NGSS Pacing Guide Overview

- **1 Matter and Change (HS-PS1-1)**
  - Define Chemistry
    - List examples of branches of Chemistry
    - Compare and Contrast Basic Research, Applied Research, and technological development.
  - Matter and Its Properties
    - Classify matter
    - Distinguish between physical and chemical properties
    - Law of conservation of energy
    - Distinguish between mixtures and pure substances
  - Elements
    - Use periodic table to name elements and symbols
    - Describe arrangement of periodic table
    - List characteristics of metals, nonmetals, and metalloids
- **2 The Atom (HS-PS1-1)**
  - The Atom
    - Law of conservation of mass
    - Law of definite proportions
    - Law of multiple proportions
    - Dalton's Atomic Theory
    - Explain the relationship between Dalton's Theory and the Laws
  - Atomic Structure
    - Summarize the observed properties of cathode rays
    - Summarize Rutherford's experiment that led to the discovery of the nucleus
    - List the properties of protons, neutrons, and electrons
    - Define the atom
  - Counting Atoms
    - Explain what isotopes are
    - Define atomic number and mass number, and explain how they apply to isotopes
    - Define mole, Avogadro's number, and molar mass, and state how they are related
    - Solve problems involving mass in grams, amount in moles, and number of atoms in an element
- **3 Arrangement of Electrons in Atoms (HS-PS1-1)**
  - The Development of a New Atomic Model
    - Explain the mathematical relationship among the speed, wavelength, and frequency of electromagnetic radiation
    - Describe the Bohr Model of the hydrogen atom
  - Quantum Model of the Atom
    - Discuss de Broglie's role in the development of the quantum model of the atom
    - Compare and contrast the Bohr Model and the quantum model of the atom
    - Explain how the Heisenberg uncertainty principle and the Schrodinger wave equation led to the idea of atomic orbitals
    - List the four quantum numbers and describe their significance
    - Relate the number of sublevels corresponding to each of an atom's main energy levels, the number of orbitals per sublevel, and the number of orbitals per main energy level
  - Electron Configuration
    - List the total number of electrons needed to fully occupy each main energy level
    - State the Aufbau principle, the Pauli exclusion principle, and Hund's rule

        - Describe the electron configurations for the atoms of any element using orbital notation, electron-configuration notation, and noble gas notation.
- **4 Periodic Law (HS-PS1-1)**
    - History of the Periodic Table
        - Explain the roles of Mendeleev and Moseley in the development of the periodic table
        - Describe the modern periodic table
        - Explain how the periodic law can be used to predict the physical and chemical properties of the elements
        - Describe how the elements belonging to a group of the periodic table are interrelated in terms of atomic number
    - Electron Configuration and the Periodic Table
        - Describe the relationship between electrons in sublevels and the length of each period on the periodic table
        - Locate and name the four blocks of the periodic table
        - Discuss the relationship between the group configuration and group numbers
        - Describe the locations in the periodic table and the general properties of the alkali metals, alkaline-earth metals, halogens, and noble gases.
    - Electron Configuration and Periodic Properties
        - Define atomic and ionic radii, ionization energy, electron affinity, and electronegativity
        - Compare the periodic trends, define valence electrons, and state how many are present in atoms of each main-group element
        - Compare the d-block elements with the main-group elements
- **5 Chemical Bonding (HS-PS1-2, HS-PS1-7)**
    - Introduction to Chemical Bonding
        - Define Chemical Bond
        - Explain why most atoms for chemical bonds
        - Describe ionic and covalent bonding
        - Explain why most chemical bonding is neither purely ionic nor covalent
        - Classify bonding type according to electronegativity differences
    - Covalent Bonding and Molecular Compounds
        - Define molecule and molecular formula
        - Explain the relationships among potential energy, distance between approaching atoms, bond length, and bond energy
        - State the octet rule
        - List the six basic steps in writing Lewis structures
        - Explain how to determine Lewis structures for molecules containing single bonds, multiple bonds, or both
        - Explain why scientists use resonance structures to represent some molecules
    - Ionic Bonding and Ionic Compounds
        - Compare and contrast a chemical formula for a molecular compound with one for an ionic compound
        - Discuss the arrangements of ions in crystals, define lattice energy and explain its significance
        - List and compare the distinctive properties of ionic and molecular compounds
        - Write the Lewis structure for a polyatomic ion given the identity of the atoms combined and other appropriate information
    - Metallic Bonding
        - Describe the electron-sea model of metallic bonding
        - Explain why metals are good electrical conductors
        - Explain why metal surfaces are shiny
        - Explain why metals are malleable and ductile but ionic-crystalline compounds are not
    - Molecular Geometry

        - Explain VSEPR theory
        - Predict the shapes of molecules or polyatomic ions using VSEPR theory
        - Explain how the shapes of molecules are accounted for by hybridization theory
        - Describe dipole-dipole forces, hydrogen bonding, induced dipoles, and London dispersion forces and their effects on properties such as boiling points and melting points
        - Explain what determines molecular polarity
- **6 Chemical Formulas and Chemical Compounds (HS-PS1-2, HS-PS1-7)**
    - Chemical Names and Formulas
        - Explain the significance of a chemical formula
        - Determine the formula of an ionic compound formed between two given ions
        - Name an ionic compound given its formula
        - Using prefixes, name a binary molecular compound from its formula, and write the formula of a binary molecular compound given its name
    - Oxidation Numbers
        - List the rules for assigning oxidation numbers
        - Give the oxidation number for each element in the formula of a chemical compound
        - Name binary molecular compounds using oxidation numbers and the Stock system.
    - Using Chemical Formulas
        - Calculate the formula mass or molar mass of any given compound
        - Use molar mass to convert between mass in grams and amount in moles of a chemical compound
        - Calculate the number of molecules, formula units, or ions in a given molar amount of a chemical compound
        - Calculate the percentage composition of a given chemical compound.
    - Determining Chemical Formulas
        - Define empirical formula, and explain how the term applies to ionic and molecular compounds
        - Determine an empirical formula from either a percentage or a mass composition
        - Explain the relationship between the empirical formula and the molecular formula of a given compound
        - Determine a molecular formula from an empirical formula.
- **7 Chemical Equations and Reactions (HS-PS1-4, HS-PS1-5, HS-PS1-7)**
    - Describing chemical reactions
        - List observations that suggest a chemical reaction has taken place
        - List three requirements for a correctly written chemical equation
        - Write a word equation and a formula equation for a given chemical reaction
        - Balance a formula equation by inspection
    - Types of chemical reactions
        - Define and give general equations for synthesis, decomposition, single-displacement, double-displacement
        - Classify a reaction
        - List three kinds of synthesis and six kinds of decomposition reactions
        - List four kinds of single-displacement, and three types of double-displacement reactions
        - Predict the product of simple reactions given the reactants
    - Activity series of elements
        - Explain the significance of the activity series
        - Use an activity series to predict whether a given reaction will occur and what the products will be
- **8 States of Matter (HS-PS1-3)**
    - Kinetic-Molecular Theory of Matter
        - State and describe how it explains certain properties of matter

        - List five assumptions of the KMT of gases
        - Define real and ideal gases
        - Describe each of the following characteristic properties of gases:
            - Expansion, density, fluidity, compressibility, diffusion, and effusion
        - Describe the conditions under which a real gas deviates from “ideal” behavior
    - KMT for Solids and Liquids
        - Describe the motion of particles, and the properties associated
        - Discuss the phase change processes
        - Define vaporization and freezing
        - Define crystal structure and unit cell
    - Changes of state
        - Explain the relationship between equilibrium and changes of state
        - Interpret phase change diagrams
        - Explain what is meant by equilibrium vapor pressure
        - Describe process of boiling, freezing, melting, and sublimation
    - Water
        - Describe the structure of a water molecule
        - Discuss the physical properties of water
        - Explain how the properties are determined by the structure of water
        - Calculate amount of energy absorbed or released when a quantity of water changes state
- **9 Acids and Bases (HS-PS1-3, HS-PS1-6)**
    - Properties of Acids and Bases
        - List five general properties of aqueous acids and bases
        - Name common binary acids and oxyacids, given their chemical formulas
        - List five acids commonly used in industry and laboratory, and give two properties of each
        - Define acid and base according to Arrhenius’s theory of ionization
        - Explain the difference between strong and week bases
    - Acid-Base Theories
        - Define and recognize Bronsted-Lowry acids and bases
        - Define a Lewis acid and a Lewis base
        - Name compounds that are acids under the Lewis definition by not under the Bronsted-Lowry definition
    - Acid-Base Reactions
        - Describe a conjugate acid, conjugate base, and an amphoteric compound
        - Explain the process of neutralization
        - Define acid rain, and describe its effects
- **10 Nuclear (HS-PS1-8)**
    - 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. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.]

Course & Domain: Chemistry **Grade: 11**

Unit Title: Matter and Change

Approximate # of Lessons: 3

ASSOCIATED STANDARDS
Students who demonstrate understanding can:

HS-PS1-1. **Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*]**

The Performance Expectations above were developed using the following elements from A Framework for K-12 Science Education:

SCIENCE & ENGINEERING PRACITCES

-Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

DISCIPLINARY CORE IDEAS

-PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)

CROSS CUTTING CONCEPTS

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

Observable features of the student performance by the end of the course:

- 1 Components of the model
    - a From the given model, students identify and describe* the components of the model that are relevant for their predictions, including:

        - i. Elements and their arrangement in the periodic table;
        - ii. A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons;
        - iii. Electrons in the outermost energy level of atoms (i.e., valence electrons); and
        - iv. The number of protons in each element.
- 2 Relationships
    - a Students identify and describe* the following relationships between components in the given model, including:
        - i. The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons.
        - ii. Elements in the periodic table are arranged by the numbers of protons in atoms.
- 3 Connections
    - a Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.
    - b Students predict the following patterns of properties:
        - i. The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements;
        - ii. The number and charges in stable ions that form from atoms in a group of the periodic table; June 2015 Page 1 of 2
        - iii. The trend in reactivity and electronegativity of atoms down a group, and across a row in the periodic table, based on attractions of outermost (valence) electrons to the nucleus; and
        - iv. The relative sizes of atoms both across a row and down a group in the periodic table.

Connections to other DCIs in this grade-band:
HS.LS1.C (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-7);

Articulation of DCIs across grade-bands:
MS.PS1.A (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8);**MS.PS1.B** (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-6),(HS-PS1-7),(HS-PS1-8)

Common Core State Standards Connections:
ELA/Literacy -

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. *(HS-PS1-1)*

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS1-4)*

LESSON 1 : Classification of Matter

# of Periods Required: 1-2

The student will be able to:

- Classify matter into categories including: pure substances and mixtures
- Explain the difference between homogeneous and heterogeneous mixtures

ACTIVITY:

- **Students will complete the Science Warm Up asking to recall prior knowledge and write down what they think a pure substance, and mixture are, and give examples**
- **Students will take notes on Classifying Different Types of Matter. Topics covered will include:**
    1. **States of Matter**
    2. **The difference between pure substances and mixtures**
    3. **The Two types of mixtures**
- **Students will complete a worksheet in groups with questions building on the notes taken.**
- **Students will complete the Nuts and Bolts mini Lab activity**
    - **In this activity, students will be given 8 different bags filled with various assortments of nuts and bolts. They must classify each bag as either being homogeneous or heterogeneous, as well as if they are all compounds, elements, or a mixture of both compounds and elements. The compounds are represented by the nuts and bolts screwed together, where they elements are the various components separated as single parts**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Premade Sample Mixtures for demonstration**
- **Note Handout (fill-in)**
- **Nuts and Bolts Worksheet**
- **8 bags premade with various mixtures of nuts and bolts**

ASSESSMENT:

- **Before**
    - **Student's background knowledge will be assessed by answering the Warm Up. Samples of mixtures and solutions will be shown to the class and they will be asked to identify based on prior physical science knowledge.**
- **During**
    - **Student understanding will be checked by walking around the room and assessing progress on the Worksheet handout. Questions will be answered, and students will be prompted to redo any incorrect answers**
    - **Lab Investigation: Students will be responsible for demonstrating their understanding of the concepts in the Nuts and Bolts mini-Lab Activity.**
- **After**

- **Students will be given a test at the end of the Properties of Matter Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 : Chemical and Physical Properties and Changes

# of Periods Required: 1-2

The student will be able to:
- Classify changes as either physical or chemical
- Classify properties of substances as either physical or chemical
- Explain the law of conservation of mass

ACTIVITY:
- **Students will answer the questions on the Science Warm Up handout**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them**
- **Students will work on a Chemical and Physical Properties Worksheet with a partner**
- **Students will complete the Chemical and Physical Properties Task Card station activity**

MATERIALS:
- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Task Card with Questions located at lab stations**
- **Notebook and something to write with (students)**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up**
- **During**
  - **Student understanding will be checked by walking around the room and assessing progress on the Worksheet handout. Questions will be answered, and students will be prompted to redo any incorrect answers**
  - **Lab Investigation: Students will be responsible for demonstrating their understanding of the concepts by answering the Task Card Questions located at the lab stations.**
- **After**
  - **Students will be given a test at the end of the Properties of Matter Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 3: Measurements and Calculations

# of Periods Required: 1-2

The student will be able to:

Objectives:

- Distinguish between qualitative and quantitative measurement
- Identify data as accurate or precise
- **Explain the Law of Conservation of Mass**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them**
- **Students will participate in a Pre-Lab discussion on identifying Qualitative and Quantitative observations when doing a lab activity. Students will be given a couple of examples of each. Students will review safety procedure, then the teacher will discuss the Procedure for the Qualitative Observations of a Candle Lab. Students will then get with their lab partner and complete the lab activity.**
- **Students will discuss their conclusions and questions from the lab with their lab partner and answer the analysis questions.**
- **Students will complete a formal lab write-up in their lab books.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**

For Lab:

- **Beaker, 250-mL**
- **Erlenmeyer Flask, 125-mL**
- **Glass square**
- **Microspatula**
- **Metric ruler**
- **Microslide**
- **Rubber stopper**
- **Safety goggles**
- **Lab apron**
- **Candle**
- **Matches, 2 or 3**
- **Toothpicks, 2**
- **Limewater solution**
- **String**
- **Aluminum foil**
- **Cobalt chloride paper**
- **Student Lab Books**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up, as well as the worksheet aligning with the previous class period's notes (Chemical and Physical Properties).**
- **During**
  - **Lab Investigation: Students will be responsible for demonstrating their understanding of the concepts introduced by completing the Qualitative Observation of a Candle lab investigation.**
  - **The students will answer analysis questions following the lab procedure.**
- **After**
  - **Students will participate in an active classroom discussion about their recorded observations, and analysis in the next class period.**
  - **Students will be given a test at the end of the Properties of Matter Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: Atoms: The Building Blocks of Matter

Approximate # of Lessons: 2

ASSOCIATED STANDARDS
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DISCIPLINARY CORE IDEAS

-PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)

CROSS CUTTING CONCEPTS

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)
- **Observable features of the student performance by the end of the course:**
    - 1 Components of the model
        - a From the given model, students identify and describe* the components of the model that are relevant for their predictions, including:
            - i. Elements and their arrangement in the periodic table;

- ii. A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons;
- iii. Electrons in the outermost energy level of atoms (i.e., valence electrons); and iv. The number of protons in each element.

- 2 Relationships a Students identify and describe* the following relationships between components in the given model, including:
  - i. The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons.
  - ii. Elements in the periodic table are arranged by the numbers of protons in atoms.
- 3 Connections a Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom. b Students predict the following patterns of properties:
  - i. The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements;
  - ii. The number and charges in stable ions that form from atoms in a group of the periodic table; June 2015 Page 1 of 2
  - iii. The trend in reactivity and electronegativity of atoms down a group, and across a row in the periodic table, based on attractions of outermost (valence) electrons to the nucleus; and
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LESSON 1 (TITLE): The Atom: From Philosophical Idea to Scientific Theory

# of Periods Required: 1-2

The student will be able to:

- Explain the discovery of the atom by the contributions from Democritus, Dalton, Thompson, and Rutherford.
- Explain the Gold Foil Experiment in detail.
- Describe the three subatomic particles and their locations.

ACTIVITY:

- **Students will complete the Science Warm Up asking to recall prior knowledge and write down and label the different parts of an atom.**
- **Students will take notes on The History of Atomic Structure. Topics covered will include:**
  - **Democritus**
  - **John Dalton**
  - **J.J. Thomson and the Cathode Ray Tube**
  - **Rutherford and the Gold Foil Experiment**
  - **Protons and Neutrons**
  - **Subatomic Particles**
- **Students will complete a worksheet that aligns with the notes taken on the history of the atom. They will be allowed to work with a partner.**
- **Students will be given a handout guiding them to create a History of the Atom Timeline. They will use their textbook as a resource, as well as the classroom iPads.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Premade Sample Mixtures for demonstration**
- **Note Handout (fill-in)**
- **Worksheet handout with questions regarding notes/concepts discussed**
- **History of the Atom Timeline worksheet**
- **White Poster Paper**
- **Coloring tools (colored pencils, crayons, markers)**
- **Scissors**
- **Construction Paper**
- **Glue**
- **iPad Cart**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up**
- **During**

  - **Student understanding will be checked by walking around the room and assessing progress on the Worksheet handout. Questions will be answered, and students will be prompted to redo any incorrect answers**
  - **Lab Investigation: Students will be responsible for demonstrating their understanding of the concepts by creating a History of the Atom Timeline with a partner.**
- **After**
  - **Students will demonstrate their understanding of the Atomic History by sharing their timeline with the class during the following class period.**
  - **Students will be given a test at the end of the Atomic Structure Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Atomic Structure

# of Periods Required: 2-3

The student will be able to:

- Find the atomic mass, atomic number, and symbols of elements off of the Periodic Table.
- Calculate the number of neutrons in a particular atom.
- Explain what an isotope is.

ACTIVITY:

- **Students will complete the Science Warm Up Handout matching significant moments in atomic structure discovery history with scientists.**
- **Students will complete the note fil-in handout as the teacher presents the concepts to the class. Concepts covered include:**
  - **Atomic Number**
  - **Atomic Mass**
  - **Mass Number**
  - **Neutrons**
  - **Isotopes**
- **Students will complete the atomic mass calculation worksheet with a partner.**
- **Students will complete Average Atomic Mass Calculations Worksheet**
- **Students will complete the Vegium Lab Investigation calculating the abundance of Isotopes, and atomic mass.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Worksheet handout with questions regarding notes/concepts discussed**
- **Atomic Mass calculations handout**

Lab Materials:

- **Vegium Sample (mixture of various beans and seeds)**
- **Electronic Balance**
- **Weighing Boat**

- **Lab Handout**
- **Student Lab Books**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up**
- **During**
  - **Student understanding will be checked by walking around the room and assessing progress on the Worksheet handout and Atomic Mass Calculation handout. Questions will be answered, and students will be prompted to redo any incorrect answers**
  - **Lab Investigation: Students will be responsible for demonstrating their understanding of the concepts by completing the Vegium Lab Investigation Activity.**
- **After**
  - **Students will demonstrate their understanding by completing a formal lab write-up in their lab notebooks.**
  - **Students will be given a test at the end of the Atomic Structure Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: Atoms: Arrangement of Electrons in Atoms

Approximate # of Lessons: 3

ASSOCIATED STANDARDS
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HS-PS1-1. **Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*]**

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CROSS CUTTING CONCEPTS

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)
- **Observable features of the student performance by the end of the course:**
    - 1 Components of the model
        - a From the given model, students identify and describe* the components of the model that are relevant for their predictions, including:
            - i. Elements and their arrangement in the periodic table;

- ii. A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons; iii. Electrons in the outermost energy level of atoms (i.e., valence electrons); and iv. The number of protons in each element.

- 2 Relationships
  - a Students identify and describe* the following relationships between components in the given model, including:
    - i. The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons.
    - ii. Elements in the periodic table are arranged by the numbers of protons in atoms.
- 3 Connections
  - a Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.
  - b Students predict the following patterns of properties:
    - i. The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements;
    - ii. The number and charges in stable ions that form from atoms in a group of the periodic table; June 2015 Page 1 of 2
    - iii. The trend in reactivity and electronegativity of atoms down a group, and across a row in the periodic table, based on attractions of outermost (valence) electrons to the nucleus; and
    - iv. The relative sizes of atoms both across a row and down a group in the periodic table.

Connections to other DCIs in this grade-band:
HS.LS1.C (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-7);

Articulation of DCIs across grade-bands:
MS.PS1.A (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8);**MS.PS1.B** (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-6),(HS-PS1-7),(HS-PS1-8)

Common Core State Standards Connections:
ELA/Literacy -

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. *(HS-PS1-1)*

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS1-4)*

LESSON 1 (TITLE): Introduction to Electron Configurations

# of Periods Required: 2-3

The student will be able to:

- **Explain the organization of electrons within an atom**
- **Describe what an energy level, sublevel, and atomic orbital is**
- **Draw the shapes of each sublevel**
- **Predict how many electrons can be held in each energy level**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them. Concepts covered include:**
  - **Principal Energy Levels**
  - **Sublevels**
  - **Sublevel Types (shapes)**
  - **Atomic Orbitals**
- **Students will work on an Electron Configuration Worksheet handout**
- **Students will complete Shape of Orbitals worksheet with a partner**
- **Students will complete the Flame Test Lab Investigation**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Electron Configuration Worksheet**
- **Orbital Shapes Worksheet**

Lab Materials:

- **Set of metal chloride solutions (NaCl, $CuCl_2$, KCl, $CaCl_2$, $SrCl_2$, LiCl, $CoCl_2$, $BaCl_2$)**
- **Bunsen Burner**
- **8 – 10 Q-tips**
- **Unknown solution (for each student)**
- **Cobalt glass plates**
- **Safety goggles**
- **Lab Apron**
- **Student lab notebooks**
- **Lab Procedure handout**
-

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up**

- **During**
  - **Student understanding will be checked by walking around the room and assessing progress on the Worksheet handout. Questions will be answered, and students will be prompted to redo any incorrect answers**
  - **Lab Investigation: Students will be responsible for demonstrating their understanding of the concept by completing the flame test lab investigation activity.**
- **After**
  - **Students will demonstrate their understanding by completing a formal lab write-up in their laboratory books.**
  - **Students will be given a test at the end of the Electron Configuration Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Writing Electron Configurations and Orbital Notation

# of Periods Required:1-2

The student will be able to:

- **Write electron configurations in the proper long-form notation**
- **Write orbital notations for certain elements in the proper notation**
- **Identify elements from their electron configuration or orbital notation**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them. Concepts covered include:**
  - **Electron configurations**
  - **Aufbau Principle**
  - **Orbital Notation**
  - **Pauli Principle**
  - **Hund's Rule**
  - **Identifying elements from electron configurations**
- **Students will complete Electron configuration worksheet for homework**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Electron Configuration Worksheet**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up**
- **During**
  - **Student understanding will be checked by walking around the room and assessing progress on the Worksheet handout. Questions will be answered, and students will be prompted to redo any incorrect answers**
  - **Students will demonstrate their understanding by identifying elements based on their electron orbital notation. This will be done using flashcards with a partner.**
- **After**
  - **Students will be given a test at the end of the Electron Configuration Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 3 (TITLE): <u>Noble gas abbreviations, Configurations for Ions, and Valence Electrons</u>

# of Periods Required: 1-2

The student will be able to:

- **Write electron configurations for elements and monatomic ions**
- **Write noble gas abbreviations using the previous electron configuration objectives**
- **Classify elements based on their outermost electron configuration**
- **Obtain the amount of valence electrons from an electron configuration**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them. Concepts covered include:**
  - **Noble Gas abbreviations for electron configurations**
  - **Electron configurations for Ions**
  - **Valence Electrons**
- **Students will apply the valence electron concept in the Electronic Beans Activity**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Electron Bean Handout**
- **Two different types of beans**
- **Electron shells (blank)**
  - **5 Total**
  - **2 different colors**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up**
  - **Student understanding of the prior concept taught (electron notation) will be demonstrated by going over the homework assignment**
- **During**
  - **Student understanding will be checked by walking around the room and assessing progress on the Worksheet handout. Questions will be answered, and students will be prompted to redo any incorrect answers**
  - **Students will demonstrate their understanding by showing electron configurations for various elements in the electron bean activity.**
- **After**
  - **Students will be given a quiz next class on the first three concepts covered in the Electron Configuration Unit.**
  - **Students will be given a test at the end of the Electron Configuration Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: Periodic Law

Approximate # of Lessons: 3

ASSOCIATED STANDARDS
Students who demonstrate understanding can:

HS-PS1-1. **Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*]**

The Performance Expectations above were developed using the following elements from A Framework for K-12 Science Education:

SCIENCE & ENGINEERING PRACITCES

-Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

DISCIPLINARY CORE IDEAS

-PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)

CROSS CUTTING CONCEPTS

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

Observable features of the student performance by the end of the course:

- 1 Components of the model
    - a From the given model, students identify and describe* the components of the model that are relevant for their predictions, including:

        - i. Elements and their arrangement in the periodic table;
        - ii. A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons;
        - iii. Electrons in the outermost energy level of atoms (i.e., valence electrons); and
        - iv. The number of protons in each element.
- 2 Relationships
    - a Students identify and describe* the following relationships between components in the given model, including:
        - i. The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons.
        - ii. Elements in the periodic table are arranged by the numbers of protons in atoms.
- 3 Connections
    - a Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.
    - b Students predict the following patterns of properties:
        - i. The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements;
        - ii. The number and charges in stable ions that form from atoms in a group of the periodic table; June 2015 Page 1 of 2
        - iii. The trend in reactivity and electronegativity of atoms down a group, and across a row in the periodic table, based on attractions of outermost (valence) electrons to the nucleus; and
        - iv. The relative sizes of atoms both across a row and down a group in the periodic table.

Connections to other DCIs in this grade-band:
HS.LS1.C (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-7);

Articulation of DCIs across grade-bands:
MS.PS1.A (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8);**MS.PS1.B** (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-6),(HS-PS1-7),(HS-PS1-8)

Common Core State Standards Connections:
ELA/Literacy -

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. *(HS-PS1-1)*

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS1-4)*

LESSON 1 (TITLE): History of the Periodic Table

# of Periods Required: 1-2

The student will be able to:

- **Describe how the Periodic Table is arranged today**
- **Explain basic similarities and differences among groups and periods on the Periodic Table**
- **Locate and label common groups on the Periodic Table**
- **Locate and list properties of metals and nonmetals**
- **Describe what a metalloid is**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them**
- **Students will work on a Periodic Table History Worksheet with a partner**
- **Students will complete a "trends" activity using hypothetical elements and placing them into a periodic table based on different patterns and trends they find among the "Merry Men"**
- **Students will compare their periodic tables with others in the class.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Worksheet handout with Periodic Table History questions**
- **"Merry Men" Activity handouts**
- **Scissors (to cut out elements)**
- **Glue**
- **Construction Paper to place elements on**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up**
- **During**
  - **Activity: Students will be responsible for demonstrating their understanding of the concepts introduced by completing the Merry Men Periodic Table**
  - **The students will answer questions on the PT History Worksheet**
- **After**
  - **Students will participate in an active classroom discussion about the trends and patterns they found among their Merry Men, as well as how they organized them into a periodic table.**
  - **Students will be given a test at the end of the Periodic Law Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Atomic Size

# of Periods Required: 1-2

The student will be able to:

- **Explain how atomic radius is found**
- **Explain the trend for atomic size across periods and down groups**
- **Explain what shielding is, and describe the role it plays in atomic size**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout**
  - **Review of Periodic Table Basics**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them**
- **Students will work on Atomic Radius Worksheet with a partner**
- **Students will follow guidelines on a handout to color code the Periodic Table into the groups among the Periodic Table**
- **Students will answer question on the exit ticket before the bell rings at the end of class**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Worksheet handout with Atomic Radius questions**
- **Periodic Table Color Coding worksheet**
- **Periodic Table**
- **Colored Pencils**
- **Highlighters (2-3)**
- **Exit Ticket**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up**
  - **Student's understanding of periodic table trends will be assessed based on completion of homework assignment**
- **During**
  - **Activity: Students will be responsible for demonstrating their understanding of the concepts introduced by completing the Color Coding the Periodic Table guidelines**
  - **The students will answer questions about atomic radius on worksheet handout.**
  - **Students will hand in their response to the exit ticket question on their way out of class.**
- **After**
  - **Students will be given a test at the end of the Periodic Law Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 3 (TITLE): Ionization Energy

# of Periods Required: 1-2

The student will be able to:

- **Explain what ionization energy is**
- **Describe the ionization energy trend from the Periodic Table**
- **Explain why it requires more energy to remove each subsequent electron after the first**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout**
- **Students will discuss any questions from the Homework handout that they may have**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them**
- **Students will work on an Ionization Energy Trends Worksheet with a partner**
- **Students will participate in the Periodicity Lab activity and will observe the reaction of various metals with hydrogen and predict their periodicity based on how they react.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Worksheet handout with Ionization Energy questions**
- **Colored in Periodic Table**

Lab:

- **Student Lab notebook**
- **Lab Procedure Handout and Data Table**
- **apron**
- **goggles**
- **24 well spot plate**
- **graduated thin stem pipets**
- **black construction paper**
- **toothpicks**
- **distilled water**
- **0.10 M Mg^{2+}**
- **0.10 M Ca^{2+}**
- **0.10 M Sr^{2+}**
- **0.10 M Ba^{2+}**
- **0.10 M SO_4^{2+}**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up, as well as the worksheet aligning with the previous class period's notes (Atomic Radius)**
- **During**
  - **Lab Investigation: Students will be responsible for demonstrating their understanding of the concepts introduced by completing the Periodicity Lab investigation.**
  - **The students will answer analysis questions following the lab procedure.**
- **After**
  - **Students will participate in an active classroom discussion about their recorded observations, and analysis in the next class period.**
  - **Students will be given a test at the end of the Periodic Law Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: Chemical Bonding

Approximate # of Lessons: 3

ASSOCIATED STANDARDS

Students who demonstrate understanding can:

HS-PS1-2. **Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]**

HS-PS1-3. **Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]**

The Performance Expectations above were developed using the following elements from A Framework for K-12 Science Education:

SCIENCE & ENGINEERING PRACITCES

-Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

-Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)

Obtaining, Evaluating, and Communicating Information

- Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)

DISCIPLINARY CORE IDEAS

-PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)

PS1.B: Chemical Reactions

- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions

CROSS CUTTING CONCEPTS

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

Observable features of the student performance by the end of the course:

- 1 Articulating the explanation of phenomena a Students construct an explanation of the outcome of the given reaction, including:
    - i. The idea that the total number of atoms of each element in the reactant and products is the same;
    - ii. The numbers and types of bonds (i.e., ionic, covalent) that each atom forms, as determined by the outermost (valence) electron states and the electronegativity;
    - iii. The outermost (valence) electron state of the atoms that make up both the reactants and the products of the reaction is based on their position in the periodic table; and iv. A discussion of how the patterns of attraction allow the prediction of the type of reaction that occurs (e.g., formation of ionic compounds, combustion of hydrocarbons).
- 2 Evidence a Students identify and describe* the evidence to construct the explanation, including:
    - i. Identification of the products and reactants, including their chemical formulas and the arrangement of their outermost (valence) electrons;
    - ii. Identification that the number and types of atoms are the same both before and after a reaction;
    - iii. Identification of the numbers and types of bonds (i.e., ionic, covalent) in both the reactants and the products;
    - iv. The patterns of reactivity (e.g., the high reactivity of alkali metals) at the macroscopic level as determined by using the periodic table; and
    - v. The outermost (valence) electron configuration and the relative electronegativity of the atoms that make up both the reactants and the products of the reaction based on their position in the periodic table.
- 3 Reasoning
    - a Students describe* their reasoning that connects the evidence, along with the assumption that theories and laws that describe their natural world operate today as they did in the past and will continue to do so in the future, to construct an explanation for how the patterns of

outermost electrons and the electronegativity of elements can be used to predict the number and types of bonds each element forms.
    - b In the explanation, students describe* the causal relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity.
- 4 Revising the explanation
    - a Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision.

Observable features of the student performance by the end of the course:

- 1 Identifying the phenomenon to be investigated a Students describe* the phenomenon under investigation, which includes the following idea: the relationship between the measurable properties (e.g., melting point, boiling point, vapor pressure, surface tension) of a substance and the strength of the electrical forces between the particles of the substance.
- 2 Identifying the evidence to answer this question
    - a Students develop an investigation plan and describe* the data that will be collected and the evidence to be derived from the data, including bulk properties of a substance (e.g., melting point and boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between particles.
    - b Students describe* why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substances, including the following descriptions*:
        - i. The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the identity of the particles does not change (e.g., when water is boiled the molecules are still present but further apart).
        - ii. Thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles close together.
        - iii. The patterns of interactions between particles at the molecular scale are reflected in the patterns of behavior at the macroscopic scale.
        - iv. Together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale.
- 3 Planning for the investigation
    - a In the investigation plan, students include:
        - i. A rationale for the choice of substances to compare and a description* of the composition of those substances at the atomic molecular scale.
        - ii. A description* of how the data will be collected, the number of trials, and the experimental set up and equipment required.
    - b Students describe* how the data will be collected, the number of trials, the experimental set up, and the equipment required.
- 4 Collecting the data a Students collect and record data — quantitative and/or qualitative — on the bulk properties of substances.
- 5 Refining the design
    - a Students evaluate their investigation, including evaluation of:
        - i. Assessing the accuracy and precision of the data collected, as well as the limitations of the investigation; and
        - ii. The ability of the data to provide the evidence required.
    - b If necessary, students refine the plan to produce more accurate, precise, and useful data.

Connections to other DCIs in this grade-band:

HS.LS1.C (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-7); **HS.ESS2.C** (HS-PS1-2),(HS-PS1-3)

Articulation of DCIs across grade-bands:

MS.PS1.A (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8); **MS.PS1.B** (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-6),(HS-PS1-7),(HS-PS1-8); **MS.PS2.B** (HS-PS1-3),(HS-PS1-4),(HS-PS1-5);

Common Core State Standards Connections:

ELA/Literacy -

WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),*(HS-PS1-5)*
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),*(HS-PS1-6)*
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3)*

Mathematics -

HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),*(HS-PS1-3),(HS-PS1-4),(HS-PS1-5)*,(HS-PS1-7),(HS-PS1-8)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)*

LESSON 1 (TITLE): Bonding Basics and Ionic Bonding

# of Periods Required: 2-3

The student will be able to:

- **Explain how ionic and covalent bonding occurs**
- **Write dot diagrams for elements in the s and p blocks**
- **Determine the number of valence electrons in a particular atom**
- **Write formulas for ionic compounds**
- **Explain what an empirical formula is**
- **List and explain the properties of ionic bonds**
- **Show bonding in ionic compounds using electron dot diagrams**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout regarding prior knowledge of Ionic Bonding from their 9th grade physical science class.**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them. Concepts include:**
  - **Ionic v. Covalent**
  - **Octet Rule**
  - **Valence Electrons for groups**
  - **Electron Dot Structure for groups**
  - **Electron Configurations for Ions Review**
  - **Formation of Ionic Compounds**
  - **Electron dot structures to show transfer of electrons and charge**
  - **Emperical Formulas**
- **Students will complete Ionic Bonding Worksheets (2)**
- **Students will participate in an Ionic Bond Matching activity that involves being assigned either a Cation or Anion, and making matches with each other. They then write down the formula for at least five matches that they have made.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Ionic Bonding practice worksheet**
- **Ionic Bond Cation and Anion cards**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will work on Ionic Bonding Practice upon completing notes**

- **Students will complete the Ionic Bonding matching activity**

- **After**
  - **Students will participate in an active classroom discussion about their formulas they formed when bonding together during the interactive class activity.**
  - **Students will be given a test at the end of the Bonding Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Covalent Bonding

# of Periods Required: 2-3

The student will be able to:

- **Write structural formulas and dot formulas for covalently bonded molecules**
- **Identify shared and unshared electrons**
- **Explain the difference between single, double, and triple bonds - and write them using structural formulas/dot formulas**

ACTIVITY:

- **Students will complete the warm-up handout reviewing Ionic Bonding**
- **Students will complete the note fill-in handout as the new concept of Covalent Bonding is introduced**
- **Students will complete Covalent Bonding practice worksheet.**
- **Students will observe the properties of how ionic and covalent compounds differ in a Lab Investigation**
- **Students will analyze their data and compare the differences between Ionic and Covalent Compounds**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Covalent Bonding practice worksheet**

Lab Materials:

- **Lab Procedure Handout**
- **Student Lab Notebook**
- **Sodium Chloride**
- **Hot plate**
- **Two Evaporating Dishes**
- **Wax**
- **Safety goggles**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
  - **Student understanding of the prior class concept will be assessed by discussing the Ionic Bonding practice problem homework**
- **During**
  - **Students will demonstrate their understanding of Covalent Bonding by completing a practice worksheet following notes**
  - **Students will demonstrate their understanding of Covalent and Ionic Bonding during the Lab Investigation**
- **After**
  - **Students will participate in an active classroom discussion about their observations during the Lab Investigation.**
  - **Students will be given a test at the end of the Bonding Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 3 (TITLE): Molecular Geometry

# of Periods Required: 2-3

The student will be able to:

- **Explain Valence Shell Electron Pair Repulsion Theory (VSEPRT)**
- **Use structural formulas to describe the molecular geometry of atoms**
- **Identify the correct geometric name for the shape of the molecule**
- **Identify bond angles for molecules**

ACTIVITY:

- **Students will complete the warm-up handout reviewing Covalent Bonding**
- **Students will complete the note fill-in handout as the new concept of Molecular Geometry is introduced**
- **Students will complete Molecular Geometry practice worksheet.**
- **Students will observe the properties of how compounds form different molecular structures by using 3-d molecular model ball and stick kits.**
- **Students will analyze their observations and compare the differences between Ionic and Covalent Compound structures, and the different bond angles**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Molecular Geometry practice worksheet**

- **Ball and Stick Molecular Model Kits**
- **Tinker Toy Bonding Worksheet handout**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
  - **Student understanding of the prior class concept will be assessed by discussing the Covalent Bonding practice problem homework**
- **During**
  - **Students will demonstrate their understanding of Molecular Geometry by completing a practice worksheet following notes**
  - **Students will demonstrate their understanding of Molecular Geometry during the Tinker Toy Bonding activity in which they will use 3-D models to form structures of given compounds.**
- **After**
  - **Students will participate in an active classroom discussion about their observations during the Tinker Toy Activity.**
  - **Students will be given a test at the end of the Bonding Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: Chemical Formulas and Chemical Compounds

Approximate # of Lessons: 2

ASSOCIATED STANDARDS

Students who demonstrate understanding can:

HS-PS1-2. **Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]**

HS-PS1-7. **Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]**

The Performance Expectations above were developed using the following elements from A Framework for K-12 Science Education:

SCIENCE & ENGINEERING PRACITCES

Using Mathematics and Computational Thinking

- Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

-Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)

DISCIPLINARY CORE IDEAS

-PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)

CROSS CUTTING CONCEPTS

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

Energy and Matter

- The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)

CONNECTIONS TO CCSS:

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

Observable features of the student performance by the end of the course:

- 1 Representation
  - a Students identify and describe* the relevant components in the mathematical representations:
    - i. Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and mass;
    - ii. Molar mass of all components of the reaction;
    - iii. Use of balanced chemical equation(s); and
    - iv. Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction.
  - b The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information.
  - c Students identify the claim to be supported: that atoms, and therefore mass, are conserved during a chemical reaction.
- 2 Mathematical modeling
  - a Students use the mole to convert between the atomic and macroscopic scale in the analysis.
  - b Given a chemical reaction, students use the mathematical representations to
    - i. Predict the relative number of atoms in the reactants versus the products at the atomic molecular scale; and
    - ii. Calculate the mass of any component of a reaction, given any other component.
- 3 Analysis

- a Students describe* how the mathematical representations (e.g., stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore June 2015 Page 1 of 2 mass, are conserved during a chemical reaction.
- b Students describe* how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number).

Observable features of the student performance by the end of the course:

- 1 Representation
  - a Students identify and describe* the relevant components in the mathematical representations:
    - i. Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and mass;
    - ii. Molar mass of all components of the reaction;
    - iii. Use of balanced chemical equation(s); and
    - iv. Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction.
  - b The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information.
  - c Students identify the claim to be supported: that atoms, and therefore mass, are conserved during a chemical reaction.
- 2 Mathematical modeling
  - a Students use the mole to convert between the atomic and macroscopic scale in the analysis.
  - b Given a chemical reaction, students use the mathematical representations to
    - i. Predict the relative number of atoms in the reactants versus the products at the atomic molecular scale; and
    - ii. Calculate the mass of any component of a reaction, given any other component.
- 3 Analysis
  - a Students describe* how the mathematical representations (e.g., stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore June 2015 Page 1 of 2 mass, are conserved during a chemical reaction.
  - b Students describe* how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number).

LESSON 1 (TITLE): Naming Basics and Ionic Compound Naming

# of Periods Required: 2

The student will be able to:

- **List differences among ionic and covalently bonded compounds**
- **Identify polyatomic and monatomic ions and name them correctly**
- **Identify polyatomic and monatomic ions and name them properly**
- **Write the chemical formulas and names for ionic compounds**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout regarding Ionic and Covalent Compound recognition based on what they learned in the previous unit.**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them. Concepts include:**
  - **Review of Ionic Formulas**
  - **Polyatomic Ions**
  - **Molecular Model Review**
  - **Charge of Cations and Anions**
  - **Naming when given two elements or polyatomic Ions**
  - **Writing formulas given an Ionic Compound name**
- **Student will be given naming practice worksheet for Ionic Compounds**
- **Students will complete the Formula Fun Spot Plate Lab Investigation**
- **Students will discuss their results**
- **Students will complete Criss Cross naming and formula writing handout for homework**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Ionic Bond Naming practice worksheet**
- **Criss Cross Naming and Formula writing practice worksheet**

Lab Materials

- **Safety Goggles**
- **Spot Plate**
- **Dropper**
- **10 mL of the following Compounds:**
  - **Iron III Nitrate**
  - **Copper II Nitrate**
  - **Silver Nitrate**
  - **Sodium Phosphate**
  - **Sodium Carbonate**
  - **Sodium Hydroxie**
- **Grease pencil for labeling**
- **Lab Procedure Handout**
- **Student Lab Notebooks**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will work on Ionic Bond naming and formula Practice upon completing notes**
  - **Students will complete the Ionic Bond naming and formula writing practice worksheet**
  - **Lab Investigation: Students will apply their understanding of Ionic Bonds to the Formula Fun spot plate activity and see how elements react differently when bonded with different elements.**
- **After**
  - **Students will participate in an active classroom discussion about observations during the Lab Investigation.**
  - **Students will be given a test at the end of the Chemical Formulas and Compounds Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Formula and Naming for Covalent Compounds

# of Periods Required: 1-2

The student will be able to:

- **Identify polyatomic and monatomic ions and name them properly**
- **Write the chemical formulas and names for ionic compounds**
- **Write the chemical names and formulas of molecules**

ACTIVITY:

- **Students will answer the questions on the Science Warm Up handout regarding Ionic formula writing.**
- **Students will discuss responses on the Warm Up**
- **Students will fill in notes on their Note Handout while the teacher presents the new concept(s) to them. Concepts include:**
  - **Writing Chemical name from chemical formula**
  - **Naming elements that have more than one possible charge**
  - **Rules for naming Covalent Compounds**
- **Students will complete the practice problems for naming and writing formulas of covalent compounds.**
- **Students will complete Criss-Cross naming and formula writing handout for homework**
- **Students will hand in their exit ticket with the response regarding covalent naming as the leave the classroom**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Covalent Naming and Formula writing practice worksheet**
- **Criss-Cross Naming and Formula writing practice worksheet**
- **Covalent naming Exit Ticket**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will work on Covalent Bond naming and formula Practice upon completing notes**
  - **Students will complete the Covalent Bond naming and formula writing practice worksheet**
  - **Students will hand in their exit ticket which will allow the teacher to check for understanding**
- **After**
  - **Students will be given a test at the end of the Chemical Formulas and Compounds Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: Chemical Equations and Reaction Types

Approximate # of Lessons: 3

ASSOCIATED STANDARDS

Students who demonstrate understanding can:

HS-PS1-4.	**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. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]**
HS-PS1-5.	**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.[Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]**
HS-PS1-7.	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]**

The Performance Expectations above were developed using the following elements from A Framework for K-12 Science Education:

SCIENCE & ENGINEERING PRACITCES

-Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Using Mathematics and Computational Thinking

- Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

DISCIPLINARY CORE IDEAS

-PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)

CROSS CUTTING CONCEPTS

Energy and Matter

- The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

CONNECTIONS TO CCSS:

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

Observable features of the student performance by the end of the course:

- 1 Components of the model
  - a Students use evidence to develop a model in which they identify and describe* the relevant components, including:
    - i. The chemical reaction, the system, and the surroundings under study;
    - ii. The bonds that are broken during the course of the reaction;
    - iii. The bonds that are formed during the course of the reaction;
    - iv. The energy transfer between the systems and their components or the system and surroundings;
    - v. The transformation of potential energy from the chemical system interactions to kinetic energy in the surroundings (or vice versa) by molecular collisions; and
    - vi. The relative potential energies of the reactants and the products.
- 2 Relationships
  - a In the model, students include and describe* the relationships between components, including:
    - i. The net change of energy within the system is the result of bonds that are broken and formed during the reaction (Note: This does not include calculating the total bond energy changes.);
    - ii. The energy transfer between system and surroundings by molecular collisions;
    - iii. The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings (Note: This does not include calculating June 2015 Page 1 of 2 the total bond energy changes.); and
    - iv. The release or absorption of energy depends on whether the relative potential energies of the reactants and products decrease or increase.
- 3 Connections
  - a Students use the developed model to illustrate:
    - i. The energy change within the system is accounted for by the change in the bond energies of the reactants and products. (Note: This does not include calculating the total bond energy changes.)
    - ii. Breaking bonds requires an input of energy from the system or surroundings, and forming bonds releases energy to the system and the surroundings.
    - iii. The energy transfer between systems and surroundings is the difference in energy between the bond energies of the reactants and the products.
    - iv. The overall energy of the system and surroundings is unchanged (conserved) during the reaction.
    - v. Energy transfer occurs during molecular collisions.
    - vi. The relative total potential energies of the reactants and products can be accounted for by the changes in bond energy.

Observable features of the student performance by the end of the course:

- 1 Articulating the explanation of phenomena
  - a Students construct an explanation that includes the idea that as the kinetic energy of colliding particles increases and the number of collisions increases, the reaction rate increases.
- 2 Evidence
  - a Students identify and describe* evidence to construct the explanation, including:
    - i. Evidence (e.g., from a table of data) of a pattern that increases in concentration (e.g., a change in one concentration while the other concentration is held constant) increase the reaction rate, and vice versa; and
    - ii. Evidence of a pattern that increases in temperature usually increase the reaction rate, and vice versa.
- 3 Reasoning

- a Students use and describe* the following chain of reasoning that integrates evidence, facts, and scientific principles to construct the explanation:
  - i. Molecules that collide can break bonds and form new bonds, producing new molecules.
  - ii. The probability of bonds breaking in the collision depends on the kinetic energy of the collision being sufficient to break the bond, since bond breaking requires energy.
  - iii. Since temperature is a measure of average kinetic energy, a higher temperature means that molecular collisions will, on average, be more likely to break bonds and form new bonds.
  - iv. At a fixed concentration, molecules that are moving faster also collide more frequently, so molecules with higher kinetic energy are likely to collide more often.
  - v. A high concentration means that there are more molecules in a given volume and thus more particle collisions per unit of time at the same temperature.

Observable features of the student performance by the end of the course:

- 1 Representation
  - a Students identify and describe* the relevant components in the mathematical representations:
    - i. Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and mass;
    - ii. Molar mass of all components of the reaction;
    - iii. Use of balanced chemical equation(s); and
    - iv. Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction.
  - b The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information.
  - c Students identify the claim to be supported: that atoms, and therefore mass, are conserved during a chemical reaction.
- 2 Mathematical modeling
  - a Students use the mole to convert between the atomic and macroscopic scale in the analysis.
  - b Given a chemical reaction, students use the mathematical representations to
    - i. Predict the relative number of atoms in the reactants versus the products at the atomic molecular scale; and
    - ii. Calculate the mass of any component of a reaction, given any other component.
- 3 Analysis
  - a Students describe* how the mathematical representations (e.g., stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore June 2015 Page 1 of 2 mass, are conserved during a chemical reaction.
  - b Students describe* how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number).

LESSON 1 (TITLE): Diatomic Elements and Writing Formula Equations from Word Equations

# of Periods Required: 1

The student will be able to:

- **Name the diatomic elements**
- **Write formula equations given the word equation for a chemical reaction**

ACTIVITY:

- **Students will complete the warm-up handout reviewing writing formulas and formula names of compounds**
- **Students will complete the note fill-in handout as the new concept of Compound names into formula writing is introduced**
- **Students will complete word equation into formula equation practice worksheet.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Words to Formula equation practice worksheet**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding of Writing out chemical equations by completing a practice worksheet following notes**
  - **Students will demonstrate their understanding by handing in an exit ticket with equation writing practice at the end of class**
- **After**
  - **Students will be given a test at the end of the Chemical Equations and Reactions Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Balancing Chemical Equations

# of Periods Required: 2-3

The student will be able to:

- **Explain the Law of Conservation of Atoms**
- **Balance equations using the "tally method"**
- **Write the out the formula equations from word equations**
- **Balance the corresponding formula equation**

ACTIVITY:

- **Students will complete the warm-up handout reviewing writing formula names for equations**
- **Students will complete the note fill-in handout as the new concept of Balancing Chemical Equations is introduced**
- **Students will complete the Balancing Chemical Equations Packet.**
- **Students will work with a partner to complete the Confetti Chemistry Balancing Activity**
- **Students will complete the cut-and-paste balancing activity worksheet in which they will use models to demonstrate the conservation of atoms in a chemical equation and use models to learn how to balance equations**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Balancing Equations practice Packet**
- **Confetti Chemistry Balancing Worksheet**
  - **Pre-made bags of confetti**
- **Cut-and-Paste balancing worksheet**
  - **Scissors**
  - **Glue**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding of Balancing chemical equations by completing a practice worksheet following notes**
  - **Students will demonstrate their understanding by completing the Confetti Chemistry and Cut-and-Paste Activities**
- **After**
  - **Students will be given a test at the end of the Chemical Equations and Reactions Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 3 (TITLE): Reaction Types

# of Periods Required: 3-4

The student will…

- **Identify synthesis and decomposition reactions**
- **Predict the products in words for synthesis and decomposition reactions**
- **Identify a single replacement reaction**
- **Predict the products in words for single replacement reactions**
- **Identify a double replacement and combustion reaction**
- **Predict the products in words for single replacement reactions**
- **Predict the products in formulas for a combustion reaction**
- **Balance combustion reactions**

ACTIVITY:

- **Students will complete the warm-up handout reviewing Balancing Equations**
- **Students will complete the note fill-in handout as the new concept of Reaction Types is introduced**
- **Students will complete the Synthesis and Decomposition Practice Worksheet which includes balancing and identification.**
- **Students will complete the Single and Double Replacement Reaction Types Practice Worksheet which includes balancing and identification.**
- **Students complete the Combustion Reaction type practice worksheet which includes balancing and identification.**
- **Students will work with their lab partner to complete a Chemical Reactions mini lab.**
- **Students will work with their lab partner to complete the "Are You My Type" Lab Investigation in which they will follow the lab procedure and combine various compounds, record their observations, write the chemical equation for each, and identify the reaction type.**
- **Students will complete a formal lab write-up for the "Are You My Type" Lab.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Reaction Types practice Worksheets for each type of reaction introduced**

Mini Lab:

- ***2 small 150 ml beakers** *** 2" x 2" Al foil**
- *** Dropper bottle of HCl** *** Dropper bottle of $AgNO_3$**
- *** Small pieces of Zn** *** Spot plate**
- *** Plastic teaspoon** *** Piece of Mg**
- *** Tongs** *** Bunsen burner**
- *** $CuCl_2$** *** NH_4Cl**

Are You My Type Lab:

- **Copper II Chloride and Aluminum**
- **Graduated Cylinder**

- **Beaker of Water**
- **100 mL Beaker**
- **Scupula**
- **Stirring Rod**
- **Magnesium and Hydrogen Chloride (Hydrochloric Acid)**
- **Sodium Chloride and Silver Nitrate**
- **Propane**
- **Mg**
- **Spot Plate**
- **Dropper**
- **Bunsen Burner**
- **Striker**
- **Goggles**
- **Lab Procedure Handout**
- **Student Lab Notebook**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding of Reaction Types by completing practice worksheets following notes**
  - **Students will demonstrate their understanding by completing the Reaction Types Mini Lab**
  - **Students will further demonstrate their understanding by completing the Lab Investigation of all five reaction types they have been introduced to.**
- **After**
  - **Students will share their observations from the "Are You My Type" reaction types lab with the class.**
  - **Students will be given a test at the end of the Chemical Equations and Reactions Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: States of Matter

Approximate # of Lessons: 3

ASSOCIATED STANDARDS
Students who demonstrate understanding can:

HS-PS1-3. **Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]**

The Performance Expectations above were developed using the following elements from A Framework for K-12 Science Education:

SCIENCE & ENGINEERING PRACITCES

-Planning and Carrying Out Investigations
Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

DISCIPLINARY CORE IDEAS

-PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),*(secondary to HS-PS2-6)*

CROSS CUTTING CONCEPTS

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

Observable features of the student performance by the end of the course:

- 1 Identifying the phenomenon to be investigated
    - a Students describe* the phenomenon under investigation, which includes the following idea: the relationship between the measurable properties (e.g., melting point, boiling point, vapor pressure, surface tension) of a substance and the strength of the electrical forces between the particles of the substance.
- 2 Identifying the evidence to answer this question
    - a Students develop an investigation plan and describe* the data that will be collected and the evidence to be derived from the data, including bulk properties of a substance (e.g., melting point and boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between particles.
    - b Students describe* why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substances, including the following descriptions*:
        - i. The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the identity of the particles does not change (e.g., when water is boiled the molecules are still present but further apart).
        - ii. Thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles close together.
        - iii. The patterns of interactions between particles at the molecular scale are reflected in the June 2015 Page 1 of 2 patterns of behavior at the macroscopic scale.
        - iv. Together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale.
- 3 Planning for the investigation
    - a In the investigation plan, students include:
        - i. A rationale for the choice of substances to compare and a description* of the composition of those substances at the atomic molecular scale.
        - ii. A description* of how the data will be collected, the number of trials, and the experimental set up and equipment required.
    - b Students describe* how the data will be collected, the number of trials, the experimental set up, and the equipment required.
- 4 Collecting the data a Students collect and record data — quantitative and/or qualitative — on the bulk properties of substances.
- 5 Refining the design
    - a Students evaluate their investigation, including evaluation of:
        - i. Assessing the accuracy and precision of the data collected, as well as the limitations of the investigation; and
        - ii. The ability of the data to provide the evidence required.
    - b If necessary, students refine the plan to produce more accurate, precise, and useful data.

Connections to other DCIs in this grade-band: **HS.ESS2.C**(HS-PS1-3)
Articulation of DCIs across grade-bands: **MS.PS1.A** (HS-PS1-1),(HS-PS1-3),(HS-PS1-8),(HS-PS2-6; **MS.PS2.B**(HS-PS1-3),(HS-PS2-6);
Common Core State Standards Connections: *ELA/Literacy -* **WHST.9-** Conduct short as well as more sustained research projects to answer a question (including a self-

12.7	generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3)*
Mathematics -	
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-PS1-3)*,(HS-PS1-8),*(HS-PS2-6)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-3),(HS-PS1-8),(HS-PS2-6)*

LESSON 1 (TITLE): Kinetic Theory of Gases and Units of Pressure and Temperature Conversions

# of Periods Required: 2

The student will be able to:

- **Describe basic principles of the kinetic theory of gases**
- **Explain where pressure comes from and what affects it**
- **Convert in between units of pressure**
- **Explain what will happen mathematically to the average KE of particles if temperature changes**

ACTIVITY:

- **Students will complete the warm-up handout reviewing the patterns of molecules among the different states of matter.**
- **Students will complete the note fill-in handout as the new concept of Kinetic Molecular Theory among Gases and conversions between units of temperature and pressure is introduced,**
- **Students will complete a worksheet with conversion practice between units of temperature and pressure.**
- **The Teacher will show the students a demonstration showing vacuum pressure, using peeps and a vacuum chamber.**
- **Students will complete a conversion worksheet for homework.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Temperature and Pressure Practice Problems worksheets**
- **Vacuum Chamber**
- **Peeps**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding of Kinetic Theory of Gases and unit conversions by completing a practice worksheet following notes**
- **After**
  - **Students will be given a test at the end of the States of Matter Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Kinetic Molecular Theory of Liquids

# of Periods Required: _____

The student will be able to:

- **Explain the properties of liquids according to the KT**
- **Relate a KE diagram to the process of evaporation**
- **Describe the equilibrium process**
- **Describe vapor pressure and how it is affected by temperature and nature of the liquid**
- **Explain the relationship between boiling point and vapor pressure**
- **Predict a way to boil a liquid without changing the temperature of the liquid**

ACTIVITY:

- **Students will complete the warm-up handout reviewing the pressure and temperature conversions.**
- **Students will complete the note fill-in handout as the new concept of Kinetic Theory among Liquids and explain the process of evaporation rates and boiling point in relation to KMT.**
- **Students will complete a worksheet reviewing the vaporization and boiling point concepts, and the intermolecular forces.**
- **Students will complete the Evaporation Race mini-Lab in which they will look at the different evaporation rates of acetone, ethanol, and water, and how the rate of vaporization is affected by the strength of intermolecular forces.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Vaporization and Boiling Point questions worksheet**
- **3 100-150mL beakers,**
- **10mL of acetone**
- **10mL of ethanol (ethyl alcohol)**
- **10mL of water**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding of Kinetic Theory of Liquids**
  - **Students will demonstrate their understanding of intermolecular forces by completing the Evaporation Race Lab Investigation.**
- **After**
  - **Students will answer analysis questions after completing**
  - **Students will be given a test at the end of the States of Matter Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 3 (TITLE): Kinetic Molecular Theory of Solids

# of Periods Required: 1

The student will be able to:

- **Describe solids according to the Kinetic Theory**
- **Explain differences and similarities between ionic and molecular solids**

ACTIVITY:

- **Students will complete the warm-up handout reviewing the vapor pressure and boiling point.**
- **Students will complete the note fill-in handout as the new concept of Kinetic Theory among Solids and explain the process of evaporation rates and boiling point in relation to KMT.**
- **Students will complete a worksheet reviewing the KMT of Solids.**
- **Students will take a quiz that reflects on the KMT of Gases, Solids, and Liquids.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **KMT of Solids practice worksheet**
- **Quiz on KMT**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding of Kinetic Theory of Solids and unit conversions by completing a practice worksheet following notes**
  - **Students will demonstrate their understanding of the Kinetic Molecular Theory among three states of Matter by taking a quiz.**
- **After**
  - **Students will be given a test at the end of the States of Matter Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: Acids and Bases

Approximate # of Lessons: 2

ASSOCIATED STANDARDS

Students who demonstrate understanding can:

HS-PS1-3. **Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]**

HS-PS1-6. **Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]**

The Performance Expectations above were developed using the following elements from A Framework for K-12 Science Education:

SCIENCE & ENGINEERING PRACITCES

-Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

-Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)

DISCIPLINARY CORE IDEAS

-PS1.A: Structure and Properties of Matter

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),*(secondary to HS-PS2-6)*

PS1.B: Chemical Reactions

- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)

ETS1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.*(secondary to HS-PS1-6)*

CROSS CUTTING CONCEPTS

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

Observable features of the student performance by the end of the course:

- 1 Identifying the phenomenon to be investigated
  - a Students describe* the phenomenon under investigation, which includes the following idea: the relationship between the measurable properties (e.g., melting point, boiling point, vapor pressure, surface tension) of a substance and the strength of the electrical forces between the particles of the substance.
- 2 Identifying the evidence to answer this question
  - a Students develop an investigation plan and describe* the data that will be collected and the evidence to be derived from the data, including bulk properties of a substance (e.g., melting point and boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between particles.
  - b Students describe* why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substances, including the following descriptions*:
    - i. The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the identity of the particles does not change (e.g., when water is boiled the molecules are still present but further apart).
    - ii. Thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles close together.
    - iii. The patterns of interactions between particles at the molecular scale are reflected in the June 2015 Page 1 of 2 patterns of behavior at the macroscopic scale.
    - iv. Together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale.
- 3 Planning for the investigation
  - a In the investigation plan, students include:
    - i. A rationale for the choice of substances to compare and a description* of the composition of those substances at the atomic molecular scale.

        - ii. A description* of how the data will be collected, the number of trials, and the experimental set up and equipment required.
    - b Students describe* how the data will be collected, the number of trials, the experimental set up, and the equipment required.
- 4 Collecting the data a Students collect and record data — quantitative and/or qualitative — on the bulk properties of substances.
- 5 Refining the design
    - a Students evaluate their investigation, including evaluation of:
        - i. Assessing the accuracy and precision of the data collected, as well as the limitations of the investigation; and
        - ii. The ability of the data to provide the evidence required.
    - b If necessary, students refine the plan to produce more accurate, precise, and useful data.

Observable features of the student performance by the end of the course:

- 1 Using scientific knowledge to generate the design solution
    - a Students identify and describe* potential changes in a component of the given chemical reaction system that will increase the amounts of particular species at equilibrium. Students use evidence to describe* the relative quantities of a product before and after changes to a given chemical reaction system (e.g., concentration increases, decreases, or stays the same), and will explicitly use Le Chatelier's principle, including:
        - i. How, at a molecular level, a stress involving a change to one component of an equilibrium system affects other components;
        - ii. That changing the concentration of one of the components of the equilibrium system will change the rate of the reaction (forward or backward) in which it is a reactant, until the forward and backward rates are again equal; and
        - iii. A description* of a system at equilibrium that includes the idea that both the forward and backward reactions are occurring at the same rate, resulting in a system that appears stable at the macroscopic level.
- 2 Describing criteria and constraints, including quantification when appropriate
    - a Students describe* the prioritized criteria and constraints, and quantify each when appropriate. Examples of constraints to be considered are cost, energy required to produce a product, hazardous nature and chemical properties of reactants and products, and availability of resources.
- 3 Evaluating potential solutions
    - a Students systematically evaluate the proposed refinements to the design of the given chemical June 2015 Page 1 of 2 system. The potential refinements are evaluated by comparing the redesign to the list of criteria (i.e., increased product) and constraints (e.g., energy required, availability of resources).
- 4 Refining and/or optimizing the design solution
    - a Students refine the given designed system by making tradeoffs that would optimize the designed system to increase the amount of product, and describe* the reasoning behind design decisions.

Connections to other DCIs in this grade-band:); **HS.PS3.B** (HS-PS1-4),(HS-PS1-6),(HS-PS1-7),(HS-PS1-8); **HS.ESS2.C**(HS-PS1-2),(HS-PS1-3)
Articulation of DCIs across grade-bands: **MS.PS1.A** (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8);**MS.PS1.B** (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-6),(HS-PS1-7),(HS-PS1-8);**MS.PS2.B** (HS-PS1-3),(HS-PS1-4),(HS-PS1-5);
Common Core State Standards Connections: *ELA/Literacy* - **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-

	PS1-3),(HS-PS1-5)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),*(HS-PS1-6)*
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3)*
Mathematics -	
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),*(HS-PS1-3),(HS-PS1-4),(HS-PS1-5)*,(HS-PS1-7),(HS-PS1-8)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)*

LESSON 1 (TITLE): Introduction to Solutions and Units of Concentration

# of Periods Required: 1-2

The student will able to:

- **Explain the differences between the three different types of solutions**
- **Describe how to make a supersaturated solution**
- **Describe how to increase the rate of dissolving**
- **Define molarity in terms of its mathematical formula**
- **Calculate moles, liters, or molarity of a given solution**

ACTIVITY:

- **Students will complete the warm-up handout reviewing solutions and mixtures**
- **Students will complete the note fill-in handout as notes are given for solutions and calculating molar concentration.**
- **Students will complete the Molar Conversion calculations worksheet.**
- **The teacher will demonstrate how to make an acidic solution base on a certain concentration. The students will work through the Molar calculation before the demo is done.**
- **The students will complete extra molarity concentration practice problems for homework.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Molar Conversion calculations worksheet (x2)**

Teacher demo Materials:

- **0.5mol of HCl Solute**
- **1 L Distilled water**
- **1 L Volumetric Flask**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding of Molarity Concentration calculatons by completing a practice worksheet following notes**
  - **Students will demonstrate their understanding by completing the molar calculation for the teacher's demonstration**
- **After**
  - **Students will be given a test at the end of the Acids and Bases Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Acids and Bases Naming and Characteristics

# of Periods Required: 2-3

The student will be able to:

- **Define an acid and base according to the Arrhenius definition**
- **Review the correct way to write the names and formulas for acids and bases**
- **Describe and list properties that pertain to acids and bases**

ACTIVITY:

- **Students will complete the warm-up handout reviewing molarity calculations**
- **Students will complete the note fill-in handout as notes are given for the characteristics of acids and bases, and how to name them.**
- **Students will complete the Acids and Bases naming worksheet.**
- **Students will demonstrate their understanding of the concepts by testing different household items as acids or bases using litmus paper in a lab investigation.**
- **Students will answer the analysis questions about the lab investigation.**
- **Students will write a formal lab report for the lab**
- **Students will take a quiz to assess their understanding of the material**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Acids and Bases naming worksheet**
- **Red and Blue litmus paper**
- **Household solutions**
- **Water**
- **Paper towels**
- **Microwells**
- **Lab Procedure handout**
- **Student lab notebook**
- **Acids and Bases quiz**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
  - **Collect and review Molar calculations homework**
- **During**
  - **Students will demonstrate their understanding of acid and base naming by completing a practice worksheet following notes**
  - **Students will demonstrate their understanding by completing the lab investigation of testing household items to be an acid or base, and comparing it to their hypothesis**
- **After**
  - **Students will be given a quiz on acids and bases including properties and concentration calculations.**

- **Students will be given a test at the end of the Acids and Bases Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 3 (TITLE): Acid Base Calculations and Neutralization Reactions

# of Periods Required: _____

The student will be able to:

- **Explain the correlation to strength of acids and bases to pH and pOH scale**
- **Calculate pH, pOH, $[H^+]$, and $[OH^-]$**
- **Explain what a neutralization reaction is**
- **Write the corresponding formulas in neutralization reactions**
- **Calculate an unknown concentration of an acid or base using a titration**

ACTIVITY:

- **Students will complete the warm-up handout reviewing acid and base naming**
- **Students will complete the note fill-in handout as notes are given for acid base calculations and neutralization reactions.**
- **Students will complete the calculations and titration practice problems worksheet.**
- **Students will demonstrate their understanding of the concepts by completing a titration lab to test the different acidity levels in different types of sodas in a lab investigation.**
- **Students will calculate the concentrations found and complete the analysis questions in a formal lab report.**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Calculation of pH and pOH worksheet**
- **Neutralization worksheet**
- **Student lab notebooks**
- **Lab procedure handout**
- **Bottle of Sierra Mist**
- **Bottle of Sprite**
- **Unknown Soda**
- **3 Test Tubes (per group)**
- **Phenolphthalein indicator**
- **1 mL Transfer Pipettes**
- **10 mL Graduate Cylinder**
- **0.2 M NaOH**
- **Safety goggles**
- **Lab apron**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
  - **Collect and review acid and base naming homework**
- **During**
  - **Students will demonstrate their understanding of acid and base calculations by completing a practice worksheet following notes**
  - **Students will demonstrate their understanding by completing the lab investigation of acidity levels in different types of soda using neutralization of an acid with a base**
- **After**
  - **Students will discuss their unknown molarity of an acid concentration with the class after completing their lab analysis.**
  - **Students will be given a test at the end of the Acids and Bases Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

Course & Domain: Chemistry Grade: 11

Unit Title: Nuclear Chemistry

Approximate # of Lessons: 2

ASSOCIATED STANDARDS
Students who demonstrate understanding can:

HS-PS1-8. **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. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]**

The Performance Expectations above were developed using the following elements from A Framework for K-12 Science Education:

SCIENCE & ENGINEERING PRACITCES

Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8)

DISCIPLINARY CORE IDEAS

PS1.C: Nuclear Processes

- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.

CROSS CUTTING CONCEPTS

Energy and Matter

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Observable features of the student performance by the end of the course:

- 1 Components of the model
  - a Students develop models in which they identify and describe* the relevant components of the models, including:
    - i. Identification of an element by the number of protons;
    - ii. The number of protons and neutrons in the nucleus before and after the decay;
    - iii. The identity of the emitted particles (i.e., alpha, beta — both electrons and positrons, and gamma); and
    - iv. The scale of energy changes associated with nuclear processes, relative to the scale of energy changes associated with chemical processes.

- 2 Relationships
    - a Students develop five distinct models to illustrate the relationships between components underlying the nuclear processes of 1) fission, 2) fusion and 3) three distinct types of radioactive decay.
    - b Students include the following features, based on evidence, in all five models:
        - i. The total number of neutrons plus protons is the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after.
        - ii. The scale of energy changes in a nuclear process is much larger (hundreds of thousands or even millions of times larger) than the scale of energy changes in a chemical process.
- 3 Connections
    - a Students develop a fusion model that illustrates a process in which two nuclei merge to form a single, larger nucleus with a larger number of protons than were in either of the two original nuclei.
    - b Students develop a fission model that illustrates a process in which a nucleus splits into two or more fragments that each have a smaller number of protons than were in the original nucleus
    - c In both the fission and fusion models, students illustrate that these processes may release June 2015 Page 1 of 2 energy and may require initial energy for the reaction to take place.
    - d Students develop radioactive decay models that illustrate the differences in type of energy (e.g., kinetic energy, electromagnetic radiation) and type of particle (e.g., alpha particle, beta particle) released during alpha, beta, and gamma radioactive decay, and any change from one element to another that can occur due to the process.
    - e Students develop radioactive decay models that describe* that alpha particle emission is a type of fission reaction, and that beta and gamma emission are not.

Connections to other DCIs in this grade-band:); **HS.PS3.B** (HS-PS1-4),(HS-PS1-6),(HS-PS1-7),(HS-PS1-8); **HS.ESS2.C**(HS-PS1-2),(HS-PS1-3)
Articulation of DCIs across grade-bands: **MS.PS1.A** (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8);**MS.PS1.B** (HS-PS1-1),(HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-6),(HS-PS1-7),(HS-PS1-8);**MS.PS2.B** (HS-PS1-3),(HS-PS1-4),(HS-PS1-5);
Common Core State Standards Connections: *ELA/Literacy* - **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3),(HS-PS1-5) **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3),*(HS-PS1-6)* **WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3) **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3)* *Mathematics* - **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin

	in graphs and data displays. (HS-PS1-2),*(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),*(HS-PS1-7),(HS-PS1-8)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)*

LESSON 1 (TITLE): The Nucleus and Radioactive Decay

# of Periods Required: 2-3

The student will be able to:

- **Explain what a nuclide is and describe the different ways nuclides ca be represented**
- **Define and relate the terms mass defect and nuclear binding energy**
- **Explain the relationship between number and nucleons and stability of nuclei**
- **Explain why nuclear reactions occur, and know how to balance a nuclear equation**
- **Define and relate the terms radioactive decay and nuclear radiation and describe the different types of radioactive decay and their effects on the nucleus**
- **Define the term half-life and relate it to the stability of the nucleus**

ACTIVITY:

- **Students will complete the warm-up handout reviewing Balancing Equations and atomic structure**
- **Students will complete the note fill-in handout as the new concept of atomic nucleus and radioactive decay is introduced**
- **Students will complete the practice problems for balancing nuclear equations.**
- **Students will complete an activity using beans to demonstrate how the nucleus of an atom changes when radioactive decay occurs**
- **Students will work with a partner to complete the "Half-Life of Macaroni" mini lab activity**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Nuclear equations balancing worksheet**
- **Radioactive Beans activity handout**
    - **Periodic Table**
    - **Two colors of beans, at least 10 of each bean**
- **Half-life of Macaroni Activity Handout**
    - **1 cup of macaroni**
    - **1 empty cup**
    - **Tweezers**
    - **Tray or box**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding of Atomic Nucleus and Radioactive Decay by completing practice worksheets following notes**
  - **Students will demonstrate their understanding by completing the Radioactive Beans and Half-Life of Macaroni Activities**
- **After**
  - **Students will be given a test at the end of the Nuclear Chemistry Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 2 (TITLE): Nuclear Radiation

# of Periods Required: 1-2

The student will be able to:

- **Compare the penetrating ability and shielding requirements of alpha particles, beta particles, and gamma rays**
- **Define the terms roentgen and rem, and distinguish between them**
- **Describe three devices used in radiation detection**
- **Discuss applications of radioactive nuclides**

ACTIVITY:

- **Students will complete the warm-up handout reviewing radioactive decay and particles**
- **Students will complete the note fill-in handout as the new concept nuclear radiation is introduced**
- **Students will pass around the Film badges used to measure exposure of radiation by employees who work with radiation**
- **Students will complete an activity to test their own exposure to radiation**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Film Badge**
- **Your Personal Radiation activity worksheet**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding by completing the Personal Radiation Activity**
- **After**
  - **Students will be given a test at the end of the Nuclear Chemistry Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**

LESSON 3 (TITLE): Nuclear Fission and Fusion

# of Periods Required: 1-2

The student will be able to:

- **Define nuclear fission, chain reaction, and nuclear fusion and distinguish between them**
- **Explain how a fission reaction is used to generate power**
- **Discuss the possible benefits and the current difficulty of controlling fusion reactions**

ACTIVITY:

- **Students will complete the warm-up handout reviewing nuclear radiation**
- **Students will complete the note fill-in handout as the new concept of fusion and fission is introduced**
- **Students will pass fill out the worksheet showing the difference in affect on the nucleus of a particle in fusion v. fission**
- **Students will watch a video on the nuclear disaster in Fukushima**
- **Students will discuss their thoughts and concerns throughout the video, and will predict what they believe to happen next as we continue**
- **Students will do a web search on harnessing fusion, including a web scavenger hunt through Iter's website**
- **Students will be presented with information on the Chernobyl disaster**
- **Students will then research what the most up-to-date status is for Chernobyl**
- **Students will present their findings in small group sessions, then each group will present to the class**

MATERIALS:

- **Science Warm Up Handout**
- **Computer hooked up to Projector**
- **Elmo document camera**
- **Note Handout (fill-in)**
- **Video on Fukushima**
- **Video on Chernobyl**
- **iPad cart**

ASSESSMENT:

- **Before**
  - **Student's background knowledge will be assessed by answering the Warm Up.**
- **During**
  - **Students will demonstrate their understanding by completing their research on the Chernobyl status**
- **After**
  - **Students will be given a test at the end of the Nuclear Chemistry Unit which will assess their overall understanding on this particular topic, as well as the concepts built upon this topic.**