Chemistry Pacing Guide

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.

First Nine Weeks

1. Enduring Understanding - Science is a systematic inquiry process where conclusions are dervied from questions through appropriate and accurate investigative techniques.

1a. Essential Question - What steps do scientists use to investigate problems?

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

1b. Essential Question - What guidelines must be followed to design and conduct a scientific investigation?

NS.33.C.1	Develop and explain the appropriate procedure, controls, and variables (dependent and independent) in scientific experimentation
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.33.C.6	Communicate experimental results using appropriate reports, figures, and tables
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.5	Formulate valid conclusions without *bias*
NS.33.C.4	Gather and analyze data using appropriate summary statistics

1c. Essential Question - How can technology be appropriately used in solving and communicatig life science problems?

NS.35.C.2	Use appropriate equipment and technology as tools for solving problems
NS.35.C.3	Utilize technology to communicate research findings
NS.34.C.3	Research current events and topics in chemistry

1d. Essential Question - What is the connection between pure science and science applied to the real world?

NS.35.C.1	Collect and analyze scientific data using appropriate mathematical calculations, figures, and tables
NS.37.C.1	Research and evaluate science careers using the following criteria: educational requirements salary

	availability of jobs working conditions
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
2. Enduring Understanding - All matter is composed of atoms.	
2a. Essential Question - What is the basic structure of matter?	
P.6.C.1	Compare and contrast *matter* based on uniformity of particles: pure substances *solutions* heterogeneous mixtures
2b. Essential Question - How are the steps of the scientific method used in laboratory investigations?	
P.6.C.2	Distinguish between *extensive* and *intensive physical properties* of *matter*
2c. Essential Question - What is the difference between physical and chemical properties?	
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*
2d. Essential Questions - What are the properties of mixtures and pure substances?	
P.6.C.5	Predict the *chemical properties* of substances based on their electron configuration: active inactive inert
3. Enduring Understanding - The properties of an atom are determined by the atomic structure.	
3a. Essential Question - How are subatomic particles arranged and how do variations in the arrangement affect the properties of the atom?	

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*				
	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				

Standard 2	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*				
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 $c = \nu\lambda$ Where ν = *frequency* λ = *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*				

Strand: Periodicity			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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*				
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				
	P.7.C.1	Demonstrate an understanding of the *Law of Multiple Proportions*				

Strand: Bonding			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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*				
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)				
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*				
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				

Strand: Stoichiometry			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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				
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				
Standard 14	Students shall predict *products* based upon the type of chemical reaction.					
	S.14.C.1	Given the *products* and *reactants* predict *products* for the following types of *reactions:* *synthesis* *decomposition* *single displacement* *double displacement* *combustion*				
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				

Strand: Gas Laws			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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*				
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	$P_{Total} = P_1 + P_2 + P_3 \ldots$
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	$PV = nRT$

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*				

Strand: Acids and Bases			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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				
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*				
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*				
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*				
Strand: Kinetics and Energetics			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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*				

Strand: Equilibrium			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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:* $mA + nB \rightarrow sP + rQ$ $K_{eq} = \frac{[P]^s [Q]^r}{[A]^m [B]^n}$				
	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*				
Strand: Oxidation-Reduction Reactions			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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				
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				

Strand: Organic Chemistry			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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*				
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*				
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				
Strand: Nuclear Chemistry			First Nine Weeks	Second Nine Weeks	Third Nine Weeks	Fourth Nine Weeks
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*				
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				
Standard 37	Students shall describe various careers in chemistry and the training required for the selected career