Wilson Area School District
Planned Course Guide

Title of Course: Chemistry

Subject Area: Science

Grade Level: 10-12

Course Description: This course is designed to provide students a college preparatory background in chemistry - the study of matter and its changes. Students will be able to describe the evolution of our understanding of matter - from the theories of antiquity to the modern day model of the atom. The students will be able to qualitatively and quantitatively describe the changes in matter and their applications to society.

Time/Credit for this Course: 1 year /1 credit

Curriculum Writing Committee: Paul Stewart

Curriculum Map

Timeline	**Unit**	**Essential Questions**	**Standards / Performance Expectations**
6 weeks (15 classes)	Atomic Structure	Why do elements behave differently? Why is gold so valuable? Why are some atoms radioactive? Why is oxygen necessary for most life? How do particles combine to form the variety of matter one observes? What is the universe, and what goes on in stars? How are instruments that transmit and detect waves used to extend human senses? What is light? How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there? What are the characteristic properties and behaviors of waves?	**STEELS Standards/Performance Expectations:** 3.2.9-12.A - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level. 3.2.9-12.H - Develop models to illustrate changes in the composition of the atomic nucleus and the energy released during fission, fusion, and radioactive decay. 3.2.9-12.G Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction 3.2.9-12.L Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. 3.5.9-12.E Evaluate how technology and engineering advancements alter human health and capabilities. 3.3.9-12.A Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. 3.3.9-12.C Communicate scientific ideas about the way stars, over their life cycle, produce elements. 3.2.9-12.X Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy 3.2.9-12.W Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. 3.2.9-12.V Evaluate the claims, evidence, and reasoning behind the

			idea that electromagnetic radiation can be described either by a wave model or a particle model and that for some situations one model is more useful than the other. 3.2.9-12.T Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
3 weeks (7 classes)	Periodic Trends	How can we predict elemental behavior? What other elements might behave similarly to gold? What makes one element magnetic and another not? How do particles combine to form the variety of matter one observes? What underlying forces explain the variety of interactions observed?	3.2.9-12.A Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level 3.2.9-12.B Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. 3.2.9-12.C Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties
6 weeks (15 classes)	Bonding	Why do molecules and compounds form? Why does ice melt at a lower temperature than iron? What is a compound of sodium and chloride are necessary for life but either one as elements are toxic. What factors influence the state of matter? How do particles combine to form the variety of matter one observes? How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?	3.2.9-12.A - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level. 3.2.9-12.B Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. 3.2.9-12.C Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. 3.2.9-12.D Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. 3.2.9-12.L Use mathematical representations of Newton's Law of

			Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. 3.5.9-12.E Evaluate how technology and engineering advancements alter human health and capabilities. 3.2.9-12.N Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. 3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
4 weeks (10 classes)	Reactions and stoichiometry	How can we use chemistry to make plastics or sugars? What factors determine whether a reaction will or will not take place? How do we know how much of each reactant to use? How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?	3.2.9-12.D Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. 3.2.9-12.F Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium 3.2.9-12.G Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. 3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
4 weeks (10 classes)	Energy and Thermochemistry	How do hand-warmers and instant ice packs	3.2.9-12.D Develop a model to illustrate that the release or absorption

		work? Why does burning wood produce heat? How far can a car go on a gallon of gasoline? Why is aluminum used as a heat sink in radar applications? What is energy?	of energy from a chemical reaction system depends upon the changes in total bond energy. 3.2.9-12.F Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. 3.2.9-12.H Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. 3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. 3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). 3.2.9-12.Q Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.
4 weeks (10 classes)	Gas Laws	How does the pressure in a car tire change with temperature? How is the lowest theoretical temperature determined? Why is the diaphragm necessary to breathe? How can one predict an object's continued motion, changes in motion, or stability? How do substances combine or change (react) to make new substances? How does one characterize and explain	3.2.9-12.B Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles 3.2.9-12.D Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. 3.2.9-12.E Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. 3.2.9-12.F Refine the design of a chemical system by specifying a

		these reactions and make predictions about them? How do particles combine to form the variety of matter one observes? What underlying forces explain the variety of interactions observed? What is meant by conservation of energy? How is energy transferred between objects or systems?	change in conditions that would produce increased amounts of products at equilibrium. 3.2.9-12.I Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. 3.2.9-12.J Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
4 weeks (10 classes)	Equilibrium	Why does the battery in your phone "die"? How do systems stay balanced? How do particles combine to form the variety of matter one observes? How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them What underlying forces explain the variety of interactions observed? What is meant by conservation of energy? How is energy transferred between objects or systems?	3.2.9-12.E Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. 3.2.9-12.F Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. 3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
4 weeks (10 classes)	Sustainability	Why have CFCs been banned? How can hydroponics be used to conserve natural habitats? How do humans change the planet?	3.3.9-12.E Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. 3.3.9-12.L Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

		What regulates weather and climate? How and why is the Earth constantly changing?	3.3.9-12.M Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. 3.3.9-12.S Analyze geoscience data and the results from global climate models to make an evidence- based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. 3.3.9-12.P Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

Wilson Area School District
Planned Course Materials

Course Title: Chemistry

Textbook: Modern Chemistry, Holt Copyright 2012

Supplemental Books: World of Chemistry, McDougal

Teacher Resources:
- Laboratory Materials
- Teacher Prepared Worksheets
- Gizmos

Curriculum Scope & Sequence

Planned Course: Chemistry

Unit 1: Atomic Structure

Time Frame: 5-6 weeks (15 classes)

State Standards:
3.2.9-12.A - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level.
3.2.9-12.H - Develop models to illustrate changes in the composition of the atomic nucleus and the energy released during fission, fusion, and radioactive decay.
3.2.9-12.G Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction
3.2.9-12.L Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
3.5.9-12.E Evaluate how technology and engineering advancements alter human health and capabilities.
3.3.9-12.A Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.
3.3.9-12.C Communicate scientific ideas about the way stars, over their life cycle, produce elements.
3.2.9-12.X Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy
3.2.9-12.W Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
3.2.9-12.V Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model and that for some situations one model is more useful than the other.
3.2.9-12.T Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

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

- Big Idea(s):
  - All forms of matter exist as a result of the combination or rearrangement of atoms.
  - Phenomena involving nuclei explain the formation of the elements, radioactivity, and the release of energy.
  - Waves are repeating patterns of motion that transfer energy and information without transferring matter.
  - Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave pattern of changing electric and magnetic fields that interact with matter
  - Useful modern technologies and instruments have been designed based on an understanding of waves and their interactions with matter.
- DCI's (Disciplinary Core Ideas)
  - Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
  - 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.
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
- 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.
- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary)

- Content Descriptors
    - Subatomic Particles
        - Identify protons, neutrons, and electrons and their composition, charges, masses, and locations in the atom
        - Determine atomic number, mass number, and number of subatomic particles for a given element or isotope or ion
    - Atomic Number and Mass number
        - Define atomic number as the number of protons in an atom
        - Define mass number as the sum of protons and neutrons
        - Use atomic number and mass number to:
            1. Identify an element
            2. Distinguish between different isotopes
    - Isotopes and Atomic Mass
        - Define isotopes as atoms of the same element with different numbers of neutrons
        - Explain the concept of average atomic mass
        - Calculate average atomic mass from isotope data
        - Describe how isotope stability relates to nuclear stability
        - Recognize real-world applications of isotopes (e.g., carbon dating, nuclear medicine)
    - Atomic Models and Historical Development
        - Understand the development of atomic theory through major contributors:
            1. Dalton
            2. Thomson
            3. Rutherford
            4. Bohr
            5. Quantum
        - Compare and contrast historical models based on experimental evidence (e.g., gold foil experiment)
        - Understand that current models are based on indirect evidence and probability distributions
    - Electron Configurations (Basic Level)
        - Use aufbau principle and hunds rule to write electron configurations and orbital diagrams for elements in periods 1-5.
        - Predict electron configurations and properties based on understanding of quantum model
    - Nuclear Processes
        - Distinguish between fission, fusion, and radioactive decay; model nuclear changes; describe real-world uses (e.g., medicine, energy)

        - Relate these changes in the nucleus to isotopic stability and emitted EM radiation
        - Understand the societal / medical applications of alpha and beta emitters and means of detection
        - Stars, their life cycle, and creation of elements
    - Waves
        - Their properties and descriptions
        - EM Radiation and spectrum
        - Role of spectral lines in determination of models of atoms
        - Photoelectric effect
        - Particle/Wave nature of matter

Core Activities: Students will complete/participate in the following or equivalent activities:
- Flame Test Lab – Connects to electron transitions and energy levels
- Build an Atom Simulation (PhET) – Models protons, neutrons, electrons, and isotopes
- Isotope Sorting and Mass Average Activity – Models average atomic mass with manipulatives
- Periodic Table Scavenger Hunt – Investigate patterns using atomic structure clues
- Subatomic Particle Puzzle Challenge – Identify elements from partial particle data
- Examination of spectral lines

Extensions:
- Quantum numbers
- Shorthand electron configurations

Remediation:
- Departmental videos
- Edpuzzles
- Khanacademy

Instructional Methods:
- Collaborative problem solving
- Laboratory Investigations
- Direct Instruction
- Research

Materials & Resources:
- Burner or equivalent
- Chromebooks
- Manipulatives to represent elements

Assessments:
- Teacher made assessments
- Gizmo Worksheets
- Laboratory Reports
- Collaborative work evaluations

Curriculum Scope & Sequence

Planned Course: Chemistry

Unit 2: Periodic Trends

Time Frame: 2-3 weeks (5-7 classes)

State Standards:
3.2.9-12.A - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level.
3.2.9-12.B Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
3.2.9-12.C Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
3.2.9-12.L Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
3.5.9-12.E Evaluate how technology and engineering advancements alter human health and capabilities.

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

- Big Idea(s):
  - All forces between objects, regardless of size or direction, arise from only a few types of interactions
- DCI's (Disciplinary Core Ideas)
  - Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
  - 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.
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
  - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
- Content Descriptors
  - Periodic Table Organization and Classification
    - Groups vs Periods
    - Group names and background
    - Main Block vs transition vs post transition etc
  - Determine electron configurations using energy levels and orbitals
    - Use the periodic table to identify valence electrons
    - Recognize the periodicity and relation between how the periodic table was arranged and quantum model of the atom
    - Relate configurations to reactivity (noble gases vs alkali metals) or (alkali metals vs alkaline earth metals)
    - Compare reactivity across a period or down a group
  - Atomic Radius
    - Describe and explain periodic trend across periods and down groups using coulombs law
    - Relate trend to increasing nuclear charge and shielding effect

        - Compare the atomic radius of an element to its ionic radius and provide an explanation for the observations
    - Ionization Energy
        - Define and explain how ionization energy changes across a period and down a group
        - Relate to atomic radius and attraction between nucleus and electrons via coulombs law.
        - Explain changes in successive ionization energies and how this relates to coulombs law
    - Electronegativity
        - Define and predict how it changes across the periodic table
        - Use trends to introduce impact of one atom on another

Core Activities: Students will complete/participate in the following:
- Graphing Periodic Trends Lab – Students graph atomic radius, ionization energy, etc.
- Electronegativity Tug-of-War – Visual game for trends and bonding behavior
- Predict the Element Game – Use periodic table clues to identify mystery elements
- Element Families Investigation – Students research and present on groups (alkali, halogens, etc.)
- Ionic Radius vs Atomic Radius Modeling Activity – Hands-on trend comparison

Extensions:
- Exceptions to trends in ionization energy
- Explaining trends among transition metals and elements containing “f” orbitals

Remediation:
- Departmental Videos
- Edpuzzle
- Khanacademy
- Gizmo’s

Instructional Methods:
- Collaborative problem solving
- Laboratory Investigations
- Direct Instruction
- Research

Materials & Resources:
- Styrofoam balls and rulers
- Photoelectric effect kit
- chromebooks

Assessments:
- Teacher made assessments
- Gizmo Worksheets
- Laboratory Reports
- Collaborative work evaluations

Curriculum Scope & Sequence

Planned Course: Chemistry

Unit 3: Bonding

Time Frame: 6 weeks (15 classes)

State Standards:
3.2.9-12.A - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level.
3.2.9-12.B Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
3.2.9-12.C Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
3.2.9-12.D Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
3.2.9-12.L Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
3.5.9-12.E Evaluate how technology and engineering advancements alter human health and capabilities.
3.2.9-12.N Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

Essential Content/Objectives: At end of the unit, students will be able to:
- Big Idea(s):
  - All forms of matter exist as a result of the combination or rearrangement of atoms.
  - How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?
- DCI's (Disciplinary Core Ideas)
  - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
  - When two objects interacting through a field change relative position, the energy stored in the field is changed.
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
  - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
  - A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.
- Content Descriptors
  - Ionic Bonding
    - Role of electronegativity
    - Degree of ionic character
  - Covalent Bonding
    - Role of electronegativity - polar or non-polar bonds

        - Lewis structures and molecular shapes
        - Molecular Polarity
    - Intramolecular vs Intermolecular
        - Similarities and differences
        - Under what conditions does each form or break
    - Molecular Polarity
        - Role of symmetry and dipoles
        - How to test for dipoles
    - Intermolecular force types
        - London Dispersion vs Dipole Dipole Forces and hydrogen bonding
        - Ion-Dipole Forces
        - Relative strengths
    - Phase Changes and states of matter
        - Characteristics of states of matter
        - Exo vs endothermic changes
        - Kinetic vs potential energy
        - Phase diagrams and heating curves
        - How does air conditioning work? Why does sweating cool you off?
    - Structure - property relationships
        - Analysis of Metallic vs Network vs Ionic vs Molecular materials
        - Relate material type to engineering
        - Relation of bonding to type of material and properties
    - Chemical and physical changes
        - What is happening at the atomic/molecular level for each type
        - How do we know which type is occurring
    - Bond enthalpies
        - Factors that influence
        - Predict which bonds are likely to form or not based on bond enthalpies

<u>Core Activities</u>: Students will complete/participate in the following:
- Bonding Card Sort – Classify ionic, covalent, and metallic bonding with examples
- Polarity Lab (Paper Chromatography or Solubility) – Explore like-dissolves-like
- Intermolecular Forces Station Lab – Analyze boiling points, evaporation, and surface tension
- Lewis Structure Building with Manipulatives – Build molecules and assess geometry
- Bonding Simulation (PhET “Molecule Shapes”) – Visualize 3D geometry and polarity

<u>Extensions:</u>
- Hybridization
- Distillation

<u>Remediation:</u>
- Departmental videos
- Edpuzzles
- Khanacademy

<u>Instructional Methods:</u>
- Collaborative problem solving
- Laboratory Investigations
- Direct Instruction
- Research

Materials & Resources:

- Distillation apparatus
- Chromebooks
- Solvents of various polarities
- Chromatography paper
- Modeling kits

Assessments:

- Teacher made assessments
- Gizmo Worksheets
- Laboratory Reports
- Collaborative work evaluations

Curriculum Scope & Sequence

Planned Course: Chemistry

Unit 4: Reactions and Stoichiometry

Time Frame: 3-4 weeks (7-10 classes)

State Standards:
3.2.9-12.B Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
3.2.9-12.C Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
3.2.9-12.D Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
3.5.9-12.E Evaluate how technology and engineering advancements alter human health and capabilities.
3.2.9-12.N Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

Essential Content/Objectives: At end of the unit, students will be able to:
- Big Idea(s):
  - All forms of matter exist as a result of the combination or rearrangement of atoms.
  - The atoms of some substances combine or rearrange to form new substances that have different properties.
- DCI's (Disciplinary Core Ideas)
  - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
  - When two objects interacting through a field change relative position, the energy stored in the field is changed.
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
  - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
  - 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.
  - 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.
- Content Descriptors:
  - Types of chemical reactions
    - Oxidation and reduction
    - Precipitation
    - Acid/Base Reactions
    - Decomposition

        - Synthesis
        - Combustion
    - Evidence of chemical changes
        - Color changes, evolution of a gas or precipitate
        - Change in properties
        - Release or absorption of energy
    - Balancing Chemical Equations
        - Law of conservation of mass and energy
        - Whole number ratios
    - Mole concept
        - Why count in moles?
        - Definition and quantitative calculations
        - Determine number of particles, mass, moles, or volume involved
    - Stoichiometry
        - Use mole ratios to predict quantities produced or needed
        - Apply to real world engineering and manufacturing
    - Reaction Energies
        - Calculating enthalpy of reaction using bond enthalpies
        - Energy Diagrams
        - Exothermic and endothermic reactions

Core Activities: Students will complete/participate in the following:
- Types of Reactions Lab – Observe and classify basic reaction types
- Balancing Equations Dry-Erase Race – Kinesthetic balancing practice
- Mole-to-Mass and Mass-to-Mass Conversions Worksheet with Visual Aids
- Limiting Reactant Lab (e.g., vinegar and baking soda, or magnesium and HCl)
- Percent Yield Calculation Lab – Simple precipitate or decomposition reaction

Extensions:
- Ice tables and LR problems
- Mole to particle calculations
- Molarity or molar volume conversions
- Significant figures
- Empirical and molecular formulas

Remediation:
- Departmental videos
- Edpuzzles
- Khanacademy

Instructional Methods:
- Collaborative problem solving
- Laboratory Investigations
- Direct Instruction
- Research

Materials & Resources:
- Filter paper and ionic compounds
- Balances
- Hydrated crystals
- Chromebooks
- Gas collection tubes

Assessments:

- Teacher made assessments
- Gizmo Worksheets
- Laboratory Reports
- Collaborative work evaluations

Curriculum Scope & Sequence

Planned Course: Chemistry

Unit 5: Energy and Thermochemistry

Time Frame: 3-4 weeks (7-10 classes)

State Standards:
3.2.9-12.D Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
3.2.9-12.F Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
3.2.9-12.H Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
3.2.9-12.Q Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.
3.2.9-12.R Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

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

- Big Idea(s):
  - Energy can be modeled as either motions of particles or as being stored in force fields
  - Phenomena involving nuclei explain the formation of the elements, radioactivity, and the release of energy
  - The total change of energy in any system is always equal to the total energy transferred into or out of the system
- DCI's (Disciplinary Core Ideas)
  - Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
  - Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
  - Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
  - Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
  - Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
  - Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

- Mathematical expressions, which quantify how the stored energy in a system Systems and System Models Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks

- Content Descriptors:
  - Bond breaking vs Bond formation
    - Exothermic vs endothermic
    - Applications to biology and ATP
    - Applications to explosives
  - Energy Diagrams
    - Boltzmann Distribution
    - Potential Energy Diagrams and Activation Energy
    - Definition of Temperature
    - Change in enthalpy
  - Specific heat capacity
    - Thermal equilibrium and heat sinks
    - Application to heating swimming pools and water heaters
    - System vs surroundings
    - Conservation of energy
    - Impact of water's high heat capacity on geologic systems

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

- Endo vs. Exo Lab (e.g., cold/hot packs or dissolving salts)
- Energy Diagram Card Sort – Identify activation energy, ΔH, reaction type
- Bond Energy Modeling with Building Blocks – Break and form bonds using visual tiles
- Conservation of Energy Demonstration – Closed system heat exchange model
- System vs Surroundings Graphic Organizer
- Calculate specific heat capacity of metal

Extensions:

- Thermodynamics - enthalpy, entropy, free energy
- Stoichiometrical calculations involving heats

Remediation:

- Departmental videos
- Edpuzzles
- Khanacademy

Instructional Methods:

- Collaborative problem solving
- Laboratory Investigations
- Direct Instruction
- Research

Materials & Resources:

- Cup Calorimeters
- Digital Thermometers
- Ice
- Chromebooks

Assessments:

- Teacher made assessments
- Gizmo Worksheets
- Laboratory Reports
- Collaborative work evaluations

Curriculum Scope & Sequence

Planned Course: Chemistry

Unit 6: Gas Laws

Time Frame: 3-4 weeks (7-10 classes)

State Standards:
3.2.9-12.B Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles
3.2.9-12.D Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
3.2.9-12.E Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
3.2.9-12.F Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
3.2.9-12.I Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
3.2.9-12.J Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

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

- Big Idea(s):
  - A change in motion of interacting objects can be explained and predicted by forces.
  - All forces between objects, regardless of size or direction, arise from only a few types of interactions
  - Energy can be modeled as either motions of particles or as being stored in force fields.
  - The total change of energy in any system is always equal to the total energy transferred into or out of the system.
  - Forces between objects can result in transfer of energy between these objects.
- DCI's (Disciplinary Core Ideas)
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
  - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
  - A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.
  - 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.
  - 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.
  - Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

- Content Descriptors:
    - Kinetic Molecular Theory
        - To be consistent with STEELS, the emphasis here will be on momentum, kinetic energy, and forces
        - Matter is composed of small particles (atoms/molecules) in constant random motion
        - Gas particles move in straight lines until they collide with other particles or container walls
        - Collisions are elastic — no net loss of kinetic energy
        - Particle speed (and thus kinetic energy) increases with temperature
        - Pressure results from particles colliding with the walls of the container
    - Relation of KMT in explanation of relationships between:
        - Volume and Pressure
        - Volume and Temperature
        - Volume and moles
        - Pressure and moles
        - Velocity and molar mass
        - Ratio of PV vs nT
    - Pressure and how it is measured
    - What makes the gas state so important to chemistry

Core Activities: Students will complete/participate in the following:
- Gas Law Balloon Demo (Boyle's or Charles's Law) – Use syringes or bottles
- Determine absolute zero graphically
- KMT Particle Diagram Drawing with Scenarios – Predict behavior at temp/pressure changes
- Gas Law Lab with Vernier Probes or Syringes – Quantify P–V or V–T relationships
- Gas Law Calculations Practice Set – Use real-world word problems
- Graphing Lab: Create Graphs for Each Gas Law

Extensions:
- Ideal vs real gas
- Calculate molar volume of gas
- Calculate molar mass of gas

Remediation:
- Departmental videos
- Edpuzzles
- Khanacademy

Instructional Methods:
- Collaborative problem solving
- Laboratory Investigations
- Direct Instruction
- Research

Materials & Resources:
- Balloons
- Trough to serve as cold water bath
- Vacuum pump
- Digital Thermometers
- Large calipers
- Chromebooks

Assessments:

- Teacher made assessments
- Gizmo Worksheets
- Laboratory Reports
- Collaborative work evaluations

Curriculum Scope & Sequence

Planned Course: Chemistry

Unit 7: Equilibrium

Time Frame: 3-4 weeks (7-10 classes)

State Standards:
3.2.9-12.E Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
3.2.9-12.F Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

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

- Big Ideas:
  - All forms of matter exist as a result of the combination or rearrangement of atoms.
  - The atoms of some substances combine or rearrange to form new substances that have different properties.
  - A change in motion of interacting objects can be explained and predicted by forces
  - Energy can be modeled as either motions of particles or as being stored in force fields.
  - The total change of energy in any system is always equal to the total energy transferred into or out of the system.
  - Forces between objects can result in transfer of energy between these objects.
  - Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.
  - The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.
- Eligible Content:
  - Kinetics
    - Reaction rates
      - How to measure
      - Importance of them
      - What influences them
    - Forward vs reverse rates and collision theory
    - Radioactive decay and age of earth
    - Radioactive decay as the source of energy at earth's core
  - Equilibrium
    - Definition
    - Practical applications of equilibrium
      - Reactions going to completion vs equilibrium
      - Dead batteries
      - Le-Chateliers principal and engineering
  - Free energy and relation to equilibrium

  - Define a closed system and explain why energy cannot enter or leave, but can change form
  - Model energy distribution at equilibrium (e.g., potential vs. kinetic, product vs. reactant side)
  - Describe how equilibrium represents an energetically stable state in a closed system
  - Explain how energy added or removed (e.g., heat) can shift equilibrium but does not change total energy
  - Identify which direction of a reversible reaction is favored based on bond stability and energy transfer

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

- Equilibrium Modeling Lab (paperclips, cups, or legos to model dynamic balance)
- Color Change Reversible Reaction (e.g., iron thiocyanate) – Observe equilibrium shifts
- Le Châtelier's Principle Simulation (Gizmo/PHET) – Predict and explain shifts
- Reaction Rate Graphing Exercise – Analyze how rates equal out at equilibrium
- Equilibrium Concept Map or Station Review – Build connections across variables
- Measure rate of reaction and modify variables to examine effect on product produced and product produced per unit time

Extensions:

- Rates of reactions calculations
- First order radioactive decay lab

Remediation:

- Departmental videos
- Edpuzzles
- Khanacademy

Instructional Methods:

- Collaborative problem solving
- Laboratory Investigations
- Direct Instruction
- Research

Materials & Resources:

- Chemicals for reversible reactions
- Baking soda and vinegar
- Hydrogen peroxide and potatoes
- Chromebooks
- Pressure probes

Assessments:

- Teacher made assessments
- Gizmo Worksheets
- Laboratory Reports
- Collaborative work evaluations

Curriculum Scope & Sequence

Planned Course: Chemistry

Unit 8: Sustainability

Time Frame: 3-4 weeks (7-10 classes)

State Standards:
3.3.9-12.E Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
3.3.9-12.L Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
3.3.9-12.M Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
3.3.9-12.S Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
3.3.9-12.P Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

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

- Big Ideas:
  - Observations of the sky can be explained by predictable patterns of the movement of Earth, moon, sun and planets.
  - We can infer Earth's planetary history by features we observe today.
  - Changes we observe on Earth are the result of energy flowing and matter cycling between interconnected systems (the geosphere, hydrosphere, atmosphere, and biosphere)
  - Water's presence and properties impact Earth's ecosystems and surface features.
  - Weather and climate are influenced by interactions involving
  - sunlight, the ocean, the atmosphere, ice, landforms, and living things.
  - Life and the planet's nonliving systems impact one another
  - All materials, energy, and fuels that humans use are derived from natural sources, some of which are renewable over time and others are not.
  - Natural processes can cause sudden or gradual changes to Earth's systems, some of which may adversely affect humans.
  - Human activities in agriculture, industry, and everyday life has an impact on the land, rivers, ocean, and air.
- Disciplinary Core Ideas (DCIs):
  - Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes.
  - The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.
  - The foundation for Earth's global climate systems is the Electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space.

- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.
- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of humangenerated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary) Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
- Resource availability has guided the development of human society. Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

- <u>Eligible Content:</u>
  - Chemical pollutants
    - Identify major environmental pollutants (e.g., NO_x, SO_x, CO_2, heavy metals, plastics) and their chemical sources
    - Trade-offs between certain chemicals and industry and society
    - Ozone hole
    - Burning of fossil fuels and impact
  - Climate change
    - Historical data
    - Modeling
    - Role of greenhouse gases
    - Theories
    - Impact on society
  - Biodegradable vs Non-biodegradable
    - Recycling
    - Significant contributions to waste and challenges
    - Sustainability
  - Energy usage
    - Nuclear processes
    - Fossil fuels
    - Conversion of mechanical energy to electrical
    - Trade-offs
  - Carbon Footprint and Sustainable chemistry and society
  - Better life through chemistry

<u>Core Activities</u>: Students will complete/participate in the following:

- Life Cycle Analysis (LCA) Comparison Project - Students compare the cradle-to-grave impact of two common items (plastic bottle vs. aluminum can, paper bag vs. plastic bag).
- Carbon Footprint Calculator + Reduction Plan - Students use online tools to calculate their personal or classroom footprint
- Renewable vs. Nonrenewable Energy Station Lab

- Clean Water Lab - Simulate water contamination and purification methods (filtration, charcoal, evaporation)
- Local Sustainability Audit (School or Community) - Collect data (recycling rates, energy usage, water use)

Extensions:
- Urban Heat Index Effect on temperature modeling
- Water testing on homes and local ecosystem
- Watershed test

Remediation:
- Departmental videos
- Edpuzzles
- Khanacademy

Instructional Methods:
- Collaborative problem solving
- Laboratory Investigations
- Direct Instruction
- Research

Materials & Resources:
- pH probe
- Dissolved oxygen kits
- Chromebooks
- Different examples of plastics

Assessments:
- Teacher made assessments
- Gizmo Worksheets
- Laboratory Reports
- Collaborative work evaluations