Chemistry

Science Curriculum Framework

Revised 2005

Course Title: Chemistry
Course/Unit Credit: 1
Course Number: 421000
Teacher Licensure: Please refer to the Course Code Management System (https://adedata.arkansas.gov/ccms/) for the most current licensure codes.
Grades: 9-12

Chemistry

Chemistry should explore the composition of matter through its properties, its atomic structure, and the manner in which it bonds and reacts with other substances. Students should be expected to use suitable mathematics and collect and analyze data. Instruction and assessment should include both appropriate technology and the safe use of laboratory equipment. Students should be engaged in hands-on laboratory experiences at least 20% of the instructional time.

Strand	Standard
Atomic Theory	
	1. Students shall understand the historical development of the *model* of the *atom.*
	2. Student shall understand the structure of the *atom.*
	3. Students shall understand how the arrangement of electrons in *atoms* relates to the *quantum model.*
Periodicity	
	4. Students shall understand the significance of the Periodic Table and its historical development.
	5. Students shall name and write formulas for *binary* and *ternary compounds.*
	6. Students shall explain the changes of *matter* using its *physical* and *chemical properties.*
	7. Students shall use atomic mass or experimental data to calculate relationships among *elements* and *compounds.*
Bonding	
	8. Students shall understand the process of *ionic bonding*.
	9. Students shall understand the process of *covalent bonding.*
	10. Students shall understand the process of metallic bonding.
	11. Students shall relate the *physical properties* as they relate to different types of bonding.
Stoichiometry	
	12. Students shall understand the relationship between balanced *chemical equations* and *mole* relationships.
	13. Students shall understand the *mole* concept and *Avogadro's number.*
	14. Students shall predict the *product(s)* based upon the type of *chemical reaction*.
	15. Students shall understand the composition of *solutions*, their formation and their strengths expressed in various units.
Gas Laws	
	16. Students shall understand the behavior of *gas* particles as it relates to the *kinetic theory.*
	17. Students shall understand the relationship among *temperature*, pressure, volume and *moles* of *gas.*
	18. Students shall apply the *stoichiometric mass* and volume relationships of *gases* in *chemical reactions*.

Strand	Standard
Acids and Bases	
	19. Students shall understand the historical development of the acid/base theories.
	20. Students shall apply rules of nomenclature to *acids, bases* and *salts.*
	21. Students shall understand the general properties of *acids, bases* and *salts.*
	22. Students shall demonstrate an understanding of *titration* as a laboratory tool.
Kinetics and Energistics	
	23. Students shall understand *enthalpy, entropy*, and *free energy* and their relationship to *chemical reactions.*
Equilibrium	
	24. Students shall apply rules of nomenclature to acids, bases, and salts.
Oxidation-Reduction Reactions	
	25. Students shall understand *oxidation-reduction* reactions to develop skills in balancing redox equations.
	26. Students shall explain the role of *oxidation-reduction* reactions in the production of electricity in a voltaic cell.
Organic Chemistry	
	27. Students shall differentiate between *aliphatic, cyclic,* and *aromatic hydrocarbons*.
	28. Students shall know and describe the functional groups in organic chemistry.
	29. Students shall demonstrate an understanding of the role of *organic compounds* in living and non-living systems.
Nuclear Chemistry	
	30. Students shall understand the process transformations of *nuclear radiation.*
	31. Students shall understand the current and historical ramifications of nuclear energy.
Nature of Science	
	32. Students shall demonstrate an understanding that science is a way of knowing.
	33. Students shall design and safely conduct a scientific inquiry.
	34. Students shall demonstrate an understanding of current theories in chemistry.
	35. Students shall use mathematics, science equipment, and technology as tools to communicate and solve problems in chemistry.
	36. Students shall describe the connections between pure and applied science.
	37. Students shall describe various careers in chemistry and the training required for the selected career.

Strand: Atomic Theory

Standard 1: Students shall understand the historical development of the *model* of the *atom.*

AT.1.C.1	Summarize the discoveries of the *subatomic particles* • Rutherford's gold foil • Chadwick's discovery of the neutron • Thomson's cathode ray • Millikan's Oil Drop
AT.1.C.2	Explain the historical events that led to the development of the current *atomic theory*

Key: AT.1.C.1 = Atomic Theory. Standard 1. Chemistry. 1st Student Learning Expectation

Strand: Atomic Theory

Standard 2: Students shall understand the structure of the *atom.*

AT.2.C.1	Analyze an atom's particle position, arrangement, and charge using: • proton • neutron • electron
AT.2.C.2	Compare the magnitude and range of *nuclear forces* to magnetic forces and gravitational forces
AT.2.C.3	Draw and explain nuclear symbols and hyphen notations for *isotopes:* • nuclear symbol: ${}^{A}_{Z}X$ Where Hyphen notation: $X - A$ Where X = element symbol; A = the mass number; Z = atomic number; the number of neutrons = $A - Z$
AT.2.C.4	Derive an *average atomic mass*
AT.2.C.5	Determine the arrangement of *subatomic particles* in the *ion(s)* of an *atom*

Key: AT.2.C.1 = Atomic Theory. Standard 2. Chemistry. 1st Student Learning Expectation

Strand: Atomic Theory

Standard 3: Students shall understand how the arrangement of electrons in *atoms* relates to the *quantum model.*

AT.3.C.1	Correlate emissions of visible light with the arrangement of electrons in *atoms:* • quantum • $c = v\lambda$ Where $v = frequency$; $\lambda = wavelength$
AT.3.C.2	Apply the following rules or principles to model electron arrangement in *atoms*: • *Aufbau Principle* (diagonal filling order) • *Hund's Rule* • *Pauli's Exclusion Principle*
AT.3.C.3	Predict the placement of *elements* on the Periodic Table and their properties using electron configuration
AT.3.C.4	Demonstrate electron placement in *atoms* using the following notations: • *orbital notations* • *electron configuration notation* • *Lewis electron dot structures*

Key: AT.3.C.1 = Atomic Theory. Standard 3. Chemistry. 1st Student Learning Expectation

Strand: Periodicity

Standard 4: Students shall understand the significance of the Periodic Table and its historical development.

P.4.C.1	Compare and contrast the historical events leading to the evolution of the Periodic Table
P.4.C.2	Describe the arrangement of the Periodic Table based on electron filling orders: • Groups • Periods
P.4.C.3	Interpret periodic trends: • *atomic radius* • *ionic radius* • *ionization energy* • *electron affinities* • *electronegativities*

Key: P.4.C.1 = Periodicity. Standard 4. Chemistry. 1st Student Learning Expectation

Strand: Periodicity

Standard 5: Students shall name and write formulas for *binary* and *ternary compounds.*

P.5.C.1	Write formulas for *binary* and *ternary compounds:* • *IUPAC* system • Greek prefixes • polyatomic *ions*
P.5.C.2	Name *binary* and *ternary compounds*
P.5.C.3	Predict the name and symbol for newly discovered *elements* using the *IUPAC* system

Key: P.5.C.1 = Periodicity. Standard 5.Chemistry. 1st Student Learning Expectation

Strand: Periodicity

Standard 6: Students shall explain the changes of *matter* using *physical properties* and *chemical properties.*

P.6.C.1	Compare and contrast *matter* based on uniformity of particles: • pure substances • *solutions* • heterogeneous mixtures
P.6.C.2	Distinguish between *extensive* and *intensive physical properties* of *matter*
P.6.C.3	Separate homogeneous mixtures using physical processes: • *chromatography*
P.6.C.4	Design experiments tracing the *energy* involved in *physical changes* and *chemical changes*
P.6.C.5	Predict the *chemical properties* of substances based on their electron configuration: • active • inactive • inert

Key: P.6.C.1 = Periodicity. Standard 6. Chemistry. 1st Student Learning Expectation

Strand: Periodicity

Standard 7: Students shall use atomic mass or experimental data to calculate relationships between *elements* and *compounds.*

P.7.C.1	Demonstrate an understanding of the *Law of Multiple Proportions*

Key: P.7.C.1 = Periodicity. Standard 7. Chemistry. 1st Student Learning Expectation

Strand: Bonding

Standard 8: Students shall understand the process of *ionic bonding.*

B.8.C.1	Determine *ion* formation tendencies for groups on the Periodic Table: • *main group elements* • *transition elements*
B.8.C.2	Derive *formula units* based on the charges of *ions*
B.8.C.3	Use the *electronegativitiy* chart to predict the *bonding* type of *compounds:* • *ionic* • *polar covalent* • *non-polar covalent*

Key: B.8.C.1 = Bonding. Standard 8. Chemistry. 1st Student Learning Expectation

Strand: Bonding

Standard 9: Students shall understand the process of *covalent bonding.*

B.9.C.1	Draw *Lewis structures* to show *valence electrons* for *covalent bonding*: • lone pairs • shared pairs • hybridization • resonance
B.9.C.2	Determine the properties of covalent *compounds* based upon double and triple bonding
B.9.C.3	Predict the polarity and geometry of a molecule based upon shared electron pairs and lone electron pairs: • *VSEPR Model*
B.9.C.4	Identify the strengths and effects of intermolecular forces (van der Waals): • *hydrogen bonding* • *dipole-dipole* • *dipole-induced dipole* • *dispersion forces* (London)

Key: B.9.C.1 = Bonding. Standard 9. Chemistry. 1st Student Learning Expectation

Strand: Bonding

Standard 10: Students shall understand the process of metallic bonding.

B.10.C.1	Explain the properties of metals due to delocalized electrons: • *molecular orbital model*

Strand: Bonding

Standard 11: Students shall relate the *physical properties* of *solids* to different types of bonding.

B.11.C.1	Distinguish between *amorphous* and *crystalline solids*
B.11.C.2	Compare and contrast the properties of *crystalline solids:* • ionic • covalent network • covalent molecular • metallic

Key: B.11.C.1 = Bonding. Standard 11. Chemistry. 1st Student Learning Expectation

Strand: Stoichiometry

Standard 12: Students shall understand the relationships between balanced *chemical equations* and *mole* relationships.

S.12.C.1	Balance *chemical equations* when all *reactants* and *products* are given
S.12.C.2	Use balanced reaction equations to obtain information about the amounts of *reactants* and *products*
S.12.C.3	Distinguish between *limiting reactants* and *excess reactants* in balanced reaction equations
S.12.C.4	Calculate *stoichiometric* quantities and use these to determine theoretical yields

Key: S.12.C.1 = Stoichiometry. Standard 12. Chemistry. 1st Student Learning Expectation

Strand: Stoichiometry

Standard 13: Students shall understand the *mole* concept and *Avogadro's number.*

S.13.C.1	Apply the *mole* concept to calculate the number of particles and the amount of substance: Avogadro's constant = 6.02×10^{23}
S.13.C.2	Determine the *empirical* and *molecular formulas* using the molar concept: • *molar mass* • *average atomic mass* • *molecular mass* • formula mass

Key: S.13.C.1 = Stoichiometry. Standard 13. Chemistry. 1st Student Learning Expectation

Strand: Stoichiometry

Standard 14: Students shall predict *products* based upon the type of chemical reaction.

S.14.C.1	Given the *reactants* predict *products* for the following types of *reactions:* • *synthesis* • *decomposition* • *single displacement* • *double displacement* • *combustion*

Key: S.14.C.1 = Stoichiometry. Standard 14. Chemistry. 1st Student Learning Expectation

Strand: Stoichiometry

Standard 15: Students shall understand the composition of *solutions*, their formation, and their strengths expressed in various units.

S.15.C.1	Distinguish between the terms *solute, solvent, solution* and *concentration*
S.15.C.2	Give examples for the nine *solvent-solute* pairs
S.15.C.3	Calculate the following concentration expressions involving the amount of *solute* and volume of solution: • *molarity* (M) • *molality (m)* • *percent composition* • *normality* (N)
S.15.C.4	Given the quantity of a *solution*, determine the quantity of another species in the reaction
S.15.C.5	Define *heat of solution*
S.15.C.6	Identify the physical state for each substance in a reaction equation

Key: S.15.C.1 = Stoichiometry. Standard 15. Chemistry. 1st Student Learning Expectation

Strand: Gas Laws

Standard 16: Student shall understand the behavior of *gas* particles as it relates to the *kinetic theory.*

GL.16.C.1	Demonstrate the relationship of the *kinetic theory* as it applies to *gas* particles: • *molecular motion* • *elastic collisions* • *temperature* • pressure • ideal gas
GL.16.C.2	Calculate the effects of *pressure, temperature,* and volume on the number of *moles* of *gas* particles in *chemical reactions*

Key: GL.16.C.1 = Gas Laws. Standard 16. Chemistry. 1st Student Learning Expectation

Strand: Gas Laws

Standard 17: Students shall understand the relationships between *temperature*, *pressure*, volume, and *moles* of a *gas.*

GL.17.C.1	Calculate the effects of *pressure, temperature,* and volume to *gases*

Gas Law	Formula
Avogadro's Law	$V_2 = V_1 \frac{n_2}{n_1}$
Boyle's Law	$P_1V_1 = P_2V_2$
Charles' Law	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
Combined Law	$\frac{P_1V_1}{T_2} = \frac{P_2V_2}{T_1}$
Dalton's Law of Partial Pressure	$P_{Total} = P_1 + P_2 + P_3 ...$
Graham's Law of Effusion	$\frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}}$
Guy-Lussac	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$
Ideal Gas Law	$PV = nRT$

Key: GL.17.C.1 = Gas Laws. Standard 17. Chemistry. 1st Student Learning Expectation

Strand: Gas Laws

Standard 18: Student shall apply the *stoichiometric mass* and volume relationships of *gases* in *chemical reactions.*

GL.18.C.1	Calculate volume/*mass* relationships in balanced *chemical reaction equations*

Key: GL.18.C.1 = Gas Laws. Standard 18. Chemistry. 1st Student Learning Expectation

Strand: Acids and Bases

Standard 19: Students shall understand the historical development of the acid/base theories.

AB.19.C.1	Compare and contrast the following acid/base theories: • Arrhenius Theory • Bronsted-Lowry Theory • Lewis Theory

Key: AB.19.C.1 = Acids and Bases. Standard 19. Chemistry. 1st Student Learning Expectation

Strand: Acids and Bases

Standard 20: Students shall demonstrate proficiency in *acid, base,* and *salt nomenclature.*

AB.20.C.1	Name and write formulas for *acids*, *bases* and *salts:* • *binary acids* • *ternary acids* • *ionic compounds*

Key: AB.20.C.1 = Acids and Bases. Standard 20. Chemistry. 1st Student Learning Expectation

Strand: Acids and Bases

Standard 21: Students shall apply rules of nomenclature to acids, bases, and salts.

AB.21.C.1	Compare and contrast *acid* and *base* properties
AB.21.C.2	Describe the role that dissociation plays in the determination of strong and weak *acids* or *bases*
	Use acid-base equilibrium constants to develop and explain: • *ionization constants* • percent of ionization • *common ion effect*
AB.21.C.3	Explain the role of the *pH* scale as applied to *acids* and *bases*

Key: AB.21.C.1 = Acids and Bases. Standard 21. Chemistry. 1st Student Learning Expectation

Strand: Acids and Bases

Standard 22: Students shall demonstrate an understanding of *titration as a* laboratory tool.

AB.22.C.1	Perform a *titration* to solve for the *concentration* of an *acid* or *base*
AB.22.C.2	Use *indicators* in *neutralization* reactions
AB.22.C.3	Investigate the role of *buffers*

Key: AB.22.C.1 = Acids and Bases. Standard 22. Chemistry. 1st Student Learning Expectation

Strand: Kinetics and Energetics

Standard 23: Students shall understand *enthalpy, entropy,* and *free energy* and their relationship to *chemical reactions.*

KE.23.C.1	Define *enthalpy* and *entropy* and explain the relationship to exothermic and endothermic reactions: • $\Delta H < U$ = *exothermic reaction* • $\Delta H > U$ = *endothermic reaction*
KE.23.C.2	Define *free energy* in terms of *enthalpy* and *entropy:* • $\Delta G = \Delta H - T\Delta S$ • $\Delta G < 0$ = spontaneous reaction • $\Delta S > 0$ = increase in disorder • $\Delta S < 0$ = decrease in disorder
KE.23.C.3	Calculate *entropy, enthalpy,* and *free energy* changes in *chemical reactions*: • $\Delta H^{\circ}_{(rxn)} = \Delta H^{\circ}_{f(products)} - \Delta H^{\circ}_{f(reactants)}$ • $\Delta G^{\circ}_{(rxn)} = \Delta G^{\circ}_{f(products)} - \Delta G^{\circ}_{f(reactants)}$ • $\Delta S^{\circ}_{(rxn)} = \Delta S^{\circ}_{(products)} - \Delta S^{\circ}_{(reactants)}$
KE.23.C.4	Define specific heat capacity and its relationship to calorimetric measurements: $q = m(\Delta T)C_p$
KE.23.C.5	Determine the *heat* of formation and the *heat* of reaction using *enthalpy* values and the Law of Conservation of Energy
KE.23.C.6	Explain the role of *activation energy* and collision theory in *chemical reactions*

Key: KE.23.C.1 = Kinetics and Energetics. Standard 23. Chemistry. 1st Student Learning Expectation

Strand: Equilibrium

Standard 24: Students shall understand the factors that affect *reaction rate* and their relationship to quantitative chemical equilibrium.

E.24.C.1	List and explain the factors which affect the rate of a reaction and the relationship of these factors to chemical equilibrium: • *reversible reactions* • reaction rate • nature of *reactants* • *concentration* • *temperature* • catalysis
E.24.C.2	Solve problems developing an equilibrium constant or the *concentration* of a reactant or *product:* • $mA + nB \rightarrow sP + rQ$ mA + nB → sP + rQ • $K_{eq} = \frac{[P]^s[Q]^r}{[A]^m[B]^n}$
E.24.C.3	Explain the relationship of *LeChatelier's Principle* to equilibrium systems: • *temperature* • pressure • *concentration*
E.24.C.4	Describe the application of equilibrium and kinetic concepts to the Haber Process: • high *concentration* of hydrogen and nitrogen • removal of ammonia • precise *temperature* control • use of a contact *catalyst* • high *pressure*

Key: E.24.C.1 = Equilibrium. Standard 24. Chemistry. 1st Student Learning Expectation

Strand: Oxidation-Reduction Reactions

Standard 25: Students shall understand *oxidation-reduction* reactions to develop skills in balancing redox equations.

ORR.25.C.1	Identify substances that are oxidized and substances that are reduced in a *chemical reaction*
ORR.25.C.2	Complete and balance redox reactions: • assign *oxidation numbers* • identify the *oxidizing agent* and *reducing agent* • write net ionic equations

Key: ORR.25.C.1 = Oxidation-Reduction Reactions. Standard 25. Chemistry. 1st Student Learning Expectation

Strand: Oxidation-Reduction Reaction

Standard 26 : Students shall explain the role of *oxidation-reduction* reactions in the production of electricity in a voltaic cell.

ORR.26.C.1	Write equations for the reactions occurring at the *cathode* and *anode* in electrolytic conduction
ORR.26.C.2	Build a voltaic cell and measure *cell potential:* • half-cells • *salt bridge*
ORR.26.C.3	Explain the process of obtaining electricity from a chemical voltaic cell: • line notation : *anode (oxidation)* ‖ *cathode (reduction)*
ORR.26.C.4	Calculate electric potential of a cell using redox potentials and predict *product*
ORR.26.C.5	Use redox potentials to predict electrolysis *products* and the electric potential of a cell

Key: ORR.26.C.1 = Oxidation-Reduction Reactions. Standard 26. Chemistry. 1st Student Learning Expectation

Strand: Organic Chemistry

Standard 27: Students shall differentiate between *aliphatic, cyclic*, and *aromatic hydrocarbons.*

OC.27.C.1	Examine the bonding and structural differences of *organic compounds:* • *alkanes* C_nH_{2n+2} • *alkenes* C_nH_{2n} • *alkynes* C_nH_{2n-2} • *aromatic hydrocarbons* • *cyclic hydrocarbons*
OC.27.C.2	Differentiate between the role and importance of *aliphatic, cyclic,* and *aromatic hydrocarbons*
OC.27.C.3	Compare and contrast *isomers*

Key: OC.27.C.1 = Organic Chemistry. Standard 27. Chemistry. 1st Student Learning Expectation

Strand: Organic Chemistry

Standard 28: Students shall describe the functional groups in organic chemistry.

OC.28.C.1	Describe the functional groups in organic chemistry: • halohydrocarbons • alcohols • ethers • aldehydes • ketones • carboxylic acids • esters • amines • amides • amino acids • nitro compounds
OC.28.C.2	Name and write formulas for *aliphatic, cyclic,* and *aromatic hydrocarbons*

Key: OC.28.C.1 = Organic Chemistry. Standard 28. Chemistry. 1st Student Learning Expectation

Strand: Organic Chemistry

Standard 29: Students shall demonstrate an understanding of the role of *organic compounds* in living and non-living systems.

OC.29.C.1	Differentiate among the biochemical functions of proteins, *carbohydrates, lipids,* and *nucleic acids*
OC.29.C.2	Describe the manufacture of polymers derived from *organic compounds:* • polymerization • crosslinking

Key: OC.29.C.1 = Organic Chemistry. Standard 29. Chemistry. 1st Student Learning Expectation

Strand: Nuclear Chemistry

Standard 30: Students shall understand the process transformations of *nuclear radiation.*

NC.30.C.1	Describe the following radiation emissions: • alpha particles • beta particles • gamma rays • positron particles
NC.30.C.2	Write and balance nuclear reactions
NC.30.C.3	Compare and contrast *fission* and *fusion*
NC.30.C.4	Apply the concept of half life to *nuclear decay*

Key: NC.30.C.1 = Nuclear Chemistry. Standard 30. Chemistry. 1st Student Learning Expectation

Strand: Nuclear Chemistry

Standard 31: Students shall understand the current and historical ramifications of nuclear energy.

NC.31.C.1	Construct *models* of instruments used to study, control, and utilize radioactive materials and nuclear processes
NC.31.C.2	Research the role of nuclear reactions in society: • transmutation • nuclear power plants • Manhattan Project

Key: NC.31.C.1 = Nuclear Chemistry. Standard 31. Chemistry. 1st Student Learning Expectation

Strand: Nature of Science

Standard 32: Students shall demonstrate an understanding that science is a way of knowing.

NS.32.C.1	Explain why science is limited to natural explanations of how the world works
NS.32.C.2	Compare and contrast *hypotheses, theories*, and *laws*
NS.32.C.3	Compare and contrast the criteria for the formation of scientific *theory* and scientific *law*
NS.32.C.4	Distinguish between a scientific *theory* and the term *"theory"* used in general conversation
NS.32.C.5	Summarize the guidelines of science: ▪ explanations are based on observations, evidence, and testing ▪ *hypotheses* must be testable ▪ understandings and/or conclusions may change with additional empirical data ▪ scientific knowledge must have peer review and verification before acceptance

Key: NS.32.C.1 = Nature of Science. Standard 32. Chemistry. 1st Student Learning Expectation

Strand: Nature of Science

Standard 33: Students shall design and safely conduct scientific inquiry.

NS.33.C.1	Develop and explain the appropriate procedure, controls, and variables (dependent and independent) in scientific experimentation
NS.33.C.2	Research and apply appropriate safety precautions (refer to Arkansas Safety Lab Guide) when designing and/or conducting scientific investigations
NS.33.C.3	Identify sources of *bias* that could affect experimental outcome
NS.33.C.4	Gather and analyze data using appropriate summary statistics
NS.33.C.5	Formulate valid conclusions without *bias*
NS.33.C.6	Communicate experimental results using appropriate reports, figures, and tables

Key: NS.33.C.1 = Nature of Science. Standard 33. Chemistry. 1st Student Learning Expectation

Strand: Nature of Science

Standard 34: Students shall demonstrate an understanding of the current theories in chemistry.

NS.34.C.1	Recognize that theories are scientific explanations that require empirical data, verification, and peer review
NS.34.C.2	Understand that scientific theories may be modified or expanded based on additional empirical data, verification, and peer review
NS.34.C.3	Research current events and topics in chemistry

Key: NS.34.C.1 = Nature of Science. Standard 34. Chemistry. 1st Student Learning Expectation

Strand: Nature of Science

Standard 35: Students shall use mathematics, science equipment, and technology as tools to communicate and solve problems in chemistry.

NS.35.C.1	Collect and analyze scientific data using appropriate mathematical calculations, figures, and tables
NS.35.C.2	Use appropriate equipment and technology as tools for solving problems
NS.35.C.3	Utilize technology to communicate research findings

Key: NS.35.C.1 = Nature of Science. Standard 35. Chemistry. 1st Student Learning Expectation

Strand: Nature of Science

Standard 36: Students shall describe the connections between pure and applied science.

NS.36.C.1	Compare and contrast chemistry concepts in pure science and applied science
NS.36.C.2	Discuss why scientists should work within ethical parameters
NS.36.C.3	Evaluate long-range plans concerning resource use and by-product disposal for environmental, economic, and political impact
NS.36.C.4	Explain how the cyclical relationship between science and technology results in reciprocal advancements in science and technology

Key: NS.36.C.1 = Nature of Science. Standard 36. Chemistry. 1st Student Learning Expectation

Strand: Nature of Science

Standard 37: Students shall describe various careers in chemistry and the training required for the selected career

NS.37.C.1	Research and evaluate science careers using the following criteria: ▪ educational requirements ▪ salary ▪ availability of jobs ▪ working conditions

Key: NS.37.C.1 = Nature of Science. Standard 37. Chemistry. 1st Student Learning Expectation

Acid	A substance which produces hydrogen ions in solution (Arrhenius); a proton donor (Bronsted-Lowry); an electron pair acceptor (Lewis)
Aliphatic	A subdivision of hydrocarbon characterized by open carbon chains and non-aromatic rings
Alkane	Aliphatic hydrocarbons having only single bonds between the carbons
Alkene	Aliphatic hydrocarbons having one or more double bonds between the carbons
Alkyne	Aliphatic hydrocarbons having one or more triple bonds between the carbons
Anode	The electrode where oxidation takes place; positive electrode
Activation energy	The minimum energy required to transform the reactants into an activated complex
Amorphous	A solid-appearing material without crystalline structure
Aromatic	Group of organic ring compounds in which electrons exhibit resonance
Atom	The smallest unit of an element that maintains the properties of that element
Average atomic mass	The weighted average of the atomic masses of the naturally occurring isotopes of an element
Avogadro's number	Number of objects in a mole equal to 6.02×10^{23}
Atomic model	A representation of an atom including the nucleus and electron cloud
Atomic radius	The radius of an atom without regard to surrounding atoms
Atomic theory	The body of knowledge concerning the existence of atoms and their characteristic structure
Aufbau principle	The principle stating that as protons are added one by one to the nucleus to build up the elements, electrons are similarly added to hydronge-like orbitals; German for "building up"
Base	A substance which produces hydroxide ions in water solution, (arrhenius); a proton acceptor (Bronsted); an electron-pair donor (Lewis)
Binary compounds	Compounds containing two elements
Buffer	A solution which can receive moderate amounts of either acid or base without significant change in its pH
Carbohydrate	An energy rich organic compound made of the elements carbon, hydrogen, and oxygen
Catalyst	A substance that changes the rate of a chemical reaction without itself being permanently consumed
Cathode	The electrode at which reduction occurs; the negative electrode
Chemical change	A change in which one or more substances are converted into different substances
Chemical equation	A representation, with symbols and formulas, of the identities and relative amounts of the reactants and products in a chemical reaction
Chemical property	The ability of a substance to undergo a change that transforms it into a different substance
Chromatography	The separation of a mixture using a technique based upon a mobile phase and a stationary phase
Chemical reaction	A reaction in which one or more substances are converted into different substances
Chrystalline solid	A solid in which the particles are arranged in a regular repeating pattern
Combustion reaction	A reaction in which a substance combines with oxygen, releasing a large amount of energy in the form of light and heat
Compound	A substance that is made from the atoms of two or more elements that are chemically bonded
Concentration	A measure of the amount of solute in a given amount of solvent or solution
Conservation of mass	Mass is neither created nor destroyed during ordinary chemical or physical reactions
Covalent bond	A chemical bond resulting from the sharing of an electron pair between two atoms
Cyclic	A subdivision of hydrocarbons characterized by having ring forms

Decomposition reaction	A reaction in which a single compound produces two or more simpler substances
Density	The ratio of mass to volume or mass divided by volume
Dipole-dipole	A force of attraction between dipoles
Dipole-induced dipole	An attraction between a dipole and a non-polar molecular molecule which has been induce to become a dipole
Dispersion forces	The forces existing between atoms that involve an accidental dipole that induces a momentary dipole in a neighbor (London dispersion)
Distillation	The process of evaporating a liquid and condensing its vapor
Double displacement reaction	A reaction in which the ions of two compounds exchange places in an aqueous solution to form two new compounds
Elastic collision	When gas particles hit one another or the container and there is no net loss of kinetic energy
Electron affinity	The energy change that occurs when an electron is acquired by an neutral atom
Electron cell potential	The driving force in galvanic cell that pulls electrons from the reducing agent in one compartment to the oxidizing agent in the other
Electron configuration notations	A description of the energy level and sublevel for all the electrons in an atom
Electronegativitiy	A measure of the ability of an atom in a chemical compound to attract electron pairs
Element	A pure substance made of only one kind of atom
Empirical formula	The simplest whole number ratio of atoms in a compound
Energy	Capacity to do work
Energy level	Any of the possible energies an electron (may have in an atom)
Endothermic reaction	A reaction that takes place with the absorption of heat
Enthalpy	That part of energy of a substance which is due to the motion of its particles (H)
Entropy	A measure of the degree of randomness (disorder) of particles (S)
Excess reactant	The amount of reactant not used completely in a chemical reaction
Exothermic reaction	A reaction that produces heat
Extensive property	Physical properties depending on the amount of matter present such as mass, weight, volume,…
Fission	A process in which a very heavy nucleus splits into more-stable nuclei of intermediate mass
Formula unit	The simplest collection of atoms from which an ionic compound formula can be established
Free energy	The chemical potential of a substance or system (G)
Fusion	The combining of light-mass nuclei to form a heavier, more stable nucleus
Gas	The state of matter in which a substance has neither definite volume nor definite shape
Heat	The energy transferred between samples of matter because of a difference in their temperature
Heat of solution	The amount of energy produced or consumed when a substance is dissolved in water.
Hund's Rule	Orbitals of equal energy are each occupied by one electron before any orbital is occupied by a second electron, and all electrons in singly occupied orbitals must have the same spin
Hybridization	The mixing of two or more atomic orbitals of similar energies to form new orbitals of equal energies
Hydrocarbon	The simplest organic compound, composed of only carbon and hydrogen
Hydrocarbon	A compound only of carbon and hydrogen

Hydrogen bond	Intermolecular force in which hydrogen bonds to a highly electronegative element such as Nitrogen, Oxygen, Ffuorine
Hypothesis	A testable statement
Indicator	A weak organic acid that changes color and is used to mark the endpoint of a titration
Intensive property	A physical property which does not depend on the amount of matter present such as freezing point, boiling point, density
Ion	An atom or group of bonded atoms with a charge (positive or negative)
Ionic bond	The chemical bond resulting from electrical attraction between large numbers of positive and negative ions (cations and anions)
Ionic compound	A compound composed of positive and negative ions (cations and anions) that are combined so that the numbers of positive and negative charges are equal
Ionic radius	The radius of an ion
Ionization constant	The equilibrium constant for the ionization of a weak electrolyte
Ionization energy	The energy required to remove an electron from an atom
Isomers	Compounds that have the same molecular formula but different structures
Isotopes	Atoms of the same element that have different masses; same number of protons, different number of neutrons
IUPAC	International Union of Pure and Applied Chemistry; international regulatory committee for chemistry
Kinetic theory	A theory based on the idea that molecular particles of matter are always in motion
Law	An observed natural phenomenon; a fact
Law of multiple proportions	If two or more different compounds are composed of the same two elements, then the ratio of the masses of the second element, combined with a fixed mass of the first element, is always a ratio of small whole numbers
Le Chatelier's principle	If a stress is placed on a system at equilibrium the system will shift so as to offset the stress
Lewis electron dot structures	Representation of a molecule, ion, or formula unit by showing atomic symbols and only outer shell electrons
Limiting reactant	The reactant which is completely used in a reaction
Lipid	An energy-rich compound made of carbon, oxygen, and hydrogen; fats, oils, waxes, and cholesterol
Lone pair	An electron pair on a given atom not involved in bonding
Main group element	Elements in the s and p block of the periodic chart, including groups 1, 2, 13,14,15,16,17,18
Mass	A measure of the amount of matter
Material Safety Data Sheet	Product documents provided by manufacturers which details safety information (MSDS)
Matter	Anything that has mass and takes up space
Model	An explanation of how phenomena occur and how data or events are related
Molar mass	The mass of one mole of a pure substance
Molality	A unit of concentration equal to the number of moles of solute dissolved into 1 kilogram of solvent
Molarity	A unit of concentration equal to the number of moles of solute dissolved in 1 liter of solution
Mole	The amount of a substance that contains as many particles as there are atoms in exactly 12 g of carbon-12; equals 6.02×10^{23}
Molecular formula	A formula indicating the actual number of each kind of atom in a molecule
Molecular mass	The mass found by adding the atomic masses of the atoms comprising a molecule

Molecular motion	The energetic movements of matter which may include vibration, rotation and translation
Molecular orbital model	A model that regards a molecule as a collection of nuclei and electrons, where the electrons are assumed to occupy orbitals much as they do in atoms, but having the orbitals extend over the entire model
Neutralization	The reaction of hydronium ions (H_3O^+) and hydroxide ions (OH^-)to form water
Non-polar covalent	A covalent bond in which the bonding electrons are shared equally by the bonded atoms
Nomenclature	A naming system
Normality	The number of equivalents of a substance dissolved in a liter of solution
Nucleic acid	A very large organic compound made up of carbon, oxygen, hydrogen, nitrogen and phosphorous; i.e., DNA and RNA
Nuclear decay	The spontaneous disintegration, or decay, of a nucleus into a slightly lighter and more stable nucleus, accompanied by emission of mass particles, electromagnetic radiation, or both
Nuclear forces	A short-range proton-neutron, proton-proton, or neutron-neutron force that holds the nuclear particles together
Nuclear radiation	The particles or electromagnetic radiation emitted from the nucleus during radioactive decay
Orbital	A three-dimensional region around the nucleus that indicates the probable location of an electron
Orbital notation	Symbolic representation of electron energy level filling; utilizes all four quantum numbers. An unoccupied orbital is represented by a line with the orbital's name written underneath the line; electrons are represented as arrows on top of the line
Organic compound	A covalently bonded [compound] containing carbon, excluding carbonates and oxides
Oxidation	The loss of electrons
Oxidation numbers	The number assigned to an atom in a molecular compound that indicates the distribution of electrons among the bonded atoms
Oxidizing agent	A substance which tends to gain electrons
Pauli's exclusion principle	In a given atom, no two electrons can have the same set of quantum numbers
Percent composition	The proportion of an element present in a compound found by dividing the mass of the element present by the mass of the compound and multiplying by 100%
pH	The negative logarithm of the hydronium ion concentration pH= -log $[H_3O^+]$
Physical change	A change in a substance that does not involve a change in the identity of the substance
Physical property	A characteristic that can be observed or measured without changing the identity of the substance
Polar covalent	A bond formed by a shared pair of electrons that are more strongly attracted to one atom than the other
Polyatomic ion	A charged group of covalently bonded atoms
Polymerization	The reaction producing a polymer from monomers
Pressure	The force per unit area on a surface
Products	A substance formed as result of a chemical change
Protein	An organic compound that is a polymer made of amino acids
Quantum	Minimum quantities of energy that may be gained or lost by an electron (quanta is plural)
Reactant	A substance that reacts in a chemical change
Reaction rate	The rate of disappearance of reactant or the rate of appearance of a product.
Reducing agent	The substance which tends to donate electrons
Reduction	The gain of electrons

Resonance	A highly stable compound having simultaneously by the characteristics of two or more structural forms that differ only in the distribution of electrons; cannot be properly represented by a single Lewis structure
Reversible reaction	A reaction which the products can be changed back into the original reactants under the proper conditions
Salt	A compound formed form the positive ion of a base and a negative ion of an acid
Salt bridge	A U-tube containing an electrolyte that connects the two compartments of a galvanic cell allowing ion flow without extensive mixing of the different solutions
Scientific bias	A preconceived ideas that falsely effect the outcome of an experiment or process
Shared pairs	Electrons that are shared between two atoms to form a bond
Single displacement reaction	A reaction in which one element replaces a similar element in a compound
Solid	The state of matter in which the substance has definite volume and definite shape
Solute	The substance present in lesser amount in a solution; the substance that is dissolved
Solution	A homogeneous mixture composed of solute and solvent
Solvent	The substance present in the greater amount in solution; capable of dissolving another substance
Stoichiometry	The solution of problems involving specific quantities of substance(s)
Subatomic particles	Includes protons, neutrons, electrons
Substituted hydrocarbon	A hydrocarbon in which one or more hydrogen atoms have been replaced by atoms of other elements
Synthesis reaction	A reaction in which two or more substances combine to form a new compound
Temperature	A measure of the average kinetic energy of the particles in a sample of matter
Ternary compound	Compound formed from three elements
Theory	An explanation of a phenomenon; a broad generalization that explains a body of facts or phenomena
Titration	A technique in which one solution is used to measure the strength of a solution of unknown strength
Transition element	Elements whose electrons enter d or f sublevels (they are located in groups 3-12 on the Periodic Table)
Valence electron	An electron that is available to be lost, gained, or shared in the formation of chemical compounds
VSEPR model	A model in which an atom in a molecule is determined by minimizing electron pair repulsions

APPENDIX

Suggested Chemistry Labs

Strand	Suggested Laboratory or Activity
Nature of Science	measurement
Atomic Theory	spectroscopy (example: spectrum analysis; triboluminescence) flame test
Periodicity	density chromatography trends
Bonding	polarity atomic modeling
Stoichiometry	synthesis of a compound decomposition of a compound single replacement reactions double replacement reactions combustion reactions gravimetric analysis concentration heat of solution
Gas Laws	pressure/volume/temperature affects of gases (examples: Charles, Boyles, molar volume of a gas)
Acid and Bases	pH titration
Kinetics and Energetics	specific heat
Oxidation Reduction	redox electrochemistry
Equilibrium	Le Chatlier Principle: temperature, volume, pressure relationships (application of stress on systems, reversible reactions)
Organic	crosslinking esterification
Nuclear Chemistry	half-life (http://home.earthlink.net/~mmc1919/halflife.html)