Course Title: Honors Chemistry

Board Approved: October 2026

Unit 1: Matter and the Periodic Table	**Time:** 6 days

Academic Standards:

3.2.9-12.A – 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.

3.2.9-12.B – 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.

3.2.9-12.C – 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.

3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Essential Content/Objective: At the end of the unit, students will be able to:

- Define matter and describe its basic characteristics.
- Identify and compare the different states of matter at room temperature.
- Classify physical and chemical properties of substances.
- Distinguish between intensive and extensive properties.
- Differentiate between physical and chemical changes based on observations.
- Define pure substances, elements, compounds, and mixtures.
- Categorize substances as elements, compounds, or mixtures (homogeneous or heterogeneous) using evidence.
- Summarize Mendeleev's contributions to the development of the periodic table.
- Explain how the periodic table is organized based on atomic number and chemical properties.
- Differentiate between metals, nonmetals, and metalloids using periodic table placement.
- Interpret information presented in a periodic table element box (atomic number, symbol, mass, etc.).

Assessment:

- Entry Tickets
  - Chemistry on Social Media
  - Identification of Physical and Chemical Changes
  - Connecting Family Traits to Atomic Families
  - Identifications of pure substances vs. mixtures/elements vs. compounds
- Teacher Prepared Problem Sets
  - Matter, States, Properties, and Change
  - Pure Substances, Mixtures, and their Compositions
  - The Periodic Table
  - Atoms and Molecules
- Virtual Lab Activities
  - States of Matter
  - Build a Molecule
- Exit Tickets

- Determine the number and types of atoms present in a chemical formula.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Matter, States, Properties, and Change"
  - Identify matter vs. energy
  - Identify states of matter of common things at room temperature
  - Identify intensive vs. extensive properties
  - Identify physical vs. chemical properties
  - Identify physical vs. chemical changes
- PhET Virtual Lab: "States of Matter"
- Teacher Prepared Problem Set: "Pure Substances, Mixtures, and their Compositions"
  - Identify pure substances vs. mixtures
  - Identify elements vs. compounds vs. homogeneous mixtures vs. heterogeneous mixtures
  - Identify if something is made of atoms, molecules, or a combination of both
- Teacher Prepared Problem Set: "The Periodic Table"
  - Recall information about the original construction of the periodic table and properties of different atomic families
- Teacher Prepared Problem Set: "Atoms and Molecules"
  - Identify relevant information about an element from the information on the periodic table (atomic symbol, atomic number, atomic mass, etc.)
  - Determine the number of each type of atoms in a molecular formula
- PhET Virtual Lab: "Build a Molecule"
- Exploration Activity: "Periodic Table Battleship"
- Design Activity: "Design a Periodic Table"
  - Students will design a periodic table of everyday items by organizing them into rows and columns based on two physical or functional properties.
  - Identify a physical vs. chemical property and physical vs. chemical change
  - Identify elements vs. compounds vs. homogeneous mixtures vs. heterogeneous mixtures
  - Briefly describe how periodic table is organized and identify the classification of a list of elements
  - Identify relevant information about an element from the information on the periodic table (atomic symbol, atomic number, atomic mass, etc.)
- "Design a Periodic Table" Project
- Matter and the Periodic Table Unit Assessment

Materials and Resources:

- Teacher Prepared Guided Notes
  - Matter, States, Properties, and Change
  - Pure Substances, Mixtures, and their Compositions
  - The Periodic Table
  - Atoms and Molecules
- Teacher Prepared Problem Sets
  - Matter, States, Properties, and Change
  - Pure Substances, Mixtures, and their Compositions
  - The Periodic Table
  - Atoms and Molecules
- PhET
  - States of Matter PhET
  - Build a Molecule PhET
  - Teacher Prepared Data Collection Sheets
  - Teacher Prepared Analysis Questions
- Design Activity
  - Cardstock
  - Markers
  - Colored Pencils
  - Rulers
- Demonstration Materials
  - Graduated Cylinders
  - Electronic Balance
  - Water
  - Hot Plate
  - Vinegar
  - Backing Soda
  - Balloon
  - Molecular Model Kit

Extensions:

- Scientific Literacy in the Media – Finding science media and parsing its validity, reliability, and possible problems with data interpretation
  - Find a news article, social media post, advertisement, or product claim that uses terms such as "chemical-free," "all-natural," "pure," "toxin-free," or "contains elements." Analyze whether the scientific language is accurate and explain any misconceptions using chemistry vocabulary from the unit.
- Question Construction – Building new practice questions and variations of questions to extend understanding
  - Choose a diatomic molecular formula and design two multiple-choice questions that assess a student's ability to determine the number and types of atoms present. Include plausible distractors based on common misconceptions and explain the reasoning behind each answer choice.
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Select a household product and examine its ingredient list. Research each ingredient and determine if they are an element, a compound, a homogenous mixture, and a heterogeneous mixture.

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. The fundamental characteristics of matter, including its classification based on state, composition, and observable properties.
    2. The distinction between physical and chemical properties and changes using experimental observations and real-world examples.
    3. The organization and historical development of the periodic table, including the arrangement of elements based on atomic structure and shared chemical characteristics.
    4. The identification and interpretation of information provided by the periodic table, including atomic symbols, atomic numbers, and atomic masses.
    5. The representation of substances at the atomic level, including differentiating between atoms and molecules and determining the quantity and type of atoms present in chemical formulas.
    6. Problem-solving strategies for classifying substances, interpreting chemical formulas, and applying periodic table information.
- Guided Practice
  - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
    1. Identifying energy vs matter
    2. Identifying the state of matter of given substance at room temperature
    3. Classifying properties as either intensive or extensive
    4. Classifying properties as either physical or chemical

Remediation:

- Videos to review content and practice
  - States of Matter
  - Physical vs Chemical Properties
  - Intensive vs Extensive Properties
  - Physical vs Chemical Changes
  - Reading One Box of the Periodic Table
  - Counting Atoms
- Matter and the Periodic Table Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

5. Classifying changes as either physical or chemical
6. Classifying substances as pure substance or mixtures
7. Classifying substances as elements, compounds, homogeneous mixtures, or heterogenous mixtures
8. Identify if something is made of atoms, molecules, or a combination of both
9. Identify relevant information about an element from the information on the periodic table (atomic symbol, atomic number, atomic mass, etc.)
10. Determine the number of each type of atoms in a molecular formula

- Independent Problem Sets
  - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
    1. Matter, States, Properties, and Change
    2. Pure Substances, Mixtures, and their Compositions
    3. The Periodic Table
    4. Atoms and Molecules
- Independent Virtual Lab Activities
  - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions.
    1. States of Matter
    2. Build a Molecule
- Demonstrations
  - Intensive vs. Extensive Properties
    1. Weigh and measure different volumes of water to demonstrate how they change as the amount of water changes, but then calculate the density of those same samples to show that the density of water does not change depending on the amount of water present.
  - Physical vs. Chemical Change

1. Boil water on a hot plate and discuss how the vapor is still chemically identical. 2. Mix vinegar and baking soda and collect the gas in a balloon and discuss how a new substance is made in order to fill the balloon. ○ Molecular Model Tour 1. Set up a number of different molecular model kits around the room and have students visit each to count the number of each type of atom in the model.	

Unit 2: Measurements	**Time:** 5 days

Academic Standards:
3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
3.5.9-12.I – Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Essential Content/Objective: At the end of the unit, students will be able to:

- Define qualitative and quantitative measurements and provide examples of each.
- Distinguish between qualitative and quantitative data in a scientific context.
- Define direct and derived measurements and explain the difference between them.
- Define metric and imperial units and compare their use in scientific measurement.
- Identify units in the metric system and convert between them by moving the decimal point appropriately.
- Determine the appropriate metric unit for a given type of measurement (e.g., mass, length, volume).
- Define scientific notation and recognize when a number is properly written in scientific notation.
- Convert numbers between standard form and scientific notation.
- Multiply and divide numbers in scientific notation using exponent rules.
- Apply scientific notation to represent and solve problems involving very large or very small values in scientific contexts.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Types of Measurements"
  - Identify qualitative vs. quantitative measurements
  - Identify direct vs. derived measurements
  - Identify measurements made in metric vs. imperial units
- Teacher Prepared Problem Set: "Converting Metric Units"

Assessment:

- Entry Tickets
  - Measurements and units in day-to-day life
  - Qualitative vs. quantitative measurements, direct vs. derived measurements, metric vs. imperial units
  - Conversion of metric units
  - Placing numbers into scientific notation
- Teacher Prepared Problem Sets
  - Types of Measurements
  - Converting Metric Units
  - Scientific Notation
  - Math with Scientific Notation
- Exit Tickets
  - Qualitative vs. quantitative measurements, direct vs. derived measurements, metric vs. imperial units
  - Conversion of metric units
  - Placing numbers into scientific notation
  - Perform multiplication and/or division of scientific notation numbers and write the final answers in proper scientific notation using exponent rules
- "Design a Unit" Activity

- Convert metric units into other/more appropriate metric units by moving decimal points an appropriate number of places
- Teacher Prepared Problem Set: "Scientific Notation"
  - Convert numbers in standard notation into scientific notation
  - Convert numbers in scientific notation into standard notation
- Teacher Prepared Problem Set: "Math with Scientific Notation"
  - Perform multiplication and/or division of scientific notation numbers and write the final answers in proper scientific notation using exponent rules
- Design Activity: "Design a Unit"
  - Students will design and define an original, nonstandard unit of length based on a randomly selected object (e.g., the length of a pencil, book, or other classroom item). After precisely measuring their chosen object in centimeters, students will establish a formal conversion factor between their self-created unit and the metric system. Students will then measure additional classroom objects in centimeters and use their conversion factor to express those measurements in their newly defined unit. Emphasis will be placed on accurate measurement technique, development of a valid conversion relationship, and correct application of proportional reasoning during unit conversions.

- Measurements Unit Assessment
  - Additional problems similar to the questions that will appear on the unit assessment.
- Question Construction – Building new practice questions and variations of questions to extend understanding
  - Use a random number generator to select a number between 1 and 10 and another number between 1 and 9. Create a measurement by placing the chosen number of zeros between the decimal point and the nonzero digit (e.g., 0.0000001 m). Determine the most appropriate metric prefix to express the measurement in a more practical form. Then, design a test or practice question that requires students to perform the conversion. Provide the correct answer and justify your choice of metric prefix by comparing it to the two nearest larger and smaller prefixes and explaining why your selected unit is the most appropriate representation.
- Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance
  - Look into measurements in the fields of biology and physics to determine what common metric units are used for length measurements and hypothesize why these units are used instead of the base unit of meters.
- Chemistry in Context – Researching

	chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue o Research a real-world accident or problem caused by incorrect measurements, unit conversions, or data interpretation.
Materials and Resources: ● Teacher Prepared Guided Notes ○ Types of Measurements ○ Converting Metric Units ○ Scientific Notation ○ Math with Scientific Notation ● Teacher Prepared Problem Sets ○ Types of Measurements ○ Converting Metric Units ○ Scientific Notation ○ Math with Scientific Notation ● Calculators ● Demonstration Materials ○ Box ○ Meter Stick ○ Water ○ Graduated Cylinder **Instructional Methods:** ● Direct Instruction ○ Students will receive direct instruction and problem examples on the following topics: 1. The distinction between qualitative and quantitative observations, including the role of different types of data in scientific investigations.	**Remediation:** ● Videos to review content and practice ○ Metric Conversions ○ Scientific Notation ○ Multiplication and Division of Scientific Notation ● Measurements Practice Test ○ Additional problems similar to the questions that will appear on the unit assessment.

2. The difference between direct and derived measurements and the interpretation of measurements collected in scientific contexts.
3. The use of metric and imperial measurement systems, including the identification of appropriate units and conversion between metric units.
4. The representation of extremely large and small values using scientific notation, including the proper formatting of scientific notation and the mathematical operations used when multiplying and dividing scientific notation values.
5. Problem-solving strategies for analyzing measurement types, performing metric conversions, and applying scientific notation in scientific calculations.

- Guided Practice
  - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
    1. Identify qualitative vs. quantitative measurements
    2. Identify direct vs. derived measurements
    3. Identify measurements made in metric vs. imperial units
    4. Converting metric units
    5. Conversions of standard notation into scientific notation
    6. Conversions of scientific notation into standard notation
    7. Performing mathematical calculations with scientific notation measurements and reporting the final answer in proper scientific notation
- Independent Problem Sets
  - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.

1. Types of Measurements 2. Converting Metric Units 3. Scientific Notation 4. Math with Scientific Notation ● Demonstrations ○ Volume of a box 1. Measure the dimensions of a metal box in centimeters and calculate the volume of the box. Then fill the box with water and then pour into a graduated cylinder to find the volume of the box. Compare the direct and derived measurements and discuss possible errors in both measurements.	

Unit 3: Experimental Data	**Time:** 6 days

Academic Standards:

3.2.9-12.A – 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

3.2.9-12.B – 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.

3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3.5.9-12.I – Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Essential Content/Objective: At the end of the unit, students will be able to:

- Define significant figures and explain their role in representing measured data accurately.
- Determine the number of significant figures in a given measurement.
- Apply rules for significant figures in addition, subtraction, multiplication, and division.
- Define density and use the formula density=mass/volume to solve for any variable.
- Measure volume using water displacement and use it to calculate density.
- Convert between Fahrenheit, Celsius, and Kelvin temperature scales.
- Explain why the Kelvin scale does not include negative values based on its scientific definition.
- Define and distinguish between precision and accuracy in measured data.
- Calculate percent error and evaluate the precision and accuracy of experimental results based on calculated values.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Significant Figures"
  - Count the number of significant figures in a measurement
  - Convert numbers in standard notation into scientific notation while maintaining the appropriate number of significant figures

Assessment:

- Entry Tickets
  - Determining the precision of data
  - Count the number of significant figures in a measurement
  - Determine if the following types of measurements are intensive or extensive: Mass, Volume, and Density
  - Determine the temperature of everyday things (boiling freezing points of water, high/low human body temperatures)
  - Description of density as a property
- Teacher Prepared Problem Sets
  - Significant Figures
  - Math with Significant Figures
  - Density
  - Temperature
  - Precision and Accuracy
- Virtual Lab Activities
- Exit Tickets

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Convert numbers in scientific notation into standard notation while maintaining the appropriate number of significant figures when possible

Teacher Prepared Problem Set: “Math with Significant Figures”

Perform calculations and report the final answer in the correct number of significant figures based on significant figure rules

Teacher Prepared Problem Set: “Density”

Calculate one property of a substance (mass, volume, or density) based on information given in density experiments

PhET Virtual Lab: “Density”
Teacher Prepared Problem Set: “Temperature”

Convert temperatures reported in Fahrenheit into Celsius and Kelvin
Convert temperatures reported in Celsius into Fahrenheit and Kelvin
Convert temperatures reported in Kelvin into Fahrenheit and Celsius
Derive and apply temperature conversion equations between Celsius and fictional temperature scales

Teacher Prepared Problem Set: “Precision and Accuracy”

Determine the average experimental density of a substance based on reported data
Determine the percent error of the average experimental density given the theoretical density
Use the provided experimental data points and the calculated percent error to determine if the experimental data is accurate and/or precise

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Count the number of significant figures in a measurement
Perform calculations and report the final answer in the correct number of significant figures based on significant figure rules
Calculate density of a substance based on information given in density experiments and use it to identify the substance
Convert temperatures reported in Fahrenheit into Celsius and Kelvin
Determine the percent error of an experimental density given the theoretical density and discuss accuracy and precision

Experimental Data Unit Assessment

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Materials and Resources:

Teacher Prepared Guided Notes

Significant Figures
Math with Significant Figures
Density
Temperature
Precision and Accuracy

Teacher Prepared Problem Sets

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Extensions:

Question Construction – Building new practice questions and variations of questions to extend understanding

Students will derive their own temperature scale based on a substance of their choice. They must research the boiling and freezing

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- Significant Figures
- Math with Significant Figures
- Density
- Temperature
- Precision and Accuracy

- PhET
  - Density PhET
  - Teacher Prepared Data Collection Sheet
  - Teacher Prepared Analysis Questions
- Calculators
- Demonstration Materials
  - 10 mL pipet
  - 10 mL beaker
  - 100 mL beaker
  - Electric Balance
  - Water

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. The use of significant figures as a method of representing the precision of measured data, including identifying significant digits and applying significant figure rules in mathematical calculations.
    2. The relationship between mass, volume, and density, including the use of density as a characteristic property of matter and the mathematical relationships used to calculate an unknown variable.
    3. The scientific temperature scales (Fahrenheit, Celsius, and Kelvin), including temperature conversions and the rationale behind the Kelvin scale's absolute zero.
    4. The development of temperature conversion equations using the linear relationships between different temperature scales.

points of that substance in Celsius and create their own temperature scale. They then must use that temperature scale to find the boiling and freezing points of water in that scale.

- Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance
  - Students will write out a list of all classes they are taking and identify how measurements are used in each class (dates, times, page numbers, word count, etc.)
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Students will research the current outdoor temperature in both Fahrenheit and Celsius, then convert each value into the other scale and compare results for consistency. Students will analyze any discrepancies and construct a brief argument explaining how differences in temperature scales and conversions can impact scientific research that relies on accurate temperature data.

Remediation:

- Videos to review content and practice
  - Counting Significant Figures
  - Scientific Notation and Significant Figures

5. The distinction between precision and accuracy in experimental data, including the use of percent error and data analysis to evaluate the quality of experimental results.
6. Problem-solving strategies for applying significant figure rules, performing density calculations, converting between temperature scales, and analyzing experimental data.

- Guided Practice
  - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
    1. Count the number of significant figures in a measurement
    2. Convert numbers in standard notation into scientific notation while maintaining the appropriate number of significant figures
    3. Convert numbers in scientific notation into standard notation while maintaining the appropriate number of significant figures when possible
    4. Perform calculations and report the final answer in the correct number of significant figures based on significant figure rules
    5. Calculate one property of a substance (mass, volume, or density) based on information given in density experiments
    6. Convert temperatures reported in Fahrenheit into Celsius and Kelvin
    7. Convert temperatures reported in Celsius into Fahrenheit and Kelvin
    8. Convert temperatures reported in Kelvin into Fahrenheit and Celsius
    9. Derive and apply temperature conversion equations between Celsius and fictional temperature scales
    10. Determine the percent error of the average experimental density given the theoretical density and use the provided experimental data points and the calculated percent error to determine if the experimental data is accurate and/or precise
  - Using Significant Figures
  - Add and Subtract with Significant Figures
  - Multiply and Divide with Significant Figures
  - Density Practice
  - Temperature Conversions
  - Accuray and Precision
- Additional Practice Problems
  - Students will be provided with additional practice problems for density calculations that describe experimental data in word-problem form to interpret and solve involving many lab-based scenarios including:
    1. Water displacement for volume measurement
    2. Differences in mass for mass measurements
    3. Identification of substances based on densities
- Measurements Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

- Independent Problem Sets
  - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
    1. Significant Figures
    2. Math with Significant Figures
    3. Density
    4. Temperature
    5. Precision and Accuracy
- Independent Virtual Lab Activities
  - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions.
    1. Density
- Demonstrations
  - Significant Figures and Errors in Measurements
    1. Use a 10 mL pipet to measure a water sample and place it in a 100 mL beaker before students observe the sample.
    2. Show students the 10 mL water sample in the 100 mL beaker and record the volume to the correct number of significant figures.
    3. Pour the same sample into a 10 mL beaker and record the volume to the correct number of significant figures and have students discuss how the numbers are different despite the sample not changing.
    4. Pour the same sample into a graduated cylinder and record the volume to the correct number of significant figures and have students discuss how the numbers are once again different.
    5. Weigh the sample of water and use the density of water to calculate the volume of water.
    6. Reveal to students how the original sample was measured and discuss with students how the measurements changed based on the measurement method and how the movement of water from

container to container and significant figures impacts the measurements/possible errors to the data.	

Unit 4: Atomic Structure	**Time:** 8 days

Academic Standards:

3.2.9-12.A – 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

3.2.9-12.B – 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.

3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3.2.9-12.H – Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Essential Content/Objective: At the end of the unit, students will be able to:

- Describe the basic structure of an atom, including the location and charge of protons, neutrons, and electrons.
- Identify the number of protons, neutrons, and electrons in an atom given its atomic symbol.
- Interpret and construct atomic symbols for neutral atoms and ions.
- Define ions, cations, and anions, and explain how gaining or losing electrons affects an atom's charge.
- Distinguish between cations and anions based on electron loss or gain.
- Identify alpha, beta, and gamma radiation and describe the characteristics of each.
- Write balanced nuclear equations for alpha, beta, and gamma decay processes.
- Define the term isotope and explain how isotopes of the same element differ.
- Calculate the average atomic mass of an element using isotopic masses and percent abundances.

Assessment:

- Entry Tickets
  - Review of subatomic particle charges and locations in an atom
  - Given information about an element (atomic symbol, atomic number, mass number, number of protons, number of neutrons, and number of electrons) find the remaining pieces of information
  - Given the number of protons, determine the element
  - Define "isotope" and given the atomic symbol of two isotopes of chlorine, determine the number of subatomic particles
  - Given the abundance of the isotopes of an element, use weighted averages to calculate the average atomic mass
- Teacher Prepared Problem Sets
  - Structure of an Atom
  - Structure of an Ion
  - Radioactivity
  - Isotopes and Average Atomic Mass
  - Isotope Abundance

- Use average atomic mass and known isotope masses to calculate the relative abundances of isotopes.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: “Structure of an Atom”
  - Given an atomic symbol for an element, determine the atomic number, mass number, number of protons, number of neutrons, and number of electrons
  - Given two pieces of information (atomic number, mass number, number of protons, number of neutrons, and number of electrons) find the remaining pieces of information and the atomic symbol
- PhET Virtual Lab: “Rutherford Scattering”
- Teacher Prepared Problem Set: "Structure of an Ion”
  - Given an atomic symbol for an ion, determine the atomic number, mass number, charge, number of protons, number of neutrons, and number of electrons
  - Given three pieces of information (atomic number, mass number, charge, number of protons, number of neutrons, and number of electrons) find the remaining pieces of information and the atomic symbol
- PhET Virtual Lab: “Build an Atom”
- Teacher Prepared Problem Set: “Radioactivity”
  - Write a nuclear equation for the alpha decay of an isotope
  - Write a nuclear equation for the beta decay of an isotope
  - Write a nuclear equation for the gamma decay of an isotope

    Given the half-life of an isotope and an amount of time elapsed, determine the amount of material remaining
- PhET Virtual Lab: “Build a Nucleus”
- Virtual Lab Activities
  - Rutherford Scattering
  - Build an Atom
  - Build a Nucleus
  - Isotopes and Atomic Mass
- Exit Tickets
  - Given information about an element (atomic symbol, atomic number, mass number, number of protons, number of neutrons, and number of electrons) find the remaining pieces of information
  - Given information about an element or ion (atomic symbol, atomic number, mass number, charge, number of protons, number of neutrons, and number of electrons) find the remaining pieces of information and the atomic symbol
  - Write nuclear equations for given isotopes based on the decay they undergo
  - Given the abundance of the isotopes of an element, use weighted averages to calculate the average atomic mass
  - Find the relative abundance of each isotope of an element
- “Element Baby Book” Project
- Atomic Structure Unit Assessment

• Teacher Prepared Problem Set: "Isotopes and Average Atomic Mass"
  ○ Given the abundance of the isotopes of an element, use weighted averages to calculate the average atomic mass
• PhET Virtual Lab: "Isotopes and Atomic Mass"
• Teacher Prepared Problem Set: "Isotopes Abundance"
  ○ Given the average atomic mass of an element and information about its ions, calculate the relative abundance of two of the isotopes
• Design Activity: "Element Baby Book"
  ○ Students will design a baby book about an assigned element and communicate information about that element in a concise and creative way	

Materials and Resources:
• Teacher Prepared Guided Notes
  ○ Structure of an Atom
  ○ Structure of an Ion
  ○ Radioactivity
  ○ Isotopes and Average Atomic Mass
  ○ Isotope Abundance
• Teacher Prepared Problem Sets
  ○ Structure of an Atom
  ○ Structure of an Ion
  ○ Radioactivity
  ○ Isotopes and Average Atomic Mass
  ○ Isotope Abundance
• PhET
  ○ Rutherford Scattering PhET
  ○ Build an Atom PhET
  ○ Build a Nucleus Phet
  ○ Isotopes and Atomic Mass Phet
  ○ Teacher Prepared Data Collection Sheets
	Extensions:
	• Scientific Literacy in the Media – Finding science media and parsing its validity, reliability, and possible problems with data interpretation
	  ○ Students find a news article that makes claims about radiation and determine the contaminating material, determine if the article correctly classifies the radiation given the material, determine if the exposure risk was misrepresented given the type of radiation and level of contamination, and determine if the contamination risk was communicated appropriately.
	• Question Construction – Building new practice questions and variations of questions to extend understanding
	  ○ Choose three atomic symbols—one representing a neutral element, one representing a cation, and one representing an anion—and create a practice problem similar to those in the "Structure of an Ion" problem set. Each problem must include at least

- Teacher Prepared Analysis Questions
- Design Activity
  - Cardstock
  - Rulers
  - Markers
  - Colored Pencils
  - Teacher Prepared Data Collection Sheet
- Demonstration Materials
  - Standard Size Marbles
  - Large Shooter Marbles
  - 1000 mL Beaker
  - Electronic Balance
  - Pennies
  - Drawstring Bag

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. The structure of the atom, including the location, relative mass, and charge of protons, neutrons, and electrons.
    2. The relationship between atomic number, mass number, and subatomic particles in neutral atoms and ions.
    3. The representation and interpretation of atomic symbols, including notation for ions and changes in electron count.
    4. The formation of ions, including the distinction between cations and anions based on electron loss or gain and resulting charge.

three pieces of information for each species so that another student can determine the remaining subatomic details.

- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Students research the importance of americium-241 in smoke detectors and research the advantage of this isotope to other similar isotopes.

Remediation:

- Videos to review content and practice
  - Calculate the Number of Subatomic Particles
  - Writing Nuclear Formulas
  - Half-Life Practice
  - Calculate Average Atomic Mass
- Atomic Structure Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

5. Types of nuclear radiation, including alpha, beta, and gamma decay, and the characteristics of each form of radiation.
6. The representation of nuclear decay processes through balanced nuclear equations.
7. Isotopes and their relationship to atomic identity, including differences in neutron number and resulting mass.
8. The calculation and interpretation of average atomic mass using isotopic masses and percent abundance.
9. Quantitative reasoning strategies for determining isotopic abundance and interpreting weighted averages in atomic mass calculations.
10. Problem-solving approaches for analyzing atomic structure, ion formation, nuclear decay, and isotopic composition.

- Guided Practice
    - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
        1. Given information about an element or ion (atomic symbol, atomic number, mass number, charge, number of protons, number of neutrons, and number of electrons) find the remaining pieces of information

2. Write a nuclear equation for the alpha decay of an isotope 3. Write a nuclear equation for the beta decay of an isotope 4. Write a nuclear equation for the gamma decay of an isotope 5. Given the half-life of an isotope and an amount of time elapsed, determine the amount of material remaining 6. Given the abundance of the isotopes of an element, use weighted averages to calculate the average atomic mass 7. Given the average atomic mass of an element and information about its ions, calculate the relative abundance of two of the isotopes ● Independent Problem Sets ○ Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction. 1. Structure of an Atom 2. Structure of an Ion 3. Radioactivity 4. Isotopes and Average Atomic Mass 5. Isotope Abundance ● Independent Virtual Lab Activities ○ Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions. 1. Rutherford Scattering 2. Build an Atom	

3. Build a Nucleus 4. Isotopes and Atomic Mass ● Demonstrations ○ Average Mass of Marbles 1. Weigh and record the mass of 1 small standard marble and 1 large shooter marble. 2. Fill a beaker with 50 small standard marbles and 50 large shooter marbles and determine the total mass of the marbles. Discuss what the approximate total weight of the marbles should be and then weigh the marbles to compare. 3. Fill a beaker with 75 small standard marbles and 25 large shooter marbles and determine the total mass of the marbles. Discuss what the approximate total weight of the marbles should be and then weigh the marbles to compare. ○ Half-Life 1. Fill a bag with 100 pennies, shake the bag, and empty onto a table. 2. Count and record the number of pennies that land face up. Place the face up pennies back in the bag and remove the pennies that land face down. 3. Repeat until 0-1 pennies remain. 4. Determine the half-life of the pennies.	

Unit 5: Light and Atomic Models	**Time:** 6 days

Academic Standards:

3.2.9-12.A – 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.
3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
3.2.9-12.O – 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.
3.2.9-12.P – 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 positions of particles (objects).
3.2.9-12.T – Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
3.2.9-12.V – 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.
3.2.9-12.W – Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

Essential Content/Objective: At the end of the unit, students will be able to:

- Define light as an electromagnetic wave and describe the relationship between wavelength, frequency, and energy.
- Convert between wavelength, frequency, and energy using appropriate formulas.
- Classify regions of the electromagnetic spectrum based on wavelength or frequency.
- Explain how different types of electromagnetic radiation relate to energy and potential effects on matter.
- Describe how light behaves as both a wave and a particle (wave-particle duality).
- Define the photoelectric effect and explain how it provides evidence for the particle nature of light.

Assessment:

- Entry Tickets
  - Review of Measurements
  - Energy → Frequency → Wavelength Calculations
  - Wavelength → Frequency → Energy Calculations
  - Review of Subatomic Particle History
  - Classifying Emission Series
- Teacher Prepared Problem Sets
  - Wave Nature of Light
  - Electromagnetic Spectrum
  - Particle Nature of Light
  - Bohr Model of an Atom
  - Electron Movement in Hydrogen
- Virtual Lab Activities
  - Energy Forms and Changes

- Apply the principle of conservation of energy to determine whether a photon can eject an electron from a metal surface.
- Calculate the kinetic energy of an ejected electron using energy conservation.
- Describe the Bohr model of the atom and explain how it accounts for line spectra through electron transitions.
- Interpret emission and absorption as energy-level transitions in hydrogen atoms.
- Use the Rydberg equation to calculate energy changes associated with electron transitions in hydrogen.
- Identify whether a specific electron transition belongs to the Lyman, Balmer, or Paschen series.
- Distinguish between emission electron transitions and absorption electron transitions.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Wave Nature of Light"
  - Energy → Frequency → Wavelength Calculations
  - Frequency → Energy and Frequency → Wavelength Calculations
  - Wavelength → Frequency → Energy Calculations
- Teacher Prepared Problem Set: "Electromagnetic Spectrum"
  - Classify an energy, frequency, or wavelength using the electromagnetic spectrum
- PhET Virtual Lab: "Energy Forms and Changes"
- Teacher Prepared Problem Set: "Particle Nature of Light"
  - Given the threshold energy or cutoff wavelength of a metal and the energy or wavelength of a light source, determine if an electron will be emitted from the surface and if so, determine how fast the electron will be moving.
  - Given information about the speed with which an electron leaves a metal surface and information about a
  - Models of Hydrogen Atoms
- Exit Tickets
  - Energy → Frequency → Wavelength Calculations
  - Classify a wavelength using the electromagnetic spectrum
  - Calculate the speed of an electron ejected from a metal surface
  - Summary of Flame Test Demonstration
  - Calculate the energy of a hydrogen emission
- Light and Atomic Models Unit Assessment

light source, determine the threshold energy or cutoff wavelength of the metal surface.
    - Given information about the speed with which an electron leaves a metal surface either the threshold energy or cutoff wavelength of the metal surface, determine the threshold energy or cutoff wavelength.
- Teacher Prepared Problem Set: "Bohr Model of an Atom"
    - Given an electron transition between energy levels in a hydrogen atom, determine the following:
        1. If the transition is an absorption and emission and explain the reasoning.
        2. What emission series the transition belongs to (if any) and explain the reasoning.
        3. What wavelength range (ultraviolet, visible, or infrared) the energy required for the transition belongs to.
- Teacher Prepared Problem Set: "Electron Movement in Hydrogen"
    - Given an electron transition between energy levels in a hydrogen atom, determine the following:
        1. The amount of energy for the transition using the Rydberg equation.
        2. If the transition is an absorption and emission and explain the reasoning based on both the calculated energy value and the electron motion.
        3. What emission series the transition belongs to (if any) and explain the reasoning.
        4. The wavelength of the transition in given metric units.
        5. What wavelength range (ultraviolet, visible, or infrared) the energy required for the transition belongs to and if the transition is in the visible range, what color the light would be.

○ Given a starting energy level for an electron in a hydrogen atom, use the Rydberg equation to calculate the energy required to remove the electron from the atom (form a cation), the wavelength of that energy, and classify the energy using the electromagnetic spectrum. ● PhET Virtual Lab: "Models of the Hydrogen Atom"	
Materials and Resources: ● Teacher Prepared Guided Notes ○ Wave Nature of Light ○ Electromagnetic Spectrum ○ Particle Nature of Light ○ Bohr Model of an Atom ○ Electron Movement in Hydrogen ● Teacher Prepared Problem Sets ○ Wave Nature of Light ○ Electromagnetic Spectrum ○ Particle Nature of Light ○ Bohr Model of an Atom ○ Electron Movement in Hydrogen ● PhET ○ Energy Forms and Changes ○ Models of Hydrogen Atoms ○ Teacher Prepared Data Collection Sheets ○ Teacher Prepared Analysis Questions ● Demonstration Materials ○ Beaker of water ○ BBQ skewers or q-tips ○ BBQ lighter ○ Sodium Chloride ○ Magnesium Chloride ○ Copper (I) Chloride ○ Potassium Chloride	**Extensions:** ● Scientific Literacy in the Media – Finding science media and parsing its validity, reliability, and possible problems with data interpretation ○ Students analyze media claims about electromagnetic radiation (e.g., microwaves, cell phones, UV light, X-rays) and determine whether the claim appropriately represents the energy of that radiation ● Question Construction – Building new practice questions and variations of questions to extend understanding ○ Students examine the differences in the "Particle Nature of Light" problem set and the full list of variables needed in photoelectric effect problems to come up with three new ways to ask a photoelectric effect problem ● Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance ○ Students research how different regions of the electromagnetic spectrum can be used in another field (i.e. medicine, art, history, etc.) ● Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue ○ Students will propose creative or unconventional items to place in a microwave and discuss the

- Lithium Chloride

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. The nature of light as an electromagnetic wave, including the relationships between wavelength, frequency, and energy and the organization of the electromagnetic spectrum.
    2. The interaction of electromagnetic radiation with matter, including differences in energy across the spectrum and the potential effects of different types of radiation.
    3. The wave-particle duality of light and the photoelectric effect as evidence for the particle nature of electromagnetic radiation.
    4. The application of conservation of energy to photon interactions with matter, including the emission of electrons from metal surfaces and the calculation of electron kinetic energy.
    5. The Bohr model of the hydrogen atom, including quantized energy levels, electron transitions, and the formation of emission and absorption spectra.
    6. The use of the Rydberg equation to analyze electron transitions in hydrogen atoms, including calculating energy changes, identifying spectral series, and relating transitions to wavelengths and regions of the electromagnetic spectrum.
    7. Problem-solving strategies for converting between wavelength, frequency, and energy; analyzing photoelectric effect scenarios; and expected results based on the properties of the material and its interaction with microwave radiation. The activity promotes scientific reasoning and curiosity while emphasizing real-world safety, particularly the hazards associated with placing metal objects in a microwave.

Remediation:

- Videos to review content and practice
  - Speed of Light, Frequency, and Wavelength Calculations
  - How To Calculate The Energy of a Photon Given Frequency & Wavelength
  - Atomic Theory Study Guide
  - Photoelectric Effect
  - Rydberg Equation
  - Electromagnetic Spectrum
- Light and Atomic Models Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

interpreting electron transitions in hydrogen atoms.

- Guided Practice
    - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
        1. Energy → Frequency → Wavelength Calculations
        2. Frequency → Energy and Frequency → Wavelength Calculations
        3. Wavelength → Frequency → Energy Calculations
        4. Classify an energy, frequency, or wavelength using the electromagnetic spectrum
        5. Given the threshold energy or cutoff wavelength of a metal and the energy or wavelength of a light source, determine if an electron will be emitted from the surface and if so, determine how fast the electron will be moving.
        6. Given an electron transition between energy levels in a hydrogen atom, determine the following:
            - ➢ The amount of energy for the transition using the Rydberg equation.
            - ➢ If the transition is an absorption and emission and explain the reasoning based on both the calculated energy value and the electron motion.

- ➢ What emission series the transition belongs to (if any) and explain the reasoning.
- ➢ The wavelength of the transition in given metric units.
- ➢ What wavelength range (ultraviolet, visible, or infrared) the energy required for the transition belongs to and if the transition is in the visible range, what color the light would be.

7. Given a starting energy level for an electron in a hydrogen atom, use the Rydberg equation to calculate the energy required to remove the electron from the atom (form a cation), the wavelength of that energy, and classify the energy using the electromagnetic spectrum.
8. Discuss trends in the energy required to remove an electron in a hydrogen atom depending on the energy level the electron starts in

- Independent Problem Sets
  - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
    1. Wave Nature of Light
    2. Electromagnetic Spectrum
    3. Particle Nature of Light
    4. Bohr Model of an Atom
    5. Electron Movement in Hydrogen
- Independent Virtual Lab Activities
  - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the

simulation, collect and organize relevant data, and draw evidence-based conclusions. 1. Energy Forms and Changes 2. Models of Hydrogen Atoms ● Demonstrations ○ Flame Test 1. Soak BBQ skewers/q-tips in water 2. Use wet BBQ skewer/q-tip to pick up a small amount of a chloride salt and hold the flame of the BBQ lighter to the salt to observe the color	

Unit 6: Electrons and their Properties	**Time:** 7 days

Academic Standards:

3.2.9-12.A – 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.
3.2.9-12.B – 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.
3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
3.2.9-12.L – Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
3.2.9-12.V – 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.
3.2.9-12.W – Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
3.2.9-12.X – Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Essential Content/Objective: At the end of the unit, students will be able to:

- Compare the Bohr and quantum models of the atom, highlighting their key differences and implications for electron behavior.
- Identify and describe the major components of the quantum model, including orbitals, sublevels, and energy levels.
- Construct long-form electron configurations using the periodic table as a guide.
- Translate an electron configuration into an orbital diagram, accurately representing all electrons.
- Determine the noble gas configuration of an atom and identify the number of valence electrons.
- Analyze electron configurations to predict chemical behavior and stability.

Assessment:

- Entry Tickets
  - Maximum number of electrons per energy level based on the Bohr Model
  - Orbital Notation Electron Configuration Prediction
  - Long - Form Electron Configuration
  - Orbital Notation Electron Configuration
  - Noble Gas Electron Configuration
  - Electron Configuration and Identification of Valence Electrons
  - Ionization Energy
- Teacher Prepared Problem Sets
  - Quantum Model of an Atom
  - Electron Configuration
  - Other Forms of Electron Configuration

- Define the four quantum numbers and explain how they describe the location and properties of electrons.
- Assign quantum numbers to specific electrons in an orbital diagram.
- Evaluate a set of quantum numbers for validity and identify errors in incorrect sets.
- Define periodicity and explain how electron configuration influences periodic trends.
- Predict the charge of ions formed by atoms based on periodic placement and electron configuration.
- Write electron configurations for common ions and compare them to their neutral atoms.
- Use periodic trends to compare two or more elements in terms of atomic radius, ionization energy, and electronegativity.
- Justify differences in periodic properties based on atomic structure, shielding, and effective nuclear charge.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Quantum Model of an Atom"
  - Write the Orbital Notation Electron Configuration of a given element.
- Teacher Prepared Problem Set: "Electron Configuration"
  - Write the Long - Form Electron Configuration of a given element.
- Teacher Prepared Problem Set: "Other Forms of Electron Configuration"
  - Write the Long - Form Electron Configuration of a given element and identify the valence electrons.
  - Write the Nobel Gas Electron Configuration of an element and identify the valence electrons.
  - Quantum Numbers
  - Periodicity and Electron Configuration
  - Periodicity and Periodic Trends
- Virtual Lab Activities
  - Coulomb's Law
- Exit Tickets
  - Orbital Notation Electron Configuration
  - Long - Form Electron Configuration
  - Noble Gas Electron Configuration and Identification of Valence Electrons
  - Orbital Notation Electron Configuration and Prediction of Quantum Numbers
  - Prediction and Electron Configuration of an Ion
  - Ionization Energy
  - Electronegativity
- Electrons and their Properties Unit Assessment

○ Determine if an electron configuration is the ground state or excited state for a given element and, if excited state, identify the excited electron. ● Teacher Prepared Problem Set: "Quantum Numbers" ○ Write the Orbital Notation Electron Configuration of a given element and determine the four quantum numbers of the last electron placed in the orbitals. ○ Write the Orbital Notation Electron Configuration of a given element and find an electron given a set of four quantum numbers. If the electron cannot be found, explain the problem with the set of quantum numbers. ○ Given the Orbital Notation Electron Configuration of an element and one circled electron, determine the four quantum numbers of the circled electron. ● Teacher Prepared Problem Set: "Periodicity and Electron Configuration" ○ Given an element, write the electron configuration (any form) and use it to predict the most likely ion. Once predicted, write the electron configuration (any form) of the ion. ● Teacher Prepared Problem Set: "Periodicity and Periodic Trends" ○ Given the choice between two elements, determine which has the highest or lowest ionization energy and explain the reasoning. ○ Given the choice between two elements, determine which has the highest or lowest atomic radius and explain the reasoning. ○ Given the choice between two elements, determine which has the highest or lowest electronegativity and explain the reasoning. ● PhET Virtual Lab: "Coulomb's Law"	

Materials and Resources:

- Teacher Prepared Guided Notes
  - Quantum Model of an Atom
  - Electron Configuration
  - Other Forms of Electron Configuration
  - Quantum Numbers
  - Periodicity and Electron Configuration
  - Periodicity and Periodic Trends
- Teacher Prepared Problem Sets
  - Quantum Model of an Atom
  - Electron Configuration
  - Other Forms of Electron Configuration
  - Quantum Numbers
  - Periodicity and Electron Configuration
  - Periodicity and Periodic Trends
- PhET
  - Coulomb's Law
  - Teacher Prepared Data Collection Sheets
  - Teacher Prepared Analysis Questions
- Demonstration Materials
  - Balloons
  - Neodymium Magnets

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. The development of atomic models, including the differences between the Bohr model and the quantum mechanical model and their implications for the behavior and location of electrons.
    2. The organization of electrons within the quantum model, including energy levels, sublevels, orbitals,

Extensions:

- Scientific Literacy in the Media – Finding science media and parsing its validity, reliability, and possible problems with data interpretation
  - Students analyze articles or advertisements that make claims about elemental properties (such as "super materials," battery technologies, or rare-earth elements) and determine whether the claims are supported by known periodic trends and electron behavior.
- Question Construction – Building new practice questions and variations of questions to extend understanding
  - Choose eight elements and draw their orbital notation electron configurations. For each element, select one electron and determine its four quantum numbers. Then, convert these examples into practice questions similar to those found in Part 2 of the "Quantum Numbers" Problem Set. The completed set of questions must include at least one problem requiring a student to identify an electron located in each of the four sublevels (s, p, d, and f) and at least one problem containing an error in each of the four quantum numbers (n, l, m, and s) that another student must identify and explain.
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Students research the role of electron configurations in modern technologies, including semiconductors, transistors, LEDs, and computer chips. Students should explain how controlling electron behavior makes these technologies possible.

and the principles governing electron arrangement.

3. The representation of electron arrangements using long-form electron configurations, noble gas configurations, and orbital diagrams, including the identification of valence electrons and excited states.
4. The use of quantum numbers to describe the location and properties of electrons, including evaluating valid and invalid sets of quantum numbers.
5. The relationship between electron configuration and chemical behavior, including predicting ion formation and comparing the electron configurations of atoms and their ions.
6. The concept of periodicity and the relationship between electron configuration and periodic trends, including atomic radius, ionization energy, and electronegativity.
7. Problem-solving strategies for constructing electron configurations, interpreting orbital diagrams, assigning quantum numbers, predicting ion formation, and analyzing periodic trends.

- Guided Practice
    - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the

Remediation:

- Videos to review content and practice
    - Electron Configuration
    - Valence Electrons
    - Quantum Numbers
    - Determine 4 Quantum Numbers
    - Ions
    - Ionization Energy and Atomic Radius
    - Electronegativity
- Electrons and their Properties Practice Test
    - Additional problems similar to the questions that will appear on the unit assessment.

class to reinforce problem-solving strategies and ensure accurate understanding.

1. Write the Orbital Notation Electron Configuration of a given element and determine the four quantum numbers of the first and last electron placed in the orbitals.
2. Write the Orbital Notation Electron Configuration or if provided with the Orbital Notation Electron Configuration of a given element and find an electron given a set of four quantum numbers. If the electron cannot be found, explain the problem with the set of quantum numbers.
3. Write the Long - Form Electron Configuration of a given element and identify the valence electrons.
4. Write the Nobel Gas Electron Configuration of an element and identify the valence electrons.
5. Determine if an electron configuration is the ground state or excited state for a given element and, if excited state, identify the excited electron.
6. Given an element, write the electron configuration (any form) and use it to predict the most likely ion. Once predicted, write the electron configuration (any form) of the ion.
7. Given the choice between two elements, determine which has the highest or lowest ionization energy and explain the reasoning.
8. Given the choice between two elements, determine which has the highest or lowest atomic radius and explain the reasoning.
9. Given the choice between two elements, determine which has the highest or lowest electronegativity and explain the reasoning.

- Independent Problem Sets

- Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
    1. Quantum Model of an Atom
    2. Electron Configuration
    3. Other Forms of Electron Configuration
    4. Quantum Numbers
    5. Periodicity and Electron Configuration
    6. Periodicity and Periodic Trends
- Independent Virtual Lab Activities
    - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions.
        1. Coulomb's Law
- Demonstrations
    - Visualizing Orbitals
        1. Use balloons to demonstrate what s, p, and d orbitals look like
    - Coulomb's Law and Distance
        1. Ask for two student volunteers and have each hold a magnet and stand on opposite sides of the room and hold their magnets out in front of them.
        2. Have the other students predict if the magnets will attract to each other if the two students were to let go of their magnets. Have student volunteers let go of their magnets to confirm/deny student predictions.
        3. Ask the students with the magnets to then stand right next to each other so the magnets are right next to each other but not touching.

4. Have the other students predict if the magnets will attract to each other if the two students were to let go of their magnets. Have student volunteers let go of their magnets to confirm/deny student predictions.	

Unit 7: Ionic Molecules	**Time:** 5 days

Academic Standards:

3.2.9-12.A – 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.

3.2.9-12.B – 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.

3.2.9-12.C – 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.

3.2.9-12.N – Communicate scientific and technical information about why the molecular-level structure is important in the function of designed materials.

Essential Content/Objective: At the end of the unit, students will be able to:

- Define ionic and covalent bonds using appropriate chemical terminology.
- Classify chemical bonds as ionic or covalent based on electronegativity differences.
- Determine whether a covalent bond is polar or nonpolar using electronegativity values.
- Predict the direction of a dipole in a polar covalent bond and assign partial charges to atoms.
- Predict the ion each element will form based on its position on the periodic table.
- Write the correct chemical formula for an ionic compound given the ions involved.
- Name an ionic compound given its chemical formula.
- Determine the chemical formula of an ionic compound based on its name.
- Identify when a transition metal requires a Roman numeral to indicate its charge.
- Use the name of a compound to determine the oxidation number of a transition metal.

Assessment:

- Entry Tickets
  - Valence Electrons and Predicted Ions
  - Valence Electrons, Lewis Structures, and Predicted Ions
  - Predicting Molecular Formulas and Chemical Names for Basic Ionic Molecules
  - Predicting Molecular Formulas and Chemical Names for Ionic Molecules with Transition Metals
- Teacher Prepared Problem Sets
  - Bonding and Lewis Structures of Atoms
  - Formulas and Names of Ionic Compounds
  - Ionic Molecules with Transition Metals
  - Ionic Molecules and Polyatomic Ions
- Virtual Lab Activities
  - Atomic Interactions
- Exit Tickets
  - Lewis Structures and Bond Classifications
  - Predicting Molecular Formulas and Chemical Names for Basic Ionic Molecules

- Recognize and define common polyatomic ions by name and formula.
- Apply appropriate use of parentheses when writing formulas with multiple polyatomic ions.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Bonding and Lewis Structures of Atoms"
    - Draw the Lewis Structures of a given element.
    - Predict if two bonded atoms will form an ionic bond, polar covalent bond, or nonpolar covalent bond and explain why. If the bond is polar covalent, determine the partial charges and dipole of the bond.
- PhET Virtual Lab: "Atomic Interactions"
- Teacher Prepared Problem Set: "Formulas and Names of Ionic Compounds"
    - Predicting Molecular Formulas and Chemical Names for Basic Ionic Molecules
- Teacher Prepared Problem Set: "Ionic Molecules with Transition Metals"
    - Predicting Molecular Formulas and Chemical Names for Ionic Molecules with Transition Metals
- Teacher Prepared Problem Set: "Ionic Molecules with Polyatomic Ions"
    - Predicting Molecular Formulas and Chemical Names for Ionic Molecules with Polyatomic Ions
- Exploration Activity: "Roll for Ions"
    - Students will be provided with a 20-sided die and two columns of ions (one cation list and one anion list). They will roll the d20 twice to obtain a cation and anion, then use those ions to write the formula and name of a charge balanced ionic compound.
    - Predicting Molecular Formulas and Chemical Names for Ionic Molecules with Transition Metals
    - Predicting Molecular Formulas and Chemical Names for Ionic Molecules with Polyatomic Ions
- Roll for Ions
- Ionic Molecules Unit Assessment

Materials and Resources:

- Teacher Prepared Guided Notes
  - Bonding and Lewis Structures of Atoms
  - Formulas and Names of Ionic Compounds
  - Ionic Molecules with Transition Metals
  - Ionic Molecules and Polyatomic Ions
- Teacher Prepared Problem Sets
  - Bonding and Lewis Structures of Atoms
  - Formulas and Names of Ionic Compounds
  - Ionic Molecules with Transition Metals
  - Ionic Molecules and Polyatomic Ions
- PhET
  - Atomic Interactions
  - Teacher Prepared Data Collection Sheets
  - Teacher Prepared Analysis Questions
- Exploration Activity
  - Teacher Prepared Data Collection Sheet
  - Teacher Prepared Ion List
  - D20 dice
- Demonstration Materials
  - Beakers
  - Water
  - Salt
  - Sugar
  - Conductivity Meter

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. The formation of chemical bonds, including the differences between ionic and covalent bonding

Extensions:

- Question Construction – Building new practice questions and variations of questions to extend understanding
  - Create 5 molecular formulas other students should be able to provide the chemical name for and create 5 chemical names that other students should be able to provide the molecular formula for. For each set, students must include at least one chemical that includes a transition metal with plausible oxidation state, one chemical that includes a polyatomic ion, one chemical where the two ions have the same charge, and one chemical where the two ions are multiples of each other.
- Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance
  - Research ionic compounds in paint pigments
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Research the ionic compound in road salt, why it is used, and any environmental impacts of using road salt.

Remediation:

- Videos to review content and practice
  - Lewis Structure of Atoms
  - Ionic vs. Covalent Bonds
  - Ionic Bonding
  - Writing Ionic Formulas
  - Ionic Compounds with Transition Metals
  - Ionic Compounds with Polyatomic Ions
- Ionic Molecules Practice Test

and the role of electron interactions in creating stable chemical arrangements.
2. The relationship between electronegativity differences and bond classification, including the identification of ionic, polar covalent, and nonpolar covalent bonds and the interpretation of bond dipoles and partial charges.
3. The representation of valence electrons using Lewis structures and the use of electron arrangements to predict chemical behavior.
4. The formation of ions based on periodic placement and the relationship between ionic charge and chemical stability.
5. The representation of ionic compounds using chemical formulas, including the proper use of ionic charges, polyatomic ions, and parentheses in chemical notation.
6. The systematic naming of ionic compounds, including the identification of transition metal charges using Roman numerals and the interpretation of compound names to determine chemical formulas.
7. Problem-solving strategies for predicting bond type and polarity, constructing ionic formulas, and converting between chemical formulas and compound names.

- Guided Practice
    - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material,

    - Additional problems similar to the questions that will appear on the unit assessment.

volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
    1. Draw the Lewis Structures of a given element.
    2. Predict if two bonded atoms will form an ionic bond, polar covalent bond, or nonpolar covalent bond and explain why. If the bond is polar covalent, determine the partial charges and dipole of the bond.
    3. Predicting Molecular Formulas and Chemical Names for Ionic Molecules with all types of ions (Easily predicted ions, transition metals, and polyatomic ions)
- Independent Problem Sets
    - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
        1. Bonding and Lewis Structures of Atoms
        2. Formulas and Names of Ionic Compounds
        3. Ionic Molecules with Transition Metals
        4. Ionic Molecules and Polyatomic Ions
- Independent Virtual Lab Activities
    - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions.
        1. Atomic Interactions
- Demonstrations
    - Conductivity of Water

1. Present two beakers of water (one purified water, one salt water). Do not let students know the difference between the samples. 2. Discuss students' understanding of electronics near water sources (being cautious with hair dryers near the bathroom sink, etc.) 3. Check the conductivity of both samples and discuss why one is conductive and one isn't. 4. Discuss the lack of conductivity of pure water but why precautions need to be taken with electronics near water at home. ○ Dissolving vs. Dissociating 1. Present two beakers of water containing purified water. 2. Discuss the last demo and what made the salt water conductive. 3. Dissolve salt in one water sample and sugar into the other water sample 4. Check the conductivity of both samples and discuss why one is conductive and one isn't due to salt dissociating and sugar dissolving.	

Unit 8: Covalent Molecules	**Time:** 7 days

Academic Standards:

3.2.9-12.A – 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.

3.2.9-12.B – 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.

3.2.9-12.C – 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.

3.2.9-12.N – Communicate scientific and technical information about why the molecular-level structure is important in the function of designed materials.

3.3.9-12.E – Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

Essential Content/Objective: At the end of the unit, students will be able to:

- Identify covalent compounds based on their chemical formulas.
- Name covalent compounds using correct prefixes and nomenclature rules.
- Write molecular formulas given the name of a covalent compound.
- Determine the number of valence electrons in an atom based on its position on the periodic table.
- Construct Lewis structures for covalent molecules containing only single bonds using valence electron counts.
- Select the central atom in a covalent molecule based on electronegativity and bonding tendencies.
- Determine when double or triple bonds are needed to satisfy the octet rule in a Lewis structure.
- Construct Lewis structures with double and triple bonds as appropriate for a given molecular formula.
- Define formal charge and calculate it for each atom in a covalent molecule.

Assessment:

- Entry Tickets
  - Explore the “dangers” of dihydrogen monoxide”
  - Counting Valence Electrons
  - Drawing Lewis Structures of molecules that make different bonds
  - Drawing Lewis Structures of an ion
  - Drawing Lewis Structures of molecules with varying numbers of electron domains
  - Draw a Lewis Structure and predict the molecular geometry of a molecule with coordination 2, 3, or 4
- Teacher Prepared Problem Sets
  - Naming and Formulas of Covalent Molecules
  - Drawing Lewis Structures
  - Formal Charge and Complex Lewis Structures
  - Lewis Structures of Polyatomic Ions and Resonance
  - VSEPR and Molecular Geometry
- Virtual Lab Activities
  - Molecule Shapes
  - Molecule Polarity

• Revise Lewis structures to minimize formal charges and identify the most likely resonance structure.
• Define resonance and draw resonance structures for molecules and polyatomic ions where applicable.
• Apply the VSEPR theory to determine the molecular geometry and approximate bond angles of a molecule.
• Predict molecular shape based on electron group arrangement and distinguish between electron and molecular geometry.
 	
Core Student Activities: Students will complete/participate in the following:
• Teacher Prepared Problem Set: "Naming and Formulas of Colvanet Molecules"
  ○ Predicting Molecular Formulas and Chemical Names for Covalent Molecules
• Teacher Prepared Problem Set: "Drawing Lewis Structures"
  ○ Determine the number of electrons in a provided covalent molecule used to build the molecular structure
  ○ Use all available atoms and electrons to build a covalent molecule that obeys the octet rule
• Teacher Prepared Problem Set: "Formula Charge and Complex Lewis Structures"
  ○ Determine the number of electrons in a provided covalent molecule used to build the molecular structure.
  ○ Use all available atoms and electrons to build a covalent molecule that obeys the octet rule and takes minimized formal charge into consideration.
• Teacher Prepared Problem Set: "Lewis Structures of Polyatomic Ions and Resonance"
  ○ Determine the number of electrons in a provided covalent molecule used to build the molecular structure.
	• Exit Tickets
	  ○ Naming Covalent Molecules
	  ○ Drawing Lewis Structures of molecules that make different bonds
	  ○ Drawing Lewis Structure of a molecule with formal charge considerations
	  ○ Draw Resonance Structures of a polyatomic ion
	  ○ Draw a Lewis Structure and predict the molecular geometry of a molecule with coordination 2, 3, or 4
	  ○ Draw a Lewis Structure and predict the molecular geometry of a molecule with coordination 5 or 6
	• Covalent Molecules Unit Assessment

○ Use all available atoms and electrons to build a covalent molecule that obeys the octet rule and takes minimized formal charge into consideration. ○ Draw all possible other resonance structures when necessary ● Teacher Prepared Problem Set: "VSEPR and Molecular Geometry" ○ Determine the number of electrons in a provided covalent molecule used to build the molecular structure. ○ Use all available atoms and electrons to build a covalent molecule that obeys the octet rule and takes minimized formal charge into consideration. ○ Use the predicted Lewis Structure to draw the 3D structure of the molecule, name the molecular geometry, and predict the average bond angles in the molecule. ● PhET Virtual Lab: "Molecule Shapes" ● PhET Virtual Lab: "Molecule Polarity" ● Exploration Activity: "Candy Model Kit" ○ Students will be given a list of molecules to draw the Lewis Structures of and then use those Lewis Structures to determine the molecular geometry and build them using toothpicks and gumdrops.	
Materials and Resources: ● Teacher Prepared Guided Notes ○ Naming and Formulas of Covalent Molecules ○ Drawing Lewis Structures ○ Formal Charge and Complex Lewis Structures ○ Lewis Structures of Polyatomic Ions and Resonance ○ VSEPR and Molecular Geometry ● Teacher Prepared Problem Sets ○ Naming and Formulas of Covalent Molecules ○ Drawing Lewis Structures	**Extensions:** ● Scientific Literacy in the Media – Finding science media and parsing its validity, reliability, and possible problems with data interpretation ○ Students locate an article of video discussing a familiar molecule (such as carbon dioxide, ozone, ammonia, water, etc.) and evaluate whether the chemical formula and molecular structure are represented correctly, whether the claims about the molecular properties are supported by scientific

- Formal Charge and Complex Lewis Structures
- Lewis Structures of Polyatomic Ions and Resonance
- VSEPR and Molecular Geometry

- PhET
  - Molecule Shapes
  - Molecule Polarity
  - Teacher Prepared Data Collection Sheets
  - Teacher Prepared Analysis Questions
- Exploration Activity: "Candy Model Kit"
  - Teacher Prepared Worksheet
  - Toothpicks
  - Gumdrops
- Demonstration Materials
  - Giant Molecular Model Kit
  - Ballons
  - Molecular Moldel Kit with springs for bonds

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. The characteristics of covalent compounds, including the systematic naming of molecular compounds and the relationship between chemical names and molecular formulas.
    2. The role of valence electrons in covalent bonding, including determining the total number of valence electrons available for bond formation.
    3. The construction and interpretation of Lewis structures, including selecting central atoms, satisfying the octet rule, and determining when single, double, or triple bonds are required.

evidence, and whether the source accurately explains why the molecule behaves as described.

- Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance
  - Students research how molecular geometry influences the biological function of a macromolecule they learned about in biology (DNA base pairing, enzyme-substrate interactions, etc.)
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Students will explore a provided list of gases in the atmosphere by drawing their Lewis Structure and predicting their molecular geometry and polarity. They will then use a model kit to explore how those molecule's bonds move and how those movements change their polarity to determine which gases are greenhouse gases based on their change in polarity while the bonds move.

Remediation:

- Videos to review content and practice
  - Naming Covalent Compounds
  - Writing Covalent Molecular Formulas
  - Drawing Lewis Structures
  - Drawing Lewis Structures
  - Resonance Structures
  - VSEPR Introduction
  - VSEPR: Trigonal Bipyramidal Family
  - VSEPR: Octahedral Family
  - Common VSEPR Mistakes
- Covalent Molecules Practice Test

4. The use of formal charge to evaluate and revise Lewis structures, including identifying the most stable structures and recognizing resonance in molecules and polyatomic ions. 5. The application of VSEPR theory to predict electron group arrangements, molecular geometry, and approximate bond angles based on electron repulsion. 6. The relationship between molecular structure and three-dimensional molecular shape, including the distinction between electron geometry and molecular geometry. 7. Problem-solving strategies for naming covalent compounds, constructing Lewis structures, minimizing formal charges, drawing resonance structures, and predicting molecular geometry and bond angles. ● Guided Practice ○ Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding. 1. Predicting Molecular Formulas and Chemical Names for Covalent Molecules. 2. Determine the number of electrons in a provided covalent molecule used to build the molecular structure.	○ Additional problems similar to the questions that will appear on the unit assessment.

3. Use all available atoms and electrons to build a covalent molecule that obeys the octet rule and takes minimized formal charge into consideration.
4. Draw all possible other resonance structures when necessary
5. Use the predicted Lewis Structure to draw the 3D structure of the molecule, name the molecular geometry, and predict the average bond angles in the molecule.

- Independent Problem Sets
  - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
    1. Naming and Formulas of Covalent Molecules
    2. Drawing Lewis Structures
    3. Formal Charge and Complex Lewis Structures
    4. Lewis Structures of Polyatomic Ions and Resonance
    5. VSEPR and Molecular Geometry
- Independent Virtual Lab Activities
  - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions.
    1. Molecule Shapes
    2. Molecule Polarity
- Demonstrations
  - Visualizing Molecular Geometries
    1. Use a giant molecular model kit to show all molecular geometries in 3D space, why the naming works based on the look of the molecule,

and how to translate the 3D structure into a 2D drawing ○ What Makes Greenhouse Gas? 1. Use a molecular model kit with springs for bonds to show how molecules move and why changes in the shape while it moves decides if a molecule will be a greenhouse gas.	

Unit 9: Moles	**Time:** 6 days

Academic Standards:
3.2.9-12.B – 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.
3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
3.2.9-12.N – Communicate scientific and technical information about why the molecular-level structure is important in the function of designed materials.

Essential Content/Objective: At the end of the unit, students will be able to:

- Apply dimensional analysis to convert between various units
- Interpret word problems to identify appropriate conversion factors and perform unit conversions.
- Define a mole and Avogadro's number in the context of chemical quantities.
- Relate the number of representative particles in a substance to the number of moles present.
- Explain the relationship between moles of molecules and moles of atoms within a compound.
- Define the law of conservation of mass and describe its connection to molar mass.
- Calculate the molar mass of a compound using atomic masses from the periodic table.
- Convert between mass, moles, and number of particles (atoms, molecules, or formula units) using appropriate mathematical relationships.
- Determine the number of atoms of each element present in a compound given the number of moles or mass of the substance.

Core Student Activities: Students will complete/participate in the following:

Assessment:

- Entry Tickets
  - Construct List of Measurement Equivalencies
  - Perform a Unit Conversion
  - Counting Atoms in a Molecule
  - Counting Atoms in a Mole of Molecules
  - Calculate a Molar Mass
- Teacher Prepared Problem Sets
  - Dimensional Analysis
  - Word Problems and Dimensional Analysis
  - Moles
  - Molar Mass
  - Mass, Moles, and Particles
- Exit Tickets
  - Perform a Unit Conversion
  - Solve a Word Problem
  - Counting Atoms in a Mole of Molecules
  - Calculate a Molar Mass
  - Convert Number of Molecule to Moles and Mass
- "Molecules of Calcium Carbonate in a Drawing" Project
- Moles Unit Assessment

- Teacher Prepared Problem Set: “Dimensional Analysis”
    - Perform conversion from one unit to another in one step
    - Perform conversion from one unit to another in more than one step
- Teacher Prepared Problem Set: “Word Problems and Dimensional Analysis”
    - Solve word problems such as medication dosages using information given universally understood conversions (like the number of minutes in an hour) and conversion information given in the problem.
- Teacher Prepared Problem Set: “Moles”
    - Given a certain number of moles of a molecule, determine the number of moles of each atom and the number of atoms in the sample.
- Teacher Prepared Problem Set: “Molar Mass”
    - Given the molecular formula of a compound, calculate the molar mass.
    - Given the chemical name of a compound, determine the molecular formula and then calculate the molar mass.
- Teacher Prepared Problem Set: “Mass, Moles, and Particles”
    - Given the mass of a sample, determine the number of moles and molecules in the sample.
    - Given the number of moles in a sample, determine the mass and number of molecules in the sample.
    - Given the number of molecules in a sample, determine the number of moles and mass of the sample
    - Given any information about a molecule (mass, moles, or number of molecules), calculate the mass, moles, or atoms of a given atom in the sample.
- Exploration Activity: “Molecules of Calcium Carbonate in a Drawing”
    - Students will weigh a blank sheet of paper and a piece of chalk, draw on the paper, then re-weigh both. Using

the mass differences, they will calculate how much chalk was used, how much was transferred to the paper, how much was lost as dust, and convert these amounts to moles and molecules.	
Materials and Resources: ● Teacher Prepared Guided Notes ○ Dimensional Analysis ○ Word Problems and Dimensional Analysis ○ Moles ○ Molar Mass ○ Mass, Moles, and Particles ● Teacher Prepared Problem Sets ○ Dimensional Analysis ○ Word Problems and Dimensional Analysis ○ Moles ○ Molar Mass ○ Mass, Moles, and Particles ● Calculators ● Exploration Activity ○ Colored Paper ○ Chalk ○ Electric Balance ● Demonstration Materials ○ Rice ○ Metal Bolts ○ Cotton Balls ○ Plastic Beads ○ Electronic Balance	**Extensions:** ● Question Construction – Building new practice questions and variations of questions to extend understanding ○ Students will create three conversion problems: one starting with mass, one with moles, and one with the number of molecules. Each problem must use a different compound and require another student to determine the remaining two quantities, as well as calculate information about one of the elements in the compound. Each problem must begin with a different given quantity and require a different final calculation involving the selected element. ● Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance ○ Students investigate how industries use mole calculations to determine the quantities of raw materials needed to produce products efficiently while minimizing waste. ● Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue ○ Students investigate how chemists measure and monitor pollutants in air or water using quantitative chemical measurements, explaining why accurate unit conversions and chemical calculations are essential for environmental monitoring and regulation.

Instructional Methods:

- Direct Instruction
    - Students will receive direct instruction and problem examples on the following topics:
        1. The application of dimensional analysis as a systematic method for solving unit conversion problems and interpreting quantitative relationships.
        2. The concept of the mole as the standard unit for measuring the amount of a substance, including the significance of Avogadro's number and representative particles.
        3. The relationships among moles, representative particles, and the composition of chemical compounds, including distinguishing between moles of compounds and moles of individual atoms.
        4. The law of conservation of mass and its relationship to molar mass as a quantitative link between chemical formulas and measurable quantities.
        5. The calculation and interpretation of molar mass using atomic masses from the periodic table.
        6. The quantitative relationships among mass, moles, representative particles, and the number of atoms within a compound.
        7. Problem-solving strategies for applying dimensional analysis, calculating molar mass, and converting between mass, moles, representative particles, and the number of atoms in chemical substances.
- Guided Practice

Remediation:

- Videos to review content and practice
    - Conversion Factors
    - Converting Units
    - Dimensional Analysis in Medication Dosing
    - Molar Mass
    - Converting Between Grams and Moles
    - Converting Between Moles, Atoms, and Molecules
- Additional Practice Problems
    - Students will be provided with additional practice problems for dimensional analysis word problems that require students to interpret what unit is being converted, what the goal unit is, and what other data in the problem can be used as conversions.
    - Students will be provided with additional practice problems for mass, mole, and particle conversions that require students to make the correct list of conversions, start the problem with the correct number, and convert to the correct unit and chemical.
- Moles Practice Test
    - Additional problems similar to the questions that will appear on the unit assessment.

- Students will complete “You Try!!” problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
    1. Perform unit conversions from one provided unit to another.
    2. Perform unit conversions in word problems.
    3. Calculate the molar mass of a compound.
    4. Given the mass of a sample, determine the number of moles and molecules in the sample.
    5. Given the number of moles in a sample, determine the mass and number of molecules in the sample.
    6. Given the number of molecules in a sample, determine the number of moles and mass of the sample
    7. Given any information about a molecule (mass, moles, or number of molecules), calculate the mass, moles, or atoms of a given atom in the sample.
- Independent Problem Sets
    - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
        1. Dimensional Analysis
        2. Word Problems and Dimensional Analysis
        3. Moles
        4. Molar Mass

5. Mass, Moles, and Particles ● Demonstrations ○ Why Mass Doesn't Tell the Whole Story 1. Make a pile of 1 dozen grains of rice, 1 dozen metal bolts, 1 dozen cotton balls, and 1 dozen plastic beads. Discuss the theoretical mass of each pile and have students rank the mass of each pile. 2. Weigh a single item from each pile and use the measurements to predict the relative mass of each pile. Discuss why the mass of individual atoms cannot be measured directly using a typical electronic balance by comparing them to the mass of a single grain of rice, which may be too small for the balance to detect.	

Unit 10: Molecular Composition	**Time:** 5 days

Academic Standards:

3.2.9-12.B – 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.

3.2.9-12.C – 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.

3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3.2.9-12.N – Communicate scientific and technical information about why the molecular-level structure is important in the function of designed materials.

Essential Content/Objective: At the end of the unit, students will be able to:

- Calculate the percent composition of each element in a compound using its chemical formula.
- Analyze percent composition data to determine the relative proportions of elements in a substance
- Use percent composition to verify a compound's identity or compare empirical data to theoretical expectations.
- Determine the amount of water in a hydrate given experimental data
- Define empirical formula and molecular formula using correct terminology.
- Determine the empirical formula of a compound given a molecular formula.
- Calculate the empirical formula from percent composition data.
- Determine the molecular formula of a compound using its empirical formula and molar mass.
- Differentiate between empirical and molecular formulas based on chemical composition and application.

Assessment:

- Entry Tickets
  - Calculate Molar Mass
  - Calculate Percent Composition
  - Convert Mass to Mole
- Teacher Prepared Problem Sets
  - Finding Percent Composition
  - Using Percent Composition
  - Empirical and Molecular Formulas
- Exit Tickets
  - Calculate Percent Composition
  - Use Percent Composition to Solve a Word Problem
  - Find Empirical and Molecular Formula
- "Water in a Hydrate" Project
- Molecular Composition Unit Assessment

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Finding Percent Composition"
  - Given the molecular formula of a compound, calculate the percent composition of each atom in the molecule
- Exploration Activity: "Water in a Hydrate"
  - Students will weigh a hydrate, heat it to remove water, then reweigh the sample to determine the amount of water lost. They will use this data to formulate the chemical formula of the hydrate.
- Teacher Prepared Problem Set: "Using Percent Composition"
  - Use information about the percent composition of atoms in a molecule to solve problems in an alternate way to dimensional analysis
- Teacher Prepared Problem Set: "Empirical and Molecular Formulas"
  - Given the percent compositions of each atom in a molecule, determine the empirical formula
  - Given the molar mass of a chemical whose empirical formula is known, determine the molecular formula.

Materials and Resources:

- Teacher Prepared Guided Notes
  - Finding Percent Composition
  - Using Percent Composition
  - Empirical and Molecular Formulas
- Teacher Prepared Problem Sets
  - Finding Percent Composition
  - Using Percent Composition
  - Empirical and Molecular Formulas
- Calculators
- Exploration Activity

Extensions:

- Scientific Literacy in the Media – Finding science media and parsing its validity, reliability, and possible problems with data interpretation
  - Students locate or are provided with a news article or product advertisement that discusses the chemical composition of a material (such as a dietary supplement, fertilizer, cosmetic, or cleaning product). Students evaluate whether the claims are supported by quantitative composition data and

- Various Hydrate Compounds
- Watch Glass
- Bunsen Burner
- Crucible
- Stir Rods

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. The quantitative composition of chemical compounds, including the calculation and interpretation of percent composition using chemical formulas and molar mass.
    2. The relationship between percent composition and chemical identity, including the use of composition data to verify compounds and compare experimental results with theoretical values.
    3. The composition of hydrates and the quantitative determination of water content using experimental data.
    4. The distinction between empirical formulas and molecular formulas, including their meaning, applications, and relationship to the composition of a compound.
    5. The determination of empirical formulas from molecular formulas and percent composition data using quantitative reasoning.
    6. The relationship between empirical formulas, molecular formulas, and molar mass, including determining molecular formulas from experimentally derived information.

determine whether the information presented is complete, accurate, and scientifically reliable.

- Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance
  - Students research how forensic scientists use elemental composition and chemical analysis techniques to identify unknown substances, compare evidence samples, or determine the composition of trace materials.
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Students analyze a food or supplement label and compare the reported elemental or compound composition to the product's ingredients. Students discuss how quantitative information is communicated to consumers and identify any limitations or potentially misleading claims.

Remediation:

- Videos to review content and practice
  - Percent Composition
  - Empirical and Molecular Formula
  - Calculating Molecular Formula from Empirical Formula
- Molecular Composition Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

7. Problem-solving strategies for calculating percent composition, determining hydrate composition, deriving empirical formulas, and determining molecular formulas from empirical formulas and molar mass.

- Guided Practice
    - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
        1. Given the molecular formula of a compound, calculate the percent composition of each atom in the molecule.
        2. Solve word problems given information using the percent composition of an atom in a molecule.
        3. Given the percent compositions of each atom in a molecule, determine the empirical formula
        4. Given the molar mass of a chemical whose empirical formula is known, determine the molecular formula.
- Independent Problem Sets
    - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
        1. Finding Percent Composition
        2. Using Percent Composition
        3. Empirical and Molecular Formulas

Unit 11: Chemical Reactions	**Time:** 6 days

Academic Standards:

3.2.9-12.B – 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.
3.2.9-12.C – 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.
3.2.9-12.D – Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
3.2.9-12.N – Communicate scientific and technical information about why the molecular-level structure is important in the function of designed materials.
3.2.9-12.O – 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.
3.2.9-12.P – 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 positions of particles (objects).
3.2.9-12.Q – Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
3.3.9-12.O – Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Essential Content/Objective: At the end of the unit, students will be able to:

- Translate a written chemical reaction into a balanced chemical equation using correct formulas and symbols.
- Classify chemical reactions as synthesis, decomposition, single displacement, double displacement, or combustion.
- Predict the products of a chemical reaction based on reactants and reaction type.
- Define the law of conservation of matter.
- Balance chemical equations to satisfy the law of conservation of matter.

Assessment:

- Entry Tickets
  - Write molecular formulas from chemical names
  - Write a chemical equation and classify
  - Predict a chemical reaction
  - Balance a chemical reaction
- Teacher Prepared Problem Sets
  - Writing Chemical Reactions
  - Predicting Chemical Reactions
  - Balancing Chemical Reactions
  - Bond Energies and Energies of Reactions
- Virtual Lab Activities

- Construct Lewis structures of reactants and products to identify bonds being broken and formed.
- Use bond energy values to calculate the total energy required to break bonds in reactants.
- Calculate the total energy released from bond formation in products.
- Determine the net energy change of a chemical reaction using bond energies.
- Define endothermic and exothermic reactions and identify each based on energy calculations or reaction descriptions.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: “Writing Chemical Reactions”
    - Students are presented with a written description of a chemical reaction and asked to identify the products and reactants. They are to use that information to write the chemical reaction with the chemicals in the correct locations.
    - Once students write the chemical reaction, they use the reactants and products to determine the classification of the reaction.
- Teacher Prepared Problem Set: "Predicting Chemical Reactions”
    - Students are provided information about half of a chemical reaction and the classification of the reaction and use this information to write a proper chemical reaction.
- Teacher Prepared Problem Set: “Balancing Chemical Reactions”
    - Given a chemical reaction, students must balance the reaction.
- PhET Virtual Lab: “Balancing Chemical Equations”
- Teacher Prepared Problem Set: “Bond Energies and Energies of Reactions”
    - Balancing Chemical Equations
- Exit Tickets
    - Write a chemical equation and classify
    - Predict a chemical reaction
    - Balance a chemical reaction
    - Determine the energy absorbed/emitted from a reaction
- “Fuel Efficiency” Project
- Chemical Reactions Unit Assessment

○ Students are provided with a balanced chemical reaction and they must use the reaction to draw the Lewis structures of all chemicals in the equations. ○ Students use the Lewis structures to calculate the amount of energy absorbed or released by the reaction based on the number and types of bonds broken and formed. ○ Students classify the reaction as endothermic or exothermic based on the amount of energy absorbed or released by the reaction. ● Exploration Activity: "Fuel Efficiency" ○ Students will be provided with the chemical structures/formulas of a variety of everyday fuel sources (propane, natural gas, gasoline, etc.) and must use the combustion reaction and bond energies to determine the amount of energy per mole each fuel provides when burned.	
Materials and Resources: ● Teacher Prepared Guided Notes ○ Writing Chemical Reactions ○ Predicting Chemical Reactions ○ Balancing Chemical Reactions ○ Bond Energies and Energies of Reactions ● Teacher Prepared Problem Sets ○ Writing Chemical Reactions ○ Predicting Chemical Reactions ○ Balancing Chemical Reactions ○ Bond Energies and Energies of Reactions ● Calculators ● PhET ○ Balancing Chemical Equations ○ Teacher Prepared Data Collection Sheets	**Extensions:** ● Scientific Literacy in the Media – Finding science media and parsing its validity, reliability, and possible problems with data interpretation ○ Students must find an advertisement for product that makes false claims based on the chemistry (for example, products that suggest they add hydrogen to water) ● Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance ○ Students will research the typical products of a combustion reaction (carbon dioxide and water) and discuss why carbon dioxide is contributing to global warming and water is not despite both being greenhouse gases.

- Teacher Prepared Analysis Questions
- Demonstration Materials
  - Flask
  - 20% hydrogen peroxide
  - Solution of potassium iodide
  - Dish soap
  - Food coloring

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. Translate written descriptions of chemical changes into properly written chemical equations and classify reactions by type.
    2. Predict the products of chemical reactions by recognizing patterns in synthesis, decomposition, single displacement, double displacement, and combustion reactions.
    3. Balance chemical equations using coefficients to satisfy the law of conservation of matter.
    4. Use Lewis structures to identify chemical bonds broken and formed during a reaction.
    5. Calculate the energy absorbed and released during a reaction using bond energy values.
    6. Determine the overall energy change of a reaction and classify reactions as endothermic or exothermic based on energy calculations and reaction descriptions.
- Guided Practice
  - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Students will research the chemical reaction responsible for handwarmers. They will use this reaction to prove that the reaction is exothermic and how much energy is produced by the reaction.

Remediation:

- Videos to review content and practice
  - Types of Chemical Reaction
  - Balancing Chemical Reactions
  - Bond Energies
  - Reaction Energies from Bond Energies
- Additional Practice Problems
  - Students will be provided with additional practice problems for energy of reaction calculations.
- Chemical Reactions Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.

1. Provided with a written description of a reaction, students must write a proper chemical reaction and classify the type of chemical reaction.
2. Provided with some information about a chemical reaction and the classification of the reaction, students must predict the remainder of the chemical reaction.
3. Balance a variety of chemical reactions.
4. Determine the amount of energy a reaction absorbs or emits based on the amount and types of chemical bonds broken and formed.
5. Classify a chemical reaction as being endothermic or exothermic.

- Independent Problem Sets
    - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
        1. Writing Chemical Reactions
        2. Predicting Chemical Reactions
        3. Balancing Chemical Reactions
        4. Bond Energies and Energies of Reactions
- Independent Virtual Lab Activities
    - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the

simulation, collect and organize relevant data, and draw evidence-based conclusions. 1. Balancing Chemical Equations ● Demonstrations ○ Elephant Toothpaste 1. 20% hydrogen peroxide is placed in a flask along with dish soap and some food coloring 2. Add a solution of potassium iodide and demonstrate a chemical reaction. 3. Discuss with students what is happening with the reaction and note key features that chemical changes are occurring.	

Unit 12: Reaction Measurements	**Time:** 6 days

Academic Standards:

3.2.9-12.B – 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.
3.2.9-12.C – 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.
3.2.9-12.D – Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
3.2.9-12.N – Communicate scientific and technical information about why the molecular-level structure is important in the function of designed materials.
3.2.9-12.O – 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.
3.2.9-12.P – 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 positions of particles (objects).
3.2.9-12.Q – Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Essential Content/Objective: At the end of the unit, students will be able to:

- Interpret balanced chemical equations to determine mole-to-mole relationships between reactants and products.
- Perform stoichiometric calculations to determine the amount of reactants needed or products formed in a chemical reaction.
- Identify the limiting reagent in a chemical reaction using mole ratios.
- Determine the amount of excess reagent remaining after a reaction is complete.
- Calculate the theoretical yield of a product based on given quantities of reactants.
- Define percent yield and explain factors that can cause actual yields to differ from theoretical values.

Assessment:

- Entry Tickets
  - Balance a chemical reaction
  - Stoichiometry
  - Predicting experimental errors
- Teacher Prepared Problem Sets
  - Stoichiometry
  - Limiting Reagents
  - Yields
- Virtual Lab Activities
  - Reactants, Products, and Leftovers
- Exit Tickets
  - Stoichiometry
  - Limiting reagent

● Calculate percent yield using actual and theoretical yield values. ● Use percent yield to evaluate reaction efficiency and determine the amounts of substances involved in the reaction. **Core Student Activities:** Students will complete/participate in the following: ● Teacher Prepared Problem Set: "Stoichiometry" ○ Provided a chemical reaction and the amount of one chemical in the reaction, students will use stoichiometry to determine the amount of another chemical in the reaction. ● Teacher Prepared Problem Set: "Limiting Reagents" ○ Provided a chemical reaction and the amount of two reactants, students will identify the limiting reagent and the excess reagent. ○ Students will use the limiting reagent to determine the amount of all chemicals at the end of the reaction. ● PhET Virtual Lab: "Reactants, Products, and Leftovers" ● Teacher Prepared Problem Set: "Yields" ○ Students will calculate theoretical yields for a given reaction and amount of starting material and use the provided actual yield to determine the percent yield of a reaction. ○ Students will use the provided actual yield of and percent yield of a reaction to determine the theoretical yield along with information about other chemicals in the chemical reaction.	○ Calculate percent yield ● Reaction Measurements Unit Assessment

Materials and Resources:

- Teacher Prepared Guided Notes
  - Stoichiometry
  - Limiting Reagents
  - Yields
- Teacher Prepared Problem Sets
  - Stoichiometry
  - Limiting Reagents
  - Yields
- Calcuators
- PhET
  - Reactants, Products, and Leftovers
  - Teacher Prepared Data Collection Sheets
  - Teacher Prepared Analysis Questions
- Demonstration Materials
  - Graham Crackers
  - Marshmallows
  - Chocolate
  - Popcorn Kernels
  - Popcorn Maker

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. Use balanced chemical equations and mole ratios to predict the amounts of reactants required and products formed in a chemical reaction.
    2. Apply stoichiometric relationships to determine the limiting reagent and excess reagent in a chemical reaction.
    3. Calculate the amounts of all substances present after a reaction using the limiting reagent.

Extensions:

- Question Construction – Building new practice questions and variations of questions to extend understanding
  - Students must construct a full limiting reagent problem that requires other students to consider the starting amounts of each reactant and incorporates percent yield.
- Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance
  - Students will be provided with the balanced chemical reaction for photosynthesis. They must research the amount of carbon dioxide a mature tree absorbs in a year, how much carbon dioxide is produced on average by one person, the population of the United States, and an estimated number of trees in the United States. They will use this information and stoichiometry to determine if there are enough trees in the country to counteract the average carbon dioxide produced by people in the United States.
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue
  - Students research how manufacturers might consider limiting reagents and percent yield in their production of products and how these things might impact the cost of those products.

Remediation:

- Videos to review content and practice
  - Mole Ratios
  - Stoichiometry
  - Introduction to Limiting Reagents

4. Calculate the theoretical yield of a product from a given amount of reactant.
5. Use actual yield and theoretical yield values to calculate percent yield and evaluate reaction efficiency.
6. Perform calculations involving actual yield, theoretical yield, and percent yield to determine unknown quantities in a chemical reaction.

- Guided Practice
  - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
    1. Perform stoichiometry calculations to predict the amount of a chemical in a reaction required or produced.
    2. Perform stoichiometry calculations to determine the limiting reagent and excess reagent of a chemical reaction.
    3. Use the limiting reagent to determine the amount of all chemicals present at the end of a chemical reaction.
    4. Use predicted theoretical yields and provided actual yields to determine the percent yield of a reaction.
    5. Perform calculations regarding theoretical yields based on information provided about actual yields and percent yields.
  - Limiting and Excess Reagents
  - Percent Yields
- Additional Practice Problems
  - Students will be provided with additional practice problems for limiting reagent calculations.
- Reaction Measurements Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

- Independent Problem Sets
    - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
        1. Stoichiometry
        2. Limiting Reagents
        3. Yields
- Independent Virtual Lab Activities
    - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions.
        1. Reactants, Products, and Leftovers
- Demonstrations
    - S'more Chemical Reactions
        1. Students are presented with 16 graham crackers, 11 marshmallows, and 5 pieces of chocolate and asked how many s'mores can be made.
        2. Once the number of s'mores that can be made is determined, students are asked to determine which ingredients are left over and how many of each.
        3. Students are asked to walk through all thought processes and a list of steps is made so as to compare them to the steps needed to solve a limiting reagent problem.
    - Percent Yield of Popcorn
        1. Students are told that a container holds exactly 100 popcorn kernels and those kernels are poured into a popcorn maker and allowed to pop.

2. Once the popcorn finishes popping, the unpopped kernels are collected and counted. 3. The percent yield of the “reaction” is discussed with students.	

Unit 13: Solutions	**Time:** 7 days

Academic Standards:

3.2.9-12.E – Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

3.2.9-12.F – Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

3.2.9-12.O – 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.

3.2.9-12.G – Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3.2.9-12.P – 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 positions of particles (objects).

Essential Content/Objective: At the end of the unit, students will be able to:

- Define solution, solute, solvent, and solubility using appropriate chemical terminology.
- Identify the solute and solvent in a given solution based on composition
- Predict the solubility of a compound in water using solubility rules or general guidelines.
- Write balanced chemical equations for precipitation reactions.
- Determine the solubility of products in a reaction and identify any precipitates formed.
- Calculate solution concentrations using various units, including molarity, mass percent, and parts per million.
- Perform dilution calculations using the molarity-volume relationship.
- Use solution concentrations to perform stoichiometric calculations involving moles, volume, and mass of reactants and products

Assessment:

- Entry Tickets
  - Homogeneous mixtures
  - Prediction of solubility
  - Write a balanced chemical equation and predict product solubility
  - Calculate molarity
  - Stoichiometry
- Teacher Prepared Problem Sets
  - Solutions and Solubility
  - Precipitation Reactions
  - Concentration
  - Molarity and Dilution
  - Solution Stoichiometry
- Virtual Lab Activities
  - Concentration
  - Molarity
- Exit Tickets
  - Prediction of solubility

- Analyze quantitative relationships in aqueous reactions using balanced equations and

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Solutions and Solubility"
  - Given a description of a solution, identify the solute and the solvent.
  - Given a list of products from a chemical reaction, determine if the product will be water soluble.
- Teacher Prepared Problem Set: "Precipitation Reactions"
  - Provided with the reactants of a reaction, predict the products, provide a balanced chemical reaction, and determine if the products are water soluble.
- Exploration Activity: "Determine the Unknown Substance"
  - Students will be given a series of reactions to complete that show a distinct difference in precipitation. They must use this data to determine the most efficient (i.e. least number of reactions) that can be used to determine the identity of an unknown substance.
- Teacher Prepared Problem Set: "Concentration"
  - Determine the concentration of a solution based on provided information.
- PhET Virtual Lab: "Concentration"
- Teacher Prepared Problem Set: "Molarity and Dilutions"
  - Calculate the concentration of a solution after being diluted.
  - Calculate the amount of solvent required to dilute a solution to a desired concentration.
  - Calculate the concentration of a starting solution based on the final concentration and the amount of solvent added.
  - Write a balanced chemical equation and predict product solubility
  - Calculate molarity
  - Dilution Calculation
  - Solution Stoichiometry
- "Determine the Unknown Substance" Project
- Solutions Unit Assessment

○ Calculate the volume of a diluted solution based on the starting concentration and the desired concentration. ● PhET Virtual Lab: “Molarity” ● Teacher Prepared Problem Set: “Solution Stoichiometry" ○ Perform stoichiometric calculations where information about at least one of the chemicals is provided as a concentration rather than a mass.	
Materials and Resources: ● Teacher Prepared Guided Notes ○ Solutions and Solubility ○ Precipitation Reactions ○ Concentration ○ Molarity and Dilution ○ Solution Stoichiometry ● Teacher Prepared Problem Sets ○ Solutions and Solubility ○ Precipitation Reactions ○ Concentration ○ Molarity and Dilution ○ Solution Stoichiometry ● Calculators ● PhET ○ Concentration ○ Molarity ○ Teacher Prepared Data Collection Sheets ○ Teacher Prepared Analysis Questions ● Exploration Activity ○ Silver nitrate ○ Copper (II) nitrate ○ Iron (III) nitrate ○ Hydrocholoric acid ○ Sodium hydroxide	**Extensions:** ● Scientific Literacy in the Media – Finding science media and parsing its validity, reliability, and possible problems with data interpretation ○ Students find a news article that discusses contamination of drinking water. They must determine the concentration of the contaminate and compare it to EPA standards for that contaminant. ● Question Construction – Building new practice questions and variations of questions to extend understanding ○ Students will design a serial dilution problem and key where other students will be asked to determine the concentration at each step of the dilution. ● Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance ○ Students research EPA standards for drinking water for one contaminant or additive in public drinking water (lead, arsenic, fluoride, etc.), determine the legal threshold, and why these thresholds became the legal standard. ● Chemistry in Context – Researching chemistry’s relevance to real world issues and addressing ways that chemistry has solved or could solve these issue ○ Students must research the concentrations of each electrolyte in a sports drink or mix and calculate in

- Ammonium hydroxide
- Sulfuric acid
- Potassium thiocyanate
- Test tubes
- Droppers

- Demonstration Materials
  - Beakers
  - Silver nitrate
  - Sodium chloride
  - Food coloring
  - Water

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. Identify the components of a solution and distinguish between solutes and solvents based on the composition of a mixture.
    2. Predict the solubility of ionic compounds using solubility rules and determine whether a precipitate will form in an aqueous reaction.
    3. Write and balance chemical equations for precipitation reactions and identify the physical states of reactants and products.
    4. Calculate solution concentrations using units such as molarity, mass percent, and parts per million.
    5. Apply the molarity-volume relationship to determine unknown concentrations and volumes during dilution.
    6. Use solution concentrations and balanced chemical equations to perform stoichiometric

ppm. They must then research the RDA of each electrolyte and determine the amount they must consume to meet the RDA.

Remediation:

- Videos to review content and practice
  - Solubility Rules
  - Precipitation Reactions
  - Writing Net Ionic Equations
  - Concentrations
  - Dilutions
  - Dilution Calculations
  - Solution Stoichiometry
- Additional Practice Problems
  - Students will be provided with additional practice problems for solution stoichiometry calculations.
- Solutions Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

calculations involving moles, masses, and volumes of reactants and products. 7. Analyze quantitative relationships in aqueous reactions by combining concentration calculations with stoichiometric principles. ● Guided Practice ○ Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding. 1. Distinguish solute from solvent in a description of a solution. 2. Determine if an ionic compound will be water soluble. 3. Write a balanced chemical reaction where the products are predicted based on the reactants and the solubility of the products is determined. 4. Calculate the concentration of a solution. 5. Calculate volume and molarity of a chemical undergoing dilution. 6. Perform stoichiometric calculations where information about at least one of the chemicals is provided as a concentration rather than a mass. ● Independent Problem Sets ○ Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.	

1. Solutions and Solubility
2. Precipitation Reactions
3. Concentration
4. Molarity and Dilution
5. Solution Stoichiometry

- Independent Virtual Lab Activities
  - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions.
    1. Concentration
    2. Molarity
- Demonstrations
  - Mixing "Water" samples
    1. Present students with two clear solutions that appear to be water (one is a solution of soluble silver nitrate and one is a solution of soluble sodium chloride). Ask the students what will happen when the solutions are mixed without informing them that the solutions are not water.
    2. Mix the two solutions and allow the silver chloride to precipitate out of solution and ask students if the starting solutions were actually water and hypothesize what they might have been.
  - Serial Dilution
    1. Start with adding a large amount of food coloring to water (quantify the addition by counting the number of drops).
    2. Pour the dark solution into a larger beaker containing water and discuss how the color and amount of food coloring changes from one beaker to the next.

3. Repeat step 2 and discuss. 4. Have students predict what happens if we were to continue this process.	

Unit 14: Gases (Time Permitting)	**Time:** 5 days

Academic Standards:

3.2.9-12.B 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

3.2.9-12.D Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

3.2.9-12.E Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

3.2.9-12.F Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

3.2.9-12.I Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

3.2.9-12.J Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

Essential Content/Objective: At the end of the unit, students will be able to:

- Define pressure and identify its units in different measurement systems.
- Convert between common units of pressure (e.g., atm, mmHg, torr, Pa).
- Explain the physical meaning of pressure in gases.
- State the Ideal Gas Law and describe the variables involved (P, V, n, R, T).
- Apply the Ideal Gas Law to solve for unknown quantities in gas problems.
- Analyze how changes in one variable affect the others in the Ideal Gas Law.
- Calculate the molar mass or density of a gas using the Ideal Gas Law.
- Derive Boyle's, Charles's, Gay-Lussac's, Avogadro's, and the Combined Gas laws from the Ideal Gas Law.

Assessment:

- Entry Tickets
  - Review of gases
  - Partial pressure calculation
  - Ideal gas law calculation
- Teacher Prepared Problem Sets
  - Pressure
  - Ideal Gas Law
  - Other Gas Laws
- Virtual Lab Activities
  - Gas Properties
- Exit Tickets
  - Partial pressure calculation
  - Ideal gas law calculation
  - Derived gas law calculation
- Gases Unit Assessment

- Apply individual gas laws to solve related problems.
- Explain Dalton's Law of Partial Pressures and calculate total pressure from partial pressures.
- Evaluate how gas mixtures behave under different conditions.
- Synthesize knowledge of multiple gas laws to solve complex problems involving gases.

Core Student Activities: Students will complete/participate in the following:

- Teacher Prepared Problem Set: "Pressure"
  - Perform conversions between different pressure units
  - Calculate partial pressures for gas mixtures
  - Read manometers
- PhET Virtual Lab: "Gas Properties"
- Teacher Prepared Problem Set: "Ideal Gas Law"
  - Perform calculations to determine either pressure, volume, moles, or temperature of a gas given the other variables.
- Teacher Prepared Problem Set: "Other Gas Laws"
  - Given information about two changing variables in a gas system, derive an appropriate equation starting from the ideal gas law and use it to solve for an unknown variable.

Materials and Resources:

- Teacher Prepared Guided Notes
  - Pressure
  - Ideal Gas Law
  - Other Gas Laws
- Teacher Prepared Problem Sets
  - Pressure
  - Ideal Gas Law
  - Other Gas Laws
- Calculators

Extensions:

- Interdisciplinary Research – Finding evidence of chemistry in other subjects explaining its relevance
  - Students research atmospheric pressure. Determine how and why atmospheric pressure changes based on altitude.
- Chemistry in Context – Researching chemistry's relevance to real world issues and addressing ways that chemistry has solved or could solve these issue

- PhET
  - Gas Properties
  - Teacher Prepared Data Collection Sheets
  - Teacher Prepared Analysis Questions
- Demonstration Materials
  - Water
  - Aluminum Can
  - Hot Plate

Instructional Methods:

- Direct Instruction
  - Students will receive direct instruction and problem examples on the following topics:
    1. Model how pressure is defined at the particle level and connect it to common measurement units used in gas systems.
    2. Demonstrate how to convert between different pressure units and explain when each unit is typically used in scientific contexts.
    3. Develop conceptual understanding of gas behavior by linking macroscopic observations (pressure, volume, temperature) to particle motion and collisions.
    4. Introduce the Ideal Gas Law as a unified relationship between gas variables and show how it can be rearranged to solve for unknown quantities.
    5. Guide students through using the Ideal Gas Law to analyze how changes in one variable affect the others in a system.
    6. Model calculations involving molar mass and gas density using the Ideal Gas Law in applied problem contexts.
  - Students research the contents of SCUBA tanks and discuss why other gases besides oxygen are added to the tanks.

Remediation:

- Videos to review content and practice
  - Pressure
  - Manometers
  - Partial Pressure
  - Ideal Gas Law Crash Course
  - Ideal Gas Law Calculations
  - Deriving Gas Laws
- Gases Practice Test
  - Additional problems similar to the questions that will appear on the unit assessment.

7. Show how the Ideal Gas Law can be manipulated to derive other gas laws, including Boyle's, Charles's, Gay-Lussac's, Avogadro's, and the Combined Gas Law.
8. Demonstrate when and how to apply individual gas laws to solve specific types of gas problems.
9. Introduce Dalton's Law of Partial Pressures and model how total pressure in gas mixtures is determined from individual gas components.
10. Connect gas law concepts to multi-step problem solving involving changing conditions and mixed gas systems.
11. Guide students through integrating multiple gas laws to solve complex, real-world gas behavior problems.

- Guided Practice
    - Students will complete "You Try!!" problems that are similar to the teacher-modeled examples while the instructor circulates throughout the classroom to monitor student understanding, provide clarification, and offer additional support as needed. Once students have demonstrated sufficient understanding of the material, volunteers will present and explain their solutions to the class to reinforce problem-solving strategies and ensure accurate understanding.
        1. Perform conversions between different pressure units
        2. Calculate partial pressures for gas mixtures
        3. Perform calculations to determine either pressure, volume, moles, or temperature of a gas given the other variables.
        4. Given information about two changing variables in a gas system, derive an appropriate equation

starting from the ideal gas law and use it to solve for an unknown variable.

- Independent Problem Sets
    - Students will be provided with time during class and/or assigned homework to complete teacher-provided problem sets independently to reinforce the concepts and skills introduced during instruction.
        1. Pressure
        2. Ideal Gas Law
        3. Other Gas Laws
- Independent Virtual Lab Activities
    - Students will complete independent virtual laboratory investigations using PhET simulations, during which they will design their own approach to exploring the simulation, collect and organize relevant data, and draw evidence-based conclusions.
        1. Gas Properties
- Demonstrations
    - Soda Can Implosion
        1. Add a small amount of water to an aluminum can and heat the can.
        2. Quickly invert the can into cold water and watch the can collapse.
        3. Discuss with students why this occurs using information about changes in temperature and pressure.