**Course Title: Chemistry**

Board Approved: October 2026

| Unit 1: Atomic Structure | Time: 8 weeks |
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**Academic Standards:**

3.2.9-12.A - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level.
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 the end of the unit, students will be able to:

1. Define matter and describe the origin of it in our universe and locally in our solar system

**Assessment:**

1. Formative Assessments
    a. Productivity Rubric
        i. Student Log of activities

a. Identify protons, neutrons, and electrons and their composition, charges, masses, and locations in the atom
b. Determine atomic number, mass number, and number of subatomic particles for a given element or isotope or ion
c. Use atomic number and mass number to:
    i. Identify an element
    ii. Distinguish between different isotopes
d. Recognize that atomic masses are relative and the mass of an element is the average atomic mass of all of the isotopes of that element
    i. Calculate average atomic mass from isotope data.
    ii. Interpret a mass spectrum to identify an element and predict the relative abundances of the isotope

2. Describe various nuclear processes, balance nuclear reactions, and show how these processes are responsible much of what we observe in our natural world
    a. Distinguish between fission, fusion, and radioactive decay; model nuclear changes
    b. Show how fusion and fission and radioactive decay created the elements we see today
    c. Predict the type of radioactive decay (alpha or beta emission) based on the n/p ratio and balance nuclear reactions.
3. Explain the formation of stars, their life cycle, and creation of heavier elements
    a. Describe processes by which stars produce light and heat
    b. Relate the mass defect to the evolution of a star and why they cannot "burn" forever
    c. Explain a supernova and how heavier elements such as gold are produced as a result
4. Define a scientific model and use experimental evidence to debate the pros and cons of different historical atomic models.
    a. Analyze mass data to provide support for Dalton's atomic theory

completed
    ii. Assessed weekly
b. Daily exit ticket on paper (10 min)

2. Summative Assessments
    a. Exam - Essential Content 1
    b. Exam - Essential Content 2 and 3
    c. Exam - Essential Content 4 and 5
3. Laboratory Reports (4)
    a. Accurate completion of teacher provided laboratory handouts
    b. Well reasoned student extension
4. Timeline
    a. Star and element composition timeline
5. Model Creation and Presentation
    a. Atomic model build and explanation to another lay person
6. Blog Post
    a. Informative blog post describing benefits of radioactive treatment for cancer

b. Describe Thomson's experiments to determine the charge/mass ratio of electron
c. Summarize the reasons for and the results of the gold-foil scattering experiment
d. Describe the properties of light and how they relate to each other (wavelength, frequency, and energy)
e. Provide evidence for electrons is discrete energy levels around the atom
f. Evaluate the strengths and weaknesses of the Bohr model of the atom

5. Analyze evidence of wave and particle nature of electrons and connect this evidence to the development of the quantum model we use today.
    a. Draw a representation of the double slit experiment and describe how the findings support the wave hypothesis for electrons
    b. Distinguish between a Bohr Orbit and a Quantum Orbital
    c. Show where atomic orbitals are around an atom and how the periodic table reflects these atomic orbitals
    d. Use the Aufbau principle and Hund's rule to write electron configurations and orbital diagrams for elements in periods 1-5.
    e. Identify similarities in electron configurations between elements in the same group of the periodic table

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

1. Read and complete all interactive unit lessons
2. Build a realistic model of a(n):
    a. Proton or neutron
    b. Isotope of a light element
3. Draw an accurate mass spectrum based on isotope data
4. Interpret mass spectra to identify elements and use these to calculate average atomic mass
5. Create an elemental timeline in the life cycle of a star and relate this to the size and color of the star
6. Write a blog post describing how radioactive isotopes are being used to treat cancer internally.

7. Provide an approximate date of origin for an ancient artifact based on radiometric dating
8. Laboratory: Find the average atomic mass of "pennium" - Link
9. Laboratory: Spectral line analysis
10. Laboratory: Creating a mass spectrum of "tokenium"
11. Laboratory: Seeing the double slit experiment

**Materials and Resources:**

1. Electronic Balances
2. Diffraction Gratings
3. Gas discharge tubes
4. Poker tokens
5. Laser pointers
6. Spectral signatures of stars
7. Pre and post 1982 pennies
8. Styrofoam balls
9. Colored markers/paint

**Instructional Methods:**

1. Teacher guided student discovery
    a. Students read and work through interactive lessons
    b. Students proactively approach teacher for feedback on lessons
    c. Done independently or in groups of two
2. Laboratory Work
    a. Students conduct investigations using teacher provided instructions
    b. Students plan and conduct an additional experiment modeled after teacher directed experiment
3. Physical Modeling and Presentation
    a. Students build tactile realistic models of atoms
    b. Students present their model to another faculty member and explain its significance
4. Blog Posting
    a. Students create a blog post which is to be viewed by the public and provide useful information

**Extensions:**

1. Research how a LASER is produced and provide a blog post
2. Write electron configurations for period 6 elements
3. Examine Dalton's original mass data to see evidence of law of multiple proportions

**Remediation:**

1. Gizmos
    a. Element Builder
    b. Average Atomic Mass
2. Teacher Prepared Videos
    a. Nuclear Processes
    b. Subatomic Particle Counting
    c. Properties of Light
    d. Calculating Average Atomic Mass
    e. Writing Electron Configurations

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| b. Students will cite their work properly scientifically<br>5. Debate<br>a. Students will via defend a model of the atom using experimental evidence<br>b. Students will assess the strength of an argument based on evidence | |

| Unit 2: Atomic Behavior and Properties | Time: 5 weeks |
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**Academic Standards:**

3.2.9-12.A - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level.

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

1. Predict the magnetic properties of an element
    a. Define paramagnetism vs diamagnetism vs ferromagnetism
    b. Use orbital diagrams to predict magnetic properties
    c. Describe how a material can be magnetized and demagnetized
    d. Explain how magnets are used in society
2. Predict the chemical properties of an element
    a. Describe the difference between physical and chemical properties
    b. Relate how the chemical properties of an element are determined by the electron configuration of an atom
    c. Predict ionic charges of an element based on electron configurations
    d. Explain the ionic charges of elements based on electron configurations
3. Predict the physical properties of an element
    a. Describe Coulomb's law and how the interactions between subatomic particles influence properties such as atomic radius and ionization energy
    b. Examine how interactions of light with matter produced properties such as color. Why are plants green?

**Assessment:**

1. Formative Assessments
    a. Productivity Rubric
        i. Student Log of activities completed
        ii. Assessed weekly
    b. Daily exit ticket on paper (10 min)
2. Summative Assessments
    a. Exam - Essential Content 1 and 2
    b. Exam - Essential Content 3 and 4
3. Laboratory Reports (3)
    a. Accurate completion of teacher provided laboratory handouts
    b. Well reasoned student extension
4. Posters
    a. Atomic Radii or ionization energy
    b. Created Periodic Table
5. Model Creation and Presentation
    a. Atomic model build and explanation to another lay person

c. Interpret absorption and emission spectra to explain color

4. Explain why the periodic table is organized as it is
    a. Define metals vs non-metals and predict where each would be on the periodic table
    b. Examine the historical measurements and observations that led to modern periodic table arrangement
    c. Predict properties (magnetism, conductivity, reactivity, etc) based on position on periodic table

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

1. Read and complete all interactive unit lessons
2. Build a realistic model of a(n):
3. Create a graph of atomic radii that shows periodicity
    a. Metal or a Non-metal
    b. Atom with strong coulombic force vs atoms with weak coulombic force
4. Design a periodic table that accurately groups elements by chemical and physical properties
5. Write a blog post describing how magnetism works and describing its relevance to a current piece of modern technology.
6. Laboratory: Magnetic or not?
    a. Predict and test different elements for magnetic properties
    b. Attempt to magnetize and demagnetize iron
7. Laboratory: Spectrophotometry
    a. Use spectrophotometer to determine absorption spectrum
    b. Relate absorption spectrum to atomic properties of elements
8. Laboratory: Conductivity
    a. Test conductivity of different metal wires and non-metals and relate to atomic electronic structure and properties
    b. Define units for conductivity

6. Blog Post
    a. Why can't we live without magnets?

**Materials and Resources:**

1. Spectrophotometer and cuvettes
2. Wires (aluminum, copper, iron, ni-chrome)
3. Ohmmeter
4. Power source
5. Magnets
6. Graph paper
7. Poster paper

**Instructional Methods:**

1. Teacher guided student discovery
    a. Students read and work through interactive lessons
    b. Students proactively approach teacher for feedback on lessons
    c. Done independently or in groups of two
2, Laboratory Work
    a. Students conduct investigations using teacher provided instructions
    b. Students plan and conduct an additional experiment modeled after teacher directed experiment
3. Physical Modeling and Presentation
    a. Students build tactile realistic models of atoms of different properties (shielding, effective nuclear charge, metal or non-metal)
    b. Students present their model to another faculty member and explain its significance
4. Blog Posting
    a. Students create a blog post which is to be viewed by the public and provide useful information
    b. Students will cite their work properly scientifically
6. Debate
    a. Students will promote their elemental "candidate" for a position
    b. Students will assess the strength of an argument based on evidence

**Extensions:**

1. Examine the effects of metal length or diameter on conductivity
2. Analyze PES spectra for evidence of periodic trends
3. Examine electron affinity and its periodicity

**Remediation:**

1. Gizmos
    a. Periodic Trends
2. Teacher Videos
    a. Para vs dia magnetism
    b. Effective nuclear charge
    c. Ionization Energy
    d. Spectrophotometry
    e. Using an ohmmeter
    f. Metals vs non-metals and semimetals

| Unit 3: Intra and Intermolecular Interactions | Time: 8 weeks |
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**Academic Standards:**

3.2.9-12.A - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level.

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

1. Describe WHY and HOW atoms form bonds
    a. Explain how valence electrons influence chemical bonding.
    b. Predict whether elements will form ionic or covalent compounds based on their own atomic structure and their neighbors atomic structure.
    c. Describe how atoms achieve stable electron configurations through bonding.
    d. Use electronegativity values to predict bond polarity.
    e. Compare ionic, covalent, and metallic bonding
2. Explain the relationship between bond type and the physical properties of substances.
    a. Compare and contrast the bonding found in ionic, molecular, metallic, and network materials
    b. Distinguish between intra and inter molecular forces and provide

**Assessment:**

1. Formative Assessments
    a. Productivity Rubric
        i. Student Log of activities completed
        ii. Assessed weekly
    b. Daily exit ticket on paper (10 min)
2. Summative Assessments
    a. Exam - Essential Content 1 and 2
    b. Exam - Essential Content 3, 4, and 5
3. Laboratory Reports (3)
    a. Identify me, Evaporation Race, and Solubility Tests
    b. Accurate completion of teacher provided laboratory handouts

examples of each
    c. Determine the number and types of bonds in a chemical compound.
    d. Identify the kind of material based on macroscopic properties
3. Describe the properties of ionic compounds and predict how they will interact with other materials
    a. Predict the effect of charge density on melting point and solubility
    b. Use charges to determine empirical formulas of ionic compounds
    c. Differentiate between monoatomic and polyatomic ions
    d. Define electrolytes and predict which ionic compounds will behave as such
    e. Examine the applications of ionic compounds and their limitations
4. Describe the properties of metallic and network compounds and predict how they will interact with other materials
    a. Explain why metals are conductive and malleable
    b. Distinguish between interstitial and substitutional alloys and identify elements involved in common alloys
    c. Explain why network materials are non-conductive and hard
    d. Provide examples of network materials and their uses
5. Describe the properties of molecular compounds and predict how they will interact with other materials
    a. Construct and interpret Lewis dot structures for atoms, polyatomic ions and molecules.
    b. Predict molecular shape using VSEPR theory.
    c. Distinguish between polar and nonpolar covalent bonds.
    d. Determine whether a molecule is polar or nonpolar based on its geometry and bond polarity.
    e. Explain how intermolecular forces affect boiling point, melting point, solubility, and other physical properties.

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

1. Read and complete all interactive lessons
2. Elemental Dating Game Activity - what kind of relationship "bond" will each pair of atoms form
    c. Well reasoned student extension
4. Dating Game Rubric
    a. Did they find the right "mate" to form the bond requested?
    b. Did they represent themselves correctly as an element
5. Model Creation and Presentation
    a. Ionic vs molecular model rubric
6. Blog Post
    a. Why does NaCl dissolve in water but $CaCO_3$ does not and why seashells stay together and protect the soft molluscs inside

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| 3. Researching Physical Properties - use bonding concepts to explain the properties of common industrial materials<br>4. Use modeling kits to physically create, rotate, and examine the geometry of various molecular compounds<br>5. Design a model of a molecular vs ionic compound using styrofoam balls<br>6. Laboratory: Identify me<br>  a. Students will need to test properties of a material to determine its nature<br>7. Laboratory: Evaporation Race<br>  a. Students will relate the speed at which a material evaporates to the strength of the forces between particles<br>8. Laboratory: Solubility Tests<br>  a. Examine the nature of the bonding by examining its interactions with water<br>  b. Rank the lattice energy of ionic compounds by examining how much they dissociate in solution<br>9. Blog Post - create a post explaining why two ionic compounds (NaCl and $CaCO_3$) behave so differently in the ocean. | |
| **Materials and Resources:**<br>1. Styrofoam balls and paint and glue<br>2. Water, ethanol, methanol, and acetone<br>3. Samples of $CaCO_3$, Silicate sand, metal alloys, and plastic<br>4. Conductivity meters<br>5. Pipettes (micro)<br>6. Modeling kits<br><br>**Instructional Methods:**<br>1. Teacher guided student discovery<br>  a. Students read and work through interactive lessons<br>  b. Students proactively approach teacher for feedback on lessons<br>  c. Done independently or in groups of two<br>2, Laboratory Work | **Extensions:**<br>1. Students create a third model of a metallic crystal showing an interstitial alloy vs pure metal<br>2. Students create an amphipathic material such as soap using fat and NaOH and test it to remove oils<br>3. Students create their own “oil spill” and are challenged to find a way to clean it up.<br><br>**Remediation:**<br>1. Gizmos<br>  a. Ionic Bonds<br>  b. Polar and Intermolecular Forces |

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| a. Students conduct Identify Me, Evaporation Race, and Solubility investigations using teacher provided instructions<br>b. Students plan and conduct an additional experiment modeled after teacher directed experiment<br>3. Physical Modeling and Presentation<br>a. Students build tactile realistic models of an ionic compound and a molecular material as assigned. Students present their model to another faculty member and explain its significance<br>4. Blog Posting<br>a. Students create a blog post as to why one ionic compound (NaCl) dissolves in the sea while another ($CaCO_3$) does not and why both are vital to life in the ocean. The blog is to be viewed by the public and provide useful information<br>b. Students will cite their work properly scientifically<br>5. Student Matching<br>a. Students will create their own dating card and find the match for the bond they wish to form | c. Covalent Bonds<br>2. Teacher Videos<br>a. Drawing lewis structures<br>b. Determining geometry<br>c. Writing formulas<br>d. Examining physical properties<br>e. Alloys<br>f. Diamonds |

| Unit 4: Reactions and Stoichiometry | Time: 8 weeks |
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**Academic 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.G - Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3.2.9-12.O - Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known

3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

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

1. Write and balance chemical equations as model representations of processes
    a. Recognize a process as a physical or chemical change (identify indicators of chemical changes)
    b. Identify the types of forces that are changing in the process (intra or inter)
    c. Maintain proper symbolic representations for states of matter and heat or energy changes.
    d. Complete atom inventories of both reactant and product side
    e. Describe why we balance equations (law of conservation of mass and energy)
    f. Distinguish between principle types of chemical reactions and categorize a reaction properly.
2. Compute correctly the amount of matter present using the mole concept (avogadro's number), molar mass, molar volume.
    a. Explain how avogadro's number was determined
    b. Use dimensional analysis to provide a pathway through calculations

**Assessment:**

1. Formative Assessments
    a. Productivity Rubric
        i. Student Log of activities completed
        ii. Assessed weekly
    b. Daily exit ticket on paper (10 min)
2. Summative Assessments
    a. Exam - Essential Content 1
    b. Exam - Essential Content 2,3
    c. Exam - Essential Content 4
3. Laboratory Reports (3)
    a. Heat of solution, Ice Cream, and Bubbles or more bubbles
    b. Accurate completion of teacher provided laboratory handouts
    c. Well reasoned student extension
4. Modeling activity rubric

c. Incorporate the use of scientific notation and significant figures in their calculations

3. Use mole ratios to predict quantities produced or needed
    a. Apply stoichiometry to real world engineering and manufacturing problems and solutions such as engines, grills, and airbags
    b. Determine the limiting reactant and how demonstrate how the limiting reactant regulates how much product can be made
    c. Calculate the amount of excess reactant remaining
    d. Work with RICE tables to organize calculations
4. Analyze the changes in thermal and potential energy over the course of a reaction or process
    a. Calculate enthalpy of reaction using bond enthalpies and heats of formation
    b. Interpret energy diagrams to determine the relative energies of reactants and product, activation energy, whether the reaction is endothermic or exothermic and energy needed to break bonds vs energy released when they form
    c. Use enthalpy of reaction to determine relative energies of reactants and products

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

1. Read and complete all interactive lessons
2. Model chemical reactions using bonding kits and measuring the time necessary to break vs form bonds
3. Create two computer animations that clearly show the difference between a physical and a chemical process
4. Design and present a poster of three energy diagrams for well-known reactions (combustion of hydrocarbon, electrolysis of water, and thermite) with pictures and accurate quantitative measurements
5. Write a blog post explaining why stoichiometry has saved the world and publish this online.
6. Laboratory: Measure the energy changes during a dissolution reaction
    a. Students will use calorimetry and specific heat to find the energy
    a. Successful synthesis and break down of reactants and products and accurate timing
5. Poster Design and Presentation Rubric
6. Blog Post
    a. Why has stoichiometry saved the world?
7. Computer Animation Rubric
    a. Does the student successfully show a physical process vs a chemical process in a creative and clear way?

change in exothermic and endothermic dissolution reactions

7. Laboratory: Make Ice Cream!
    a. Students will utilize energy changes in processes to cool a mixture of ingredients into ice cream!
8. Laboratory: Bubble or lots of bubbles!
    a. Students will adjust the amount of vinegar and baking soda to determine which is the limiting reactant.

**Materials and Resources:**

1. NaCl and distilled water
2. Calorimeters and thermometers
3. Electronic balances
4. Poster paper
5. Vinegar and baking soda
6. Chromebook animation software/or draw/powerpoint
7. Molecular modeling kits
8. Electrolysis set-up

**Instructional Methods:**

1. Teacher guided student discovery
    a. Students read and work through interactive lessons
    b. Students proactively approach teacher for feedback on lessons
    c. Done independently or in groups of two
2, Laboratory Work
    a. Students conduct Heat of Solution, Ice Cream!, and Bubbles or more bubbles laboratory investigations using teacher provided instructions
    b. Students plan and conduct an additional experiment modeled after teacher directed experiment
3. Physical Modeling and Presentation
    a. Students race vs time to disassemble reactants and reassemble products to analyze the energy and time needed to break bonds vs form them.
4. Blog Posting

**Extensions:**

1. Quantitate the amount of bubbles produced using analytical balance
2. Examine insulation of different calorimeters (vacuum tumbler vs styrofoam) once heat of solution is known
3. Hypothesize WHICH substances would produce highest heat of solution magnitudes and test

**Remediation:**

1. Gizmos
    a. Stoichiometry
    b. Balancing Chemical Reactions
    c. Dehydration Synthesis Reaction

2. Teacher Videos
    a. Precipitation Reactions
    b. Acid/Base Reactions
    c. Redox Reactions
    d. Balancing Reactions
    e. Dimensional Analysis
    f. Mole Ratios
    g. RICE tables
    h. Energy Diagrams

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| a. Students write a researched blog post describing why stoichiometry has saved the world<br>b. Students will cite their work properly scientifically<br>5. Animation Creation<br>a. Students will create rudimentary animations showing bonds breaking and forming during physical and chemical processes.<br>6. Poster Creation and Presentation<br>a. Students will design and present a poster of energy diagrams for common and famous reactions | |

| Unit 5: States of Matter | Time: 4 weeks |
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**Academic Standards:**

3.2.9-12.B - Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles

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

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

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

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

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

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

1. Describe, define, and use Kinetic Molecular Theory (KMT) to explain the differences between the states of matter and transitions between the states
    a. Compare and contrast the three states of matter with regard to potential energy, density, and viscosity
    b. List and explain the various assumptions of KMT
        i. Matter is composed of small particles (atoms/molecules) in constant random motion
        ii. Elastic collisions
        iii. Ideal Gas and solution assumptions
        iv. Particle speed (and thus kinetic energy) increases with temperature
        v. Pressure results from particles colliding with the walls of the container
    c. Name and describe what is occurring during each phase change
        i. Explain the changes in thermal and potential energy during

**Assessment:**

1. Formative Assessments
    a. Productivity Rubric
        i. Student Log of activities completed
        ii. Assessed weekly
    b. Daily exit ticket on paper (10 min)
2. Summative Assessments
    a. Exam - Essential Content 1
    b. Exam - Essential Content 2 and 3
3. Laboratory Reports (4)
    a. Viscosity, Volume and Temperature and absolute zero, Heating Curves, and Elastic Collisions
    b. Accurate completion of teacher provided laboratory handouts
    c. Well reasoned student extension

these changes
    ii. Distinguish between the system and the surroundings
    iii. Explain how sweating cools you off and how an air conditioner works
    iv. Label heating and cooling curves
    v. Identify the states of matter present in a phase diagram
2. Use KMT to explain qualitatively and quantitatively the relationships between the following for a gas:
    a. Volume and Pressure
    b. Volume and Temperature
    c. Volume and moles
    d. Pressure and moles
    e. Velocity and molar mass
    f. Ratio of PV vs nT
3. Define pressure and how it is measured both atmospherically and in a closed container

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

1. Read and complete all interactive lessons
2. Create a study table which contains pictures, particle drawings, relative potential energy, density and viscosity of each state of matter
3. Label heating and cooling curves and phase diagrams
4. Write a blog post explaining how an air conditioner works and all of the phase changes involved!
5. Create a particulate model of each state of matter
6. Laboratory: Measure the flow rates of syrup at cool and warm temperatures and explain difference in flow rates based on KMT
7. Laboratory: Study the effect of temperature on the volume of a balloon by measuring the circumference of the balloon at two different temperatures - the data then being used to extrapolate absolute zero
8. Laboratory: Creating a heating curve. Heat a mixture of ice through melting and then boiling recording temperature vs time.
9. Laboratory: Recreate a macroscopic analogy of elastic collisions using steel

4. Modeling Rubric
    a. Student models accurately depict the states of matter
5. Graphic Design of Study Table for States of matter
6. Blog Post
    a. How does air conditioning work and what phase changes are occurring?
7. Forensic Analysis
    a. Students will demonstrate excellent research, analysis, and argument skills

balls or billiard balls and measuring their speed before and after the collision
10. Forensic Study: Students will use all available data to determine if Tom Brady deliberately underinflated his footballs

**Materials and Resources:**

1. Football and pressure gauge
2. Poster paper
3. Billiard balls or steel balls
4. Styrofoam balls and paint
5. Stop watches and phones
6. Balloons, water baths, and thermometers
7. Syrup and straws

**Instructional Methods:**

1. Teacher guided student discovery
    a. Students read and work through interactive lessons
    b. Students proactively approach teacher for feedback on lessons
    c. Done independently or in groups of two
2, Laboratory Work
    a. Students conduct viscosity, volume and temperature, elastic collision, and heating curve labs
    b. Students plan and conduct an additional experiment modeled after teacher directed experiment
3. Study Graphic Designs
    a. Students organize their states of matter information into a colorful, attractive, informative design for study and presentation.
    b. Present their design to a fellow faculty member
4. Blog Posting
    a. Students write a researched blog post describing how an air conditioner works and all of the phase changes therein.
5. Forensic Analysis
    a. Students will study the SCIENTIFIC particulars of the "deflategate" controversy and analyze the data through their chemistry lens and write a report on their findings

**Extensions:**

1. Analyze viscosity of different types of motor oils and their application to different temperatures and conditions
2. Research how synthetic oil is made
3. Determine observations needed to calculate the ideal gas constant ( R ) and how these measurements can be made in the lab

**Remediation:**

1. Gizmos
    a. Freezing Points
    b. Ideal Gas Law
    c. Phase Changes
2. Teacher Made Videos
    a. Kinetic Molecular Theory
    b. Measuring Pressure and Conversions
    c. States of Matter
    d. Calculating volume from circumference
    e. Calculating gas quantities
    f. Phase Diagrams
    g. Elastic Collisions

| Unit 6: Equilibrium and Kinetics | Time: 4 weeks |
|---|---|

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

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

1. Describe the key factors influencing the RATE of a chemical reaction
    a. Analyze energy diagram to predict reaction rate and effect of a catalyst
    b. Measure the initial reaction rate
    c. Discuss WHY it is important that rates be known and provide several real life examples of where we try to speed reactions up and slow them down
    d. Explain the role of temperature and reactant concentration in rate (collision theory)
    e. Apply knowledge of kinetics to the phenomena of radioactive decay and the age of Earth and radioisotope dating methods in general
2. Define the state of equilibrium and the driving forces for reactions to get there
    a. Explain when equilibrium is reached and why
    b. Interpret concentration vs time graphs in order to:
        i. Determine when a reaction reaches equilibrium
        ii. The degree of favorability of a reaction (ratio of P to R at equilibrium)
    c. Apply equilibrium concepts to real world examples such as:
        i. Dead batteries
        ii. Rusting
    d. Model energy distribution at equilibrium (e.g., potential vs. kinetic, product vs. reactant side)

**Assessment:**

1. Formative Assessments
    a. Exam - Essential Content 1
    b. Exam - Essential Content 2
2. Summative Assessments
    a. Productivity Rubric
        i. Student Log of activities completed
        ii. Assessed weekly
    b. Daily exit ticket on paper (10 min)
3. Laboratory Reports (2)
    a. Zinc and hydrochloric acid rate lab and half-life of pennium lab
    b. Accurate completion of teacher provided laboratory handouts
    c. Well reasoned student extension
4. Class demonstration reflection and data collection
5. Student data collection, interpretation will be assessed
6. Blog Post
    a. How does kinetics save our food? Rubric grade

e. Explain how energy added or removed (e.g., heat) can shift equilibrium but does not change total energy
f. Predict which way a reaction will shift to achieve equilibrium based on changes in reactants, products, volume, or temperature
g. Write equilibrium expressions, calculate equilibrium constants, and deduce the favorability of chemical reactions

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

1. Read and complete all interactive lessons
2. Label energy diagrams
3. Create a blog post discussing the application of kinetics to refrigeration and keeping food for a long time!
4. Build a roller coaster representation of energy diagram with launchers on both sides but unequal energy heights of reactants and products
5. Laboratory: Reacting zinc metal with hydrochloric acid and measuring the rate of reaction. Change the variables of surface area (powder vs chunked zinc) and the concentration of HCl vs time
6. Laboratory: Determining half-life of pennium. Shake pennies to see how many flipped per shake (unit of time). Plot and find the half-life! Predict how many shakes till they are all gone!

**Materials and Resources:**

1. Roller coaster with pin-ball launchers on each side
2. Marbles
3. Pennies (pre and post 1982)
4. Tubs for shaking
5. Zinc - powdered and chunks
6. Hydrochloric acid
7. Energy diagram drawings

**Extensions:**

1. Build a rollercoaster energy diagram with a lower activation energy to simulate a catalyst
2. Modify the rollercoaster apparatus to model the effects of higher temperatures
3. Use RICE Tables to predict quantities at equilibrium
4. Calculate the time it would take for areas like Fukushima and Chernoybl to become habitable
5. Watch “Inside Japan's Nuclear Meltdown”

| Instructional Methods: | Remediation: |
| --- | --- |
| 1. Teacher guided student discovery<br>a. Students read and work through interactive lessons<br>b. Students proactively approach teacher for feedback on lessons<br>c. Done independently or in groups of two<br>2, Laboratory Work<br>a. Students conduct zinc reaction, and pennium half-life labs. Students plan and conduct an additional experiment modeled after teacher directed experiment<br>3. Class Demonstration with student participation<br>a. Students launch marbles over the rollercoaster to see which ones make it and measure how many are on each side after a period of time<br>4. Blog Posting<br>a. Students write a researched blog post describing how kinetics keeps our food fresh! | 1. Gizmos<br>a. Equilibrium and Concentration<br>b. Collision Theory<br>2. Teacher Prepared Videos<br>a. Collision Theory<br>b. Writing equilibrium expressions<br>c. Working with RICE tables and equilibrium<br>d. Half-life calculations<br>e. Energy diagrams and equilibrium<br>f. Concentration vs time plots with regards to rate and equilibrium |