would be more reactive than another. (M)
        ii. **POGIL: 11 Coulombic Attraction** (M/T)
        iii. Small groups: Return to the possibilities discussed before the POGIL, then consider how Coulombic attraction would factor in. Attempt an explanation, along with a model comparing any two of the three metals, for how atomic structure determines reactivity in this type of process. (T)
    - Activity: Choose 1-2 of the following activities.

i. ADI lab activity with pt trends (atomic radius, ionization energy, EN, density, mp/bp, etc) lab 7 (M)
ii. Lab: Density of Group 4 elements (measure/calculate density of C, Si, Sn, Pb, then graph and use it to predict density of Ge) (M/T)
iii. **Modeling Periodic Patterns** - *The Science Teacher* article and accompanying labs. (M/T)
iv. AACT Simulation Periodic Trends or Periodic Trends II (A/M)
v. **POGIL Periodicity** or **POGIL 15 Periodic Trends** (A/M)

- Students practice giving proper justifications, based on atomic structure, for several PT trends.

9. Return to Phenomenon: Auroras again: (EU 2, T)
   - Teacher-led Review, from activity in #5 above, about what made different models good, clear, useful…
   - Small group discussions based on recent lessons:
     i. What aspects of the original models still seem relevant?
     ii. What aspects now appear to be missing from these original models?
     iii. What new concepts could be used to give a more detailed explanation of the auroras?
   - Individual task:
     i. Revise your old model, or create a new one, to explain the effects observed during an aurora based on what is known about atoms and light.