Course: *Chemistry* **Unit #2: Chemistry of Stuff**	**Year of Implementation:** 2021-2022

Curriculum Team Members *Sarah Howarth, showarth@lrhsd.org; Sheryl Chadwick, schadwick@lrhsd.org; Kelly Clark, kclark@lrhsd.org; Dusty Carroll, dcarroll@lrhsd.org*

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 (SEP)

- Practice 1 Asking Questions and Defining Problems
- 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
- Practice 8 Obtaining, Evaluating, and Communicating Information

Performance Expectations (PE)

- HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms
- HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
- HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles
- HS-PS2-4. Use mathematical representations of Coulomb's Law to describe and predict the electrostatic forces between

objects.
- HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
- HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Disciplinary Core Ideas

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 structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy, by an amount known as the binding energy, than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

PS2.B: TYPES OF INTERACTIONS

- ~~Newton's law of universal gravitation and~~ Coulomb's law provide the mathematical models to describe and predict the effects of ~~gravitational and~~ electrostatic forces between distant objects.
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

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.1: Identify problem-solving strategies used in the development of an innovative product or practice
- 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.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

- 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 relationships between structure at the molecular scale and the properties at the macroscopic scale to explain phenomena of different materials in their everyday world.

Department Goals:
Students will:

- 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.

Enduring Understandings Students will understand that. . .	*Essential Questions*
EU 1 the interactions of charged particles between and within atoms bring stability by minimizing the electric field energy.	*EU 1* ● Why do atoms come together to form molecules? ● How do charged particles interact?
EU 2 the periodic table allows us to predict how atoms will interact.	*EU 2* ● How can we model the different ways atoms interact? ● How can we use the periodic table to predict bond type between particular atoms? ● How can we communicate the composition of a compound (names, formulas, models, etc)?
EU 3 the structure and properties of substances at the bulk scale can be used to infer the strength of electrical forces between particles.	*EU 3* ● How does the particle structure of a substance relate to its bulk properties on the macroscopic scale?

EU 4 the mole provides a direct relation between observable macroscopic quantities and the atomic scale. *EU 5* the structure and composition of water results in its unique physical and chemical properties.	● How can we use our understanding of bonding and intermolecular forces to design materials for a specific function? *EU 4* ● Why do we quantify matter in different ways? ● Why was the mole invented? ● Why is dimensional analysis important? *EU 5* ● Why are there different states of matter? ● Why does ice float on water (when most solids sink in their own liquid)? ● How does the strength of intermolecular forces give water special properties? ● Why is water important for life to exist?
<u>Knowledge</u> *Students will know . . .* *EU 1* ● stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (PS1.A) ● Coulomb's law provides the mathematical models to describe and predict the effects of electrostatic forces between distant objects. (PS2.B) ● Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (PS2.B)	*<u>Skills</u>* Students will be able to. . . *EU 1* ● use Coulomb's Law to describe and predict the electrostatic forces between objects. (PS2-4, SEP 5)

EU 2 ● 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. The repeating patterns of this table reflect patterns of outer electron states. (PS1.A) ● chemical bonds join two atoms together and the behavior of the outermost electrons determines the type and characteristics of the bond formed (PS1-2) ● there are different ways to represent a chemical compound (names, formulas, models, etc)	*EU 2* ● 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 (PS1-1, SEP 4) ● Construct and revise an explanation for the numbers and types of bonds (i.e., ionic, covalent) that each atom forms, as determined by the outermost (valence) electron states and the electronegativity ● Determine the number of electrons in the outermost energy level of atoms (i.e., valence electrons) ● Model the number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements ● Determine the charges in stable ions that form from atoms in a group of the periodic table ● Write names for simple ionic and covalent compounds using IUPAC nomenclature rules ● Write chemical formulas for simple ionic and covalent compounds ● Choose the appropriate method to communicate the composition and/or structure of chemical compound for different situations
EU 3 ● the structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms and molecules. (PS1.A) ● attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (PS2.B)	*EU 3* ● Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles (PS1-1, SEP 3) ● Communicate scientific and technical information about

EU 4 ● that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (PS1.B) ● the mathematical concept of the mole is used to communicate the proportional relationships between the atomic scale and the bulk scale (PS1-7) EU 5 ● the abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks. (ESS2.C)	why the molecular-level structure is important in the functioning of designed materials. (PS2-6, SEP 8) ● Describe the relationship between the measurable properties (e.g., melting point, boiling point, vapor pressure, surface tension) of a substance and the strength of the electrical forces between the particles of the substance (intermolecular forces). ● Collect and record data — quantitative and/or qualitative — on the bulk properties of substances. *EU 4* ● calculate Molar mass of all components of the reaction ● use the mole to convert between the atomic and macroscopic scale in the analysis ● Calculate percent composition, empirical formula, and molecular formulas ● describe how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number). *EU 5* ● plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (ESS2-5, SEP 3) ● develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including: a) The heat capacity of water; b) The density of water in its solid and liquid states; and c) The polar nature of the water molecule due to its molecular structure; d) The expansion of water as it freezes, which

	can be used to infer the ability of water to break rocks into smaller pieces; e) The solubility of different materials in water, which can be used to infer chemical weathering and recrystallization
Stage Two - Assessment	
Stage Three - Instruction	

Learning Plan: **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.**

1. Phenomena - samples of metal (metal wire), polymer (plastic bags), ceramic (tile or plate), and rock salt (big crystal). (EU 2. M)
   For each item: bend, stretch, smash with hammer, put in water
   - Think-Pair-Share: generate questions
     - What do you see?
     - What do you think?
     - What do you wonder?
     - Modelling - Draw a model to show what you think is happening during each phenomenon

2. As a class, generate a list of properties of the four materials and possible explanations for why they are Different. (EU 2, M)
   - Push them towards wondering about type of elements in each example substance
   - Give them a list of elements in each of the objects from the phenomena demo

- Locate elements on the periodic table
- Any patterns?

Revisit Coulombic attraction from Unit 1. Students should enhance their models with this concept if not already included.(M)

3. Argument Driven Inquiry lab activity with PhET Electronegativity/Bond type (link) (EU1, M)
   Lab - How Does Atom Electronegativity Affect Bond Character and Molecular Polarity?

4. Teacher-led class discussion of claims from ADI labs (EU 2, A/M)
   - Types of bonds ionic vs covalent (from EN perspective)
   - Metals vs Nonmetals (location on pt, properties)
   - Where can we find the elements that make each type of bond?
   - Revisit phenomena -
     - What type of bond do you think was present in each object in the original phenomena?
     - How do we know?
     - Redraw models based on new information
     - Challenge students to consider 2 metals together (general properties of a metallic bond)

5. Unknown Substances Lab - Determine bonding types based on solubility, conductivity (solid/dissolved), melting point (high-med-low) (EU 2, T)
   - Ionic Bonding
   - Covalent Bonding
   - Metallic Bonding
     - Bonding diagrams (Lewis structures)
     - Generalized properties
     - Ions vs atoms
     - Molecules vs network
     - Alloys

Based on above activities, return to unit phenomena and update what you know about the elements that make them up. (EU 2, M)

- Students may notice that ceramics do not fit nicely - good opportunity to explain materials are not as simple as 2 or 3 elements, but that is all we will focus on in first-year chemistry

- Explore bonding characteristics in small molecules: (EU 3, A)
- Use model kits or simulation such as https://phet.colorado.edu/sims/html/build-a-molecule/latest/build-a-molecule_en.html to identify possible bonding sites for C, N, O, F, H and build models of various small molecules. (A)
- Guide students to draw Lewis structures to represent the bonding in each model (structured inquiry or teacher-led instruction)
- Various activities to practice simple Lewis structures and describing bonds.
- Teacher-led or guided-inquiry to predict relative strengths of the different bonds and how much energy it would take to stretch each.

6. Classroom Resources | Ionic & Covalent Bonding (or other formulas and names activity) (EU 2, A)

7. Introduce Relative mass and moles - Relative Mass Lab (Like Beanium, link) or Relative Mass and the Mole POGIL (EU 4, A/M)
8. Moles to Mass calculations - Practice Problem worksheet (EU 4, A)
9. Percent Composition calculations - Magnesium Oxide Lab (link) (or Percent sugar in gum, water in popcorn, carbon in a marshmallow) (EU 4, M)
10. Practice calculations using values for atmospheric pollutants, such as determining the amount of carbon dioxide generated from a given amount of carbon. (EU 4, T)
11. Molecular shapes ADI (link) molecular shapes and polarity (EU 3, M)
12. Lesson Phenomena: Evaporation of Hand sanitizer vs. water Strength of IMF (EU 3, A/M/T)
    - POGIL IM Forces and bp
    - Intramolecular vs Intermolecular
    - Material phenomena (choose one)
        - Kevlar (Kevlar Article) - The intermolecular forces between polymer molecules are what make Kevlar so strong and resistant to bullets and knives
        - Stuck on You ChemMatters (Blue Mussels BioGlue article) - explains that glues work not by making chemical bonds, but by using intermolecular forces.

13. Properties of Solids vs Liquids (EU 3, M/T)
    - How does the type of bonding affect the state of matter?

- How do IMF affect the state of matter?

14. Water's unique properties- Possible stations to explore bp/mp, universal solvent, surface tension, density, specific heat (water vs. metal) (EU 5, M/T)
    - Example Lesson Phenomena - Drops of water on a penny (or how many paperclips can you fit in a full container of water?)
        - Make a model to explain the shape of the water
        - Predict what will happen if a drop of dish soap is added
        - Use IMF to explain what happened
        - Ask how this enables water to clean more effectively
    - Example LESSON PHENOMENON: Demonstration sequence - phase changes (A/M)
        - ❖ Condensation on outside of glass only if exposed to air. Demo or video: https://www.middleschoolchemistry.com/multimedia/chapter2/lesson3
            - ➢ Think-Pair-Share: What is your explanation for this? What further evidence would support this explanation?
        - ❖ Water boiling at low pressure. Demo or video: https://www.youtube.com/watch?v=8SxhjNFAp5w
            - ➢ Think-Pair-Share: What is your explanation for this? What further evidence would support this explanation?

15. Phase changes (EU 5, A/M)

    Observe examples of melting, freezing, boiling, and condensation. Students choose one phase change and predict explanations and record any questions that arise.
    - Students model one of the phase changes to show what they think happens during the change. Model must:
        - show both particle and macroscopic views
        - represent changing conditions (like P, V, or T) and behavior of the particles to represent the observed effect
        - justify the observed effect
16. Investigate phase changes (can be open or guided inquiry or teacher-led) (EU 5, M)
    - Students explore this simulation https://phet.colorado.edu/en/simulation/states-of-matter to learn:
        - The role of temperature and pressure in phase changes
        - The role of energy during phase changes
        - The response of particles to changing conditions

- How a phase diagram works

17. Revise the original phase change model and write an explanation using the new information that explains the observed effect. (EU 5, M)
18. Ask: Why is a steam burn from above boiling water worse than a water burn from the boiling water? (EU 5 ,M)
    - Draw/model what you think (in small groups)
    - View drawings from other groups and determine any matching and any conflicting ideas.
19. Revisit Unit Phenomena - Summarize properties, including solubility in water, and then determine bonding types each item (EU 2, 3, 5, T)