Honors Chemistry

Curriculum/Content Area: Science	**Course Length:** 2 Terms
Course Title: Chemistry/Honors Chemistry	**Date last reviewed:** October 2017
Prerequisites: Biology/Algebra II	**Board approval date:** December 5, 2017
Primary Resource:	

Desired Results

Course description and purpose: In Chemistry Honors students will work to develop skills in scientific calculations and problem-solving techniques. Beyond the general chemistry curriculum, honors students will study quantum theory, thermodynamics, kinetics, acid-base reactions, pH, indicators, titrations, and advanced stoichiometric relations with more sophisticated, multi-step problems. In addition, each unit is explored in greater depth and at a faster pace than the general chemistry course. Tests, quizzes, and lab reports require students to demonstrate strong math skills along with critical, analytical and abstract thought.

Enduring Understandings:	**Essential Questions**:
1. **Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. 2. **Cause and Effect:** Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. 3. **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.	***EQs...*** 1. How can the scientific method be used to investigate questions and how can those findings be communicated? 2. How can matter be characterized and how can physical and chemical changes affect the properties, identities, and interactions of matter? 3. What happens during a chemical reaction at the molecular level and how can chemical reactions be expressed and categorized? 4. How can chemical nomenclature exhibit organizational patterns? 5. How can an element's position on the periodic table explain most chemical behavior?

4. **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. 5. **Energy and Matter:** Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior. 6. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. 7. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.	6. How can matter be quantified? 7. How can energy be transferred in systems? 8. How does the structure of an atom or compound determine its properties? 9. How does such a small number of elements produce a wide range of compounds? 10. How do the Law of Conservation of Mass and chemical equations explain the interactions of atoms and molecules both conceptually and mathematically?

Atomic Theory
Topics of Study: 1. Quantum mechanical model of atom vs. previous atomic models 2. Subatomic Particles 3. Atoms, Ions, and Isotopes 4. Electron Configurations 5. Electromagnetic Radiation and Energy, Wavelength, and Frequency 6. Wave-Particle Duality
Standards:
<u>Cross-Cutting Concepts:</u> 1. **Patterns -** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. 2. **Structure and Function -** The way an object is shaped or structured determines many of its properties and functions. 3. **Cause and Effect -** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about

smaller scale mechanisms within the system.

4. **Systems and System Models -** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Science and Engineering Practices:

1. **Developing and Using Models -** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
   a. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8)
2. **Using Mathematical and Computational Thinking -** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
   a. Use mathematical representations of phenomena to support claims. (HS-PS1-7)
3. **Engaging in Argument from Evidence -** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.
   a. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)
4. **Obtaining, Evaluating, and Communicating Information -** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.
   a. Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Disciplinary Core Ideas:

1. **PS1.A: Structure and Properties of Matter**
   a. Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
   b.
   c. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
2. **PS2.B: Types of Interactions**
   a. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact

forces between material objects.

3. **PS4.A: Wave Properties**
    a. The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.
4. **PS4.B: Electromagnetic Radiation**
    a. Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
    b. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.
    c. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

Learning Targets:

1. I can, from the quantum mechanical model, identify and describe elements and their arrangement in the periodic table. (HS-PS-1.1) (PS1.A, Developing and Using Models, System and System Models)
2. I can, from the quantum mechanical model, describe the structure of an atom/ion/isotope in terms protons, neutrons, and electrons. (HS-PS-1.1) (PS1.A, Developing and Using Models, System and System Models, Using Mathematics and Computational Thinking)
3. I can determine the number of valence electrons for an atom or ion using electron configuration. (HS-PS-1.1) (PS1.A, Developing and Using Models, System and System Models, Using Mathematics and Computational Thinking)
4. I can describe the electromagnetic spectrum in terms of wavelength, frequency, and energy and explain the mathematical relationship between speed, wavelength, energy,and frequency of electromagnetic radiation. (HS-PS4-1) (PS4.A, Cause and Effect, Using Mathematical and Computational Thinking)
5. I can describe how electromagnetic radiation behaves as both a wave and a particle. (HS-PS4-3) (PS4.B, System and System Models, Engaging in Argument from Evidence)
6. I can use wave-particle duality to describe the photoelectric effect and the nature of light and their relationship to the quantum mechanical model of the atom. (HS-PS4-3) (PS4.B, System and System Models, Engaging in Argument from Evidence)

Assessment Evidence:

Performance Assessment Options *May include, but are not limited to the following:*	**Other assessment options**

1. HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*] 2. HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [*Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.*] 3. HS-PS4-3. 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. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [*Assessment Boundary: Assessment does not include using quantum theory.*]	*May include, but are not limited to the following:*
Digital Tools & Supplementary Resources:	

Periodicity
Topics of Study: 1. Arrangement of periodic table 2. Trends in atomic radius,ionic radius, ionization energy, electronegativity and *electron affinity
Standards:
<u>Cross-Cutting Concepts:</u> 1. **Patterns -** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. 2. **Structure and Function -** The way an object is shaped or structured determines many of

its properties and functions.

Science and Engineering Practices:

1. **Developing and Using Models -** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
   a. Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

Disciplinary Core Ideas:

1. **PS1.A: Structure and Properties of Matter**
   a. Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
   b. 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.

Learning Targets:

1. I can identify and describe the relationships between main group elements and patterns of valence electrons and reactivity. (HS-PS-1.1) (PS1.A, Developing and Using Models, Patterns, Structure and Function)
2. I can use the periodic table to predict the patterns of behavior of the elements (atomic and ionic radii, ionization energy, *successive ionization energies, and electronegativity) based on the interactions between subatomic particles. (HS-PS-1.1) (PS1.A, Developing and Using Models, Patterns, Structure and Function)

Assessment Evidence:

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

Digital Tools & Supplementary Resources:

Chemical Bonding
Major Topics: 1. Types of chemical bonds 2. Chemical names/formulas 3. Lewis dot structures 4. VSEPR Theory 5. Molecular polarity 6. Miscibility 7. Intermolecular forces
Standards:

<u>Cross-Cutting Concepts:</u>
1. **Patterns -** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1)
2. **Structure and Function -** The way an object is shaped or structured determines many of its properties and functions.
3. **Cause and Effect -** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
 	
<u>Science and Engineering Practices:</u>
1. **Developing and Using Models -** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
    a. Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
 	
<u>Disciplinary Core Ideas:</u>
1. **PS1.A: Structure and Properties of Matter**
    a. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
    b. 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.

Learning Targets:
1. I can predict the number and types of bonds (ionic or covalent) formed between elements. 2. I can model the structure and arrangement of a molecule using valence electrons, electronegativity, and VSEPR theory. 3. I can describe how the patterns of interactions (hydrogen bonding, dipole-dipole

forces, dispersion forces) between particles at the molecular level are reflected in the patterns of behavior at the macroscopic level.

4. I can write the name and chemical formula for the compounds formed after chemical bonding.

Assessment Evidence:	
Performance Assessment Options *May include, but are not limited to the following:* **HS-PS1-1.** Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*] **HS-PS1-2.** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [*Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.*] **HS-PS1-3.** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [*Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.*]	**Other assessment options** *May include, but are not limited to the following:*
Digital Tools & Supplementary Resources:	

Chemical Reactions
Major Topics: 1. Characteristics and indicators of chemical reactions and corresponding equations

2. Rearrangement of atoms (breaking and forming bonds)
3. Endothermic and exothermic properties of reactions
4. Law of Conservation of Mass and Balancing equations
5. Classifying reactions
6. Predicting products: Activity Series of Metals, Solubility Rules

Standards:

Cross-Cutting Concepts:

1. **Patterns -** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1)
2. **Structure and Function -** The way an object is shaped or structured determines many of its properties and functions.
3. **Cause and Effect -** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
4. **Stability and Change -** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.
5. **Energy Flow -** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems possibilities and limitations.
6. **Systems and System Models -** Defining the system under study -- specifying its boundaries and making explicit a model of that system -- provides tools for understand and testing ideas that are applicable throughout science and engineering

Science and Engineering Practices:

1. **Developing and Using Models -** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
   - Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
2. **Constructing Explanations and Designing Solutions -** Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories.
   - Apply scientific principles and evidence to provide and explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Disciplinary Core Ideas:

1. **PS1.B: Chemical Reactions**
   a. 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 rearrangement 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.

b. 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

Learning Targets:

1. I can determine when a chemical reaction has occurred.
2. I can identify the reactants and products in a chemical reaction and in a chemical equation.
3. I can describe chemical changes in terms of bonds breaking and forming.
4. I can describe endothermic and exothermic reactions in terms of absorption or release of energy.
5. I can write a balanced chemical equations using correct chemical formulas and coefficients and explain how the law of conservation of mass relates to balanced chemical equations.
6. I can classify a reaction as one of the five types of chemical reactions and predict the products of each of the five types of reactions using the appropriate resources that apply to each type.
7. I can predict whether a single or double replacement reaction will occur, and write molecular, ionic, and net ionic equations for the reactions.

Assessment Evidence:

Performance Assessment Options *May include, but are not limited to the following:* 1. **HS-PS1-2**. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [*Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.*] 2. **HS-PS1-4**. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [*Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.*] 3. **HS-PS1-7**. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical	**Other assessment options** *May include, but are not limited to the following:*

reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [*Assessment Boundary: Assessment does not include complex chemical reactions.*]	
Digital Tools & Supplementary Resources:	

The Mole and Stoichiometry

Major Topics:

1. The mole
2. Molar mass and mole/mass conversions
3. Percent composition by mass
4. Empirical and molecular formulas
5. Stoichiometry: mole ratio
6. Actual, theoretical, and percent yield
7. Limiting/excess reactants

Standards:

Cross-Cutting Concepts:

1. **Energy and Matter -** The total amount of energy and matter in closed systems is conserved.

Science and Engineering Practices:

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

Disciplinary Core Ideas:

1. **PS1.B: Chemical Reactions**
   - **i.** 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

Learning Targets:	
1. I can explain the concept of the mole, relate it to Avogadro's number, and use it to determine the molar mass of an element or a compound given its chemical formula. 2. I can relate molar mass, mass, and the mole to solve mathematical problems involving elements and compounds (empirical formulas, molecular formulas, percent composition by mass, etc.). 3. I can differentiate between an empirical formula and a molecular formula and explain how they apply to ionic and molecular (covalent) compounds. 4. I can calculate quantities of reactants and products of a chemical reaction in terms of moles, mass, molarity of solutions, or gas volume. 5. I can use stoichiometric calculations to show that the number of atoms, and therefore mass, are conserved during a chemical reaction.	
Assessment Evidence:	
Performance Assessment Options *May include, but are not limited to the following:* HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [*Assessment Boundary: Assessment does not include complex chemical reactions.*]	**Other assessment options** *May include, but are not limited to the following:*
Digital Tools & Supplementary Resources:	

Gas Relationships
Major Topics: 1. Kinetic Molecular Theory 2. Properties/behaviors of gases 3. Pressure with units 4. Pressure vs. particle collisions 5. Gas variable relationships (Gas Laws)

Standards:

<u>**Cross Cutting Concepts:**</u>
1. **Patterns -** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
2. **Cause and Effect -** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
3. **Stability and Change -** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.
4. **Energy Flow -** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems possibilities and limitations.
5. **Systems and System Models -** Defining the system under study -- specifying its boundaries and making explicit a model of that system -- provides tools for understand and testing ideas that are applicable throughout science and engineering
 	
<u>**Science and Engineering Practices:**</u>
1. **Developing and Using Models -** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
    ○ Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (
2. **Using Mathematical and Computational Thinking -** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
    ○ Use mathematical representations of phenomena to support claims.
3. **Engaging in Argument from Evidence -** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.
    ○ Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ()
4. **Obtaining, Evaluating, and Communicating Information -** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.
    ○ Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).
 	
<u>**Advanced Placement Chemistry Big Ideas:**</u> (AP Curriculum)
1. **Big Idea #2 -** Chemical and physical properties of materials can be explained by the

structure and arrangement of atoms, ions, or molecules and the forces between them.

a. Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces between them. (AP Chemistry Enduring Understanding 2A)
    i. The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures. (AP Essential Knowledge 2A.1)
    ii. The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures. (AP Essential Knowledge 2A.2)
b. Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance including how the observable physical state changes with temperature. (AP Chemistry Enduring Understanding 2B
    i. London dispersion forces are attractive forces present between all atoms and molecules. London dispersion forces are often the strongest net intermolecular force between large molecules. (AP Essential Knowledge 2B.1)
    ii. Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force that exists when very electronegative atoms (N, O, and F) are involved. (AP Essential Knowledge 2B.2)

Learning Targets:

1. Based on the Kinetic Molecular Theory, list properties of gases and describe their behavior.
2. Explain how pressure is measured and know units of pressure and their practical applications.
3. Explain the relationship between gas pressure and particle collisions.
4. Explain the relationship between pairs of gas variables: volume and pressure; pressure and temperature; pressure and number of particles; and volume and temperature; and predict and/or calculate the change to one variable when the other variable is changed.
5. Convert between the Celsius and Kelvin temperature scales and explain the importance of the Kelvin temperature scale.

Assessment Evidence:

Performance Assessment Options *May include, but are not limited to the following:*	**Other assessment options** *May include, but are not limited to the following:*

Digital Tools & Supplementary Resources:	

Solutions
Major Topics: 1. Properties of solutions 2. Saturated, unsaturated, supersaturated solutions 3. Solution formation 4. Rates of dissolving 5. Solubility 6. Molarity (concept and calculations)
Standards:
<u>**Cross Cutting Concepts:**</u> 1. **Scale, Proportion, and Quantity -** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. 2. **Systems and System Model -** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. 3. **Structure and Function -** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions <u>**Science and Engineering Practices:**</u> 1. **Using Mathematical and Computational Thinking -** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.   a. Use mathematical representations of phenomena to support claims. 2. **Engaging in Argument from Evidence -** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.

    a. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
3. **Obtaining, Evaluating, and Communicating Information -** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.
    a. Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).
4. **Constructing Explanations and Designing Solutions -** Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories.
    a. Apply scientific principles and evidence to provide and explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Advanced Placement Chemistry Big Ideas: (AP Curriculum)

1. **Big Idea #2 -** Chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions, or molecules and the forces between them.
    a. Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces between them. (AP Chemistry Enduring Understanding 2A)
        b. The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures. (AP Essential Knowledge 2A.1)
        c. Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of solute and the strengths of all interactions among the particles of the solutes and solvent. (AP Essential Knowledge 2.A.3)
    d. Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance including how the observable physical state changes with temperature. (AP Chemistry Enduring Understanding 2B
        i. Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force that exists when very electronegative atoms (N, O, and F) are involved. (AP Essential Knowledge 2B.2)
        ii. Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions (AP Essential Knowledge 2.B.3)

2. **Big Idea #6 -** Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.
    a. Chemical equilibrium plays an important role in acid base chemistry and in solubility. (AP Chemistry Enduring Understanding 6C)
        i. The solubility of a substance can be understood in terms of chemical equilibrium ((AP Essential Knowledge 6.C.3)

Learning Targets:

1. I can describe the properties of solutions.
2. I can distinguish between saturated, unsaturated, and supersaturated solutions.
3. I can describe the process of solution formation, and explain what causes the process to be exothermic or endothermic.
4. I can explain how the freezing point and boiling points of solvents are affected by adding solutes to make solutions.
5. I can identify and determine how three factors affect the rate at which a solid solute dissolves in a liquid solvent.
6. I can compare the effects of temperature and pressure on solubility.
7. I can define molarity and calculate the molarity of a solution, including after dilution.

Assessment Evidence:

Performance Assessment Options *May include, but are not limited to the following:*	**Other assessment options** *May include, but are not limited to the following:*

Digital Tools & Supplementary Resources:

Acids and Bases

Major Topics:

1. Properties, definitions
2. The nature of proton transfer reactions
3. Conjugate acid-base pairs
4. Names and formulas
5. Strong vs. weak acids
6. pH scale
7. Indicators
8. Auto-ionization of water

9. pH/pOH calculations
10. Neutralization reactions
11. Titrations
12. Titration calculations

Standards:

Cross Cutting Concepts:

1. **Patterns -** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
2. **Cause and Effect -** Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
3. **Scale, Proportion, and Quantity -** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
4. **Systems and System Models -** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
5. **Structure and Function -** The way an object is shaped or structured determines many of its properties and functions.
6. **Stability and Change -** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

Science and Engineering Practices:

1. **Developing and Using Models -** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
   - Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
2. **Using Mathematical and Computational Thinking -** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
   - Use mathematical representations of phenomena to support claims.
3. **Engaging in Argument from Evidence -** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.
   - Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
4. **Obtaining, Evaluating, and Communicating Information -** Obtaining, evaluating,

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

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

5. **Constructing Explanations and Designing Solutions -**Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories.
   - Apply scientific principles and evidence to provide and explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Advanced Placement Chemistry Big Ideas: (AP Curriculum)

1. **Big Idea #2 -** Chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions, or molecules and the forces between them.
   a. Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces between them. (AP Chemistry Enduring Understanding 2A)
      b. The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures. (AP Essential Knowledge 2A.1)
      c. Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of solute and the strengths of all interactions among the particles of the solutes and solvent. (AP Essential Knowledge 2.A.3)
   d. Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance including how the observable physical state changes with temperature. (AP Chemistry Enduring Understanding 2B)
      i. Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force that exists when very electronegative atoms (N, O, and F) are involved. (AP Essential Knowledge 2B.2)
      ii. Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions (AP Essential Knowledge 2.B.3)
2. **Big Idea #3 -** Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
   a. Chemical reactions can be classified by considering what the reactants are,

what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions. (AP Chemistry Enduring Understanding 3B)

i. In a neutralization reaction, protons are transferred from an acid to a base. (AP Essential Knowledge 3.B.2)

3. **Big Idea #6 -** Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.
   a. Chemical equilibrium plays an important role in acid base chemistry and in solubility. (AP Chemistry Enduring Understanding 6C)
      i. The solubility of a substance can be understood in terms of chemical equilibrium ((AP Essential Knowledge 6.C.3)

Learning Targets:

1. List and describe five general properties of aqueous solutions of acids and bases.
2. Use the Arrhenius and Bronsted-Lowry definitions to build a model of an acid base reaction.
3. Revise the model of an acid base reaction to include the concept of conjugate acid-base pairs.
4. Determine the chemical formula of an acid given its name and name an acid given its chemical formula.
5. Explain the difference between strong and weak acids and bases and give common examples of each.
6. Explain and use the pH scale and how acid-base indicators are used.
7. Explain the self- (auto-) ionization of water.
8. Define and calculate pOH or $[OH^-]$ and pH or $[H_3O^+]$.
9. Explain the process of neutralization, and write chemical equations to describe acid-base neutralization reactions.
10. Explain how to carry out an acid-base titration and calculate the molarity of an unknown acid or base solution using titration data.

Assessment Evidence:

Performance Assessment Options *May include, but are not limited to the following:*	**Other assessment options** *May include, but are not limited to the following:*

Digital Tools & Supplementary Resources: