Loudoun County Public Schools
Science Curriculum Guide

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Chemistry 2016-17

Modified from the 2010 Virginia Science Standards of Learning Curriculum Framework to include pacing and resources for instruction for the 2016-17 school year

2016-2017 Chemistry
Pacing Guide *At a Glance*

Quarter	Chapter	Topic	Related SOL	Suggested No. of Lessons	Target Date for Completion
1st	1, 2, 4, 5	Foundations, Matter and Nomenclature	2h; ‡3 a, c *1 a - j	9	November 4, 2016
	3, 19	Atoms	2 a-c; 2i; **1 a - j*	4	
	11	Modern Atomic Theory	2 g, i; **1 a - j*	4	
	3, 11	Periodic Table	2 d-f; **1 a - j*	4	
2nd	12	Bonding	3 c, d; **1 a - j*	6	January 26, 2017
	7, 8, 18	Reactions	3 b, c, d, e; **1 a - j*	5	
	6	Moles	4 a, b; **1 a - j*	5	
	9	Stoichiometry	4 a, b; **1 a - j*	6	
3rd	10	Energy	3e, 5 d, e, f; **1 a - j*	5	April 6, 2017
	13	Gases	4 a; 5 a, b; **1 a - j*	5	
	14	Solids and Liquids	5 c, d; **1 a - j*	5	
	15	Solutions	4 c; 5g; **1 a - j*	5	
4th	10, 17	Equilibrium and Kinetics	3 f**;** **1 a - j*	3	June 9, 2017
	16	Acids and Bases	3 e; 4 d**;** **1 a - j*	4	
	20, 21	Organic/ Biochemistry	6a, b**;** **1 a - j*	4	
		SOL Review	all		
		Projects, Inquiry Investigation	all	9	

* Scientific Investigation, Reasoning, and Logic (Science SOL CH.1) standards are infused with content throughout the year.
‡Nomenclature is infused/ reinforced throughout the year.

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Introduction to Loudoun County Public Schools Science Curriculum

This Curriculum Guide and Framework is a merger of the Virginia Standards of Learning (SOL) and the Science Achievement Standards of Loudoun County Public Schools. Many sections are modifications of Virginia's SOL documents. Suggestions on pacing and resources represent the professional consensus of Loudoun's teachers concerning the implementation of these standards.

Contents

Science Learning Goals

The purposes of scientific investigation and discovery are to satisfy humankind's quest for knowledge and understanding and to preserve and enhance the quality of the human experience. Therefore, as a result of science instruction, students will be able to achieve the following objectives:

1. Develop and use an experimental design in scientific inquiry.
2. Use the language of science to communicate understanding.
3. Investigate phenomena using technology.
4. Apply scientific concepts, skills, and processes to everyday experiences.
5. Experience the richness and excitement of scientific discovery of the natural world through the collaborative quest for knowledge and understanding.
6. Make informed decisions regarding contemporary issues, taking into account the following:

   public policy and legislation;

   economic costs/benefits;

   validation from scientific data and the use of scientific reasoning and logic;

   respect for living things;

   personal responsibility; and

   history of scientific discovery.
7. Develop scientific dispositions and habits of mind including:

   curiosity;

   demand for verification;

   respect for logic and rational thinking;

   consideration of premises and consequences;

   respect for historical contributions;

   attention to accuracy and precision; and

   patience and persistence.
8. Develop an understanding of the interrelationship of science with technology, engineering and mathematics.
9. Explore science-related careers and interests.

Investigate and Understand

Many of the standards in the *Science Standards of Learning* begin with the phrase "Students will investigate and understand." This phrase was chosen to communicate the range of rigorous science skills and knowledge levels embedded in each standard. Limiting a standard to one observable behavior, such as "describe" or "explain," would have narrowed the interpretation of what was intended to be a rich, highly rigorous, and inclusive content standard.

"Investigate" refers to scientific methodology and implies systematic use of the following inquiry skills:

- observing;
- classifying and sequencing;
- communicating;
- measuring;
- predicting;
- hypothesizing;
- inferring;
- defining, controlling, and manipulating variables in experimentation;
- designing, constructing, and interpreting models; and
- interpreting, analyzing, and evaluating data.

"Understand" refers to various levels of knowledge application. In the *Science Standards of Learning*, these knowledge levels include the ability to:

- recall or recognize important information, key definitions, terminology, and facts;
- explain the information in one's own words, comprehend how the information is related to other key facts, and suggest additional interpretations of its meaning or importance;
- apply the facts and principles to new problems or situations, recognizing what information is required for a particular situation, using the information to explain new phenomena, and determining when there are exceptions;
- analyze the underlying details of important facts and principles, recognizing the key relations and patterns that are not always readily visible;
- arrange and combine important facts, principles, and other information to produce a new idea, plan, procedure, or product; and
- make judgments about information in terms of its accuracy, precision, consistency, or effectiveness.

Therefore, the use of "investigate and understand" allows each content standard to become the basis for a broad range of teaching objectives.

Application

Science provides the key to understanding the natural world. The application of science to relevant topics provides a context for students to build their knowledge and make connections across content and subject areas. This includes applications of science among technology, engineering, and mathematics, as well as within other science disciplines. Various strategies can be used to facilitate these applications and to promote a better understanding of the interrelated nature of these four areas.

Loudoun County Public Schools' Vision for STEM Education

According to the Congressional Research Service (2008), the United States ranks 20th among all nations in the proportion of 24-year-olds who earn degrees in natural science or engineering. In response, government, business and professional organizations have identified improvements in K-12 education in science, technology, engineering and mathematics (STEM) as a national priority. The National Academy of Sciences report, Rising Above the Gathering Storm (2007), calls for the strengthening of math and science education and for an urgent change in STEM education. The U.S. Department of Education's Report of the Academic Competitiveness Council lists several K-12 STEM Education goals. Foremost is a goal to prepare all students with science, technology, engineering, and math skills needed to succeed in the 21st century technological economy.

Increased performance in STEM fields requires STEM literacy. To become truly literate, students must have better understanding of the fields individually, and more importantly, they must understand how the fields are interrelated and interdependent. Clearly, formative experiences in STEM during their K-12 school years will allow for a deeper STEM literacy and better prepare them for university and beyond. In order to properly prepare our students, they must have a broad exposure to and a knowledge base in the STEM fields as part of their K-12 education.

The goal of STEM education at LCPS is to deepen students' knowledge, skills, and habits of mind that characterize science, technology, engineering, and mathematics. Loudoun County Public Schools has many exemplary programs designed to answer the call for STEM education. The Loudoun Governor's Career and Technical Academy at Monroe Technology Center and the Academy of Science at Dominion High School are specialized programs that meet these goals. Additionally, LCPS offers students a variety of STEM courses and opportunities that are rigorous, demanding, and help students develop skills required for the 21st century.

Based on the success of these programs, we are building capacity to provide integrated STEM education to all LCPS students. Integrated STEM in LCPS is defined as experiences that develop student understanding within one STEM area while also learning or applying knowledge and/or skills from at least one other STEM area.

Within this framework of integrated STEM, LCPS science courses will develop student's science understanding necessary to be scientifically literate; which includes science content, habits of mind, science process skills, and relevant application of scientific knowledge. Through integrated STEM science instruction students will develop an understanding of the connections with other STEM disciplines. Additionally, science instruction at LCPS is intended to generate a large pool of students prepared to pursue STEM areas in college or through further on-the-job training in the workplace.

LCPS STEM experiences will:

- Capitalize on student interest
- Build on what students already know
- Engage students in the practices of STEM
- Engage students with inquiry learning

Meaningful Watershed Educational Experiences

The “Stewardship and Community Engagement” Commitment of the *Chesapeake 2000* agreement clearly focuses on connecting individuals and groups to the Bay through their shared sense of responsibility and action. The goal of this Commitment formally engages schools as integral partners *to undertake initiatives* in helping to meet the Agreement.

Two objectives developed as part of this goal describe more specific outcomes to be achieved by the jurisdictions in promoting stewardship and assisting schools. These are:

> *Beginning with the class of 2005, provide a meaningful Bay or stream outdoor experience for every school student in the watershed before graduation from high school.*
>
> *Provide students and teachers alike with opportunities to directly participate in local restoration and protection projects, and to support stewardship efforts in schools and on school property.*

There is overwhelming consensus that knowledge and commitment build from firsthand experience, especially in the context of one’s neighborhood and community. Carefully selected experiences driven by rigorous academic learning standards, engendering discovery and wonder, and nurturing a sense of community will further connect students with the watershed and help reinforce an ethic of responsible citizenship.

Defining *a Meaningful* Bay or Stream Outdoor Experience

A *meaningful* Bay or stream outdoor experience should be defined by the following.

Experiences are investigative or project oriented.
Experiences include activities where questions, problems, and issues are investigated by the collection and analysis of data, both mathematical and qualitative. Electronic technology, such as computers, probeware, and GPS equipment, is a key component of these kinds of activities and should be integrated throughout the instructional process.

The nature of these experiences is based on learning standards and should include the following kinds of activities.

- Investigative or experimental design activities where students or groups of students use equipment, take measurements, and make observations for the purpose of making interpretations and reaching conclusions.
- Project-oriented experiences, such as restoration, monitoring, and protection projects, that are problem solving in nature and involve many investigative skills.

Experiences are richly structured and based on high-quality instructional design.

Experiences are an integral part of the instructional program.

Experiences are part of a sustained activity.

Experiences consider the watershed as a system.

Experiences involve external sharing and communication.

Experiences are enhanced by natural resources personnel.

Experiences are for all students.

Experiences such as tours, gallery visits, simulations, demonstrations, or “nature walks” may be instructionally useful, but alone do not constitute a *meaningful* experience as defined here.

The preceding text contains excerpts from:
Chesapeake Bay Program Education Workgroup
STEWARDSHIP AND MEANINGFULWATERSHED EDUCATIONAL EXPERIENCES
http://vaswcd.org/?s=meaningful+watershed+education+experience

The link is found in the Virginia Department of Education Instructional Resources for Science:
http://www.doe.virginia.gov/instruction/science/resources.shtml

http://www.doe.virginia.gov/instruction/science/elementary/lessons_bay/index.shtml

Each LCPS K-12 Science Pacing Guide indicates where the Meaningful Watershed Educational Experiences fit into the Virginia Standards of Learning. Resources for these experiences are cited in the *Resources* section of each standard.

Many of the resources are from *Lessons from the Bay* and *Virginia's Water Resources a Toolkit for Teachers*.

Model Performance Indicators

Listed in the LCPS Science curriculum guide are sample Model Performance Indicator (MPI) tables. These tables will be useful as you differentiate instruction for all of your learners, but they are especially helpful for English Language Learners. Below are frequently asked questions about MPI.

What is a Model Performance Indicator (MPI)?
An MPI is a tool that can be used to show examples of how language is processed or produced within a particular context, including the language with which students may engage during classroom instruction and assessment.

Each MPI contains three main parts:

- *Language Function*: The first part of an MPI, this shows how students are processing/producing language at each level of language proficiency
- *Content Stem*: This will remain consistent throughout an MPI strand and should reflect the knowledge and skills of the state's content standards
- *Support*: The final part of an MPI, this highlights the differentiation that should be incorporated for students at each language level by suggesting appropriate instructional supports for students at each level of language proficiency

The samples provided also include an example context for language use that provides a brief descriptor of the activity or task in which students would be engaged, while the inclusion of topic-related language helps to support the emphasis on imbedding academic language instruction into our content-area teaching practices.

How can these sample MPIs help me?
Educators can use MPI strands in several ways:

- to align students' performance to levels of language development
- as a tool for creating language objectives/targets that will help extend students' level of language proficiency
- as a means for differentiating instruction that incorporates the language of the content area in a way that meets the needs of students' levels of language proficiency

An MPI strand helps illustrate the progression of language development from one proficiency level to the next within a particular context. As these strands are examples, they represent one of many possibilities; therefore, they can be transformed in order to be made more relevant to the individual classroom context.

Where can I get more information about WIDA, MPIs, etc.?
See My Learning Plan for several WIDA training modules

- *Introduction to the WIDA ELD Standards*
- *Transforming the WIDA ELD Standards*
- *Interpreting the WIDA ACCESS Score Report*

The information above was adapted from the *2012 Amplification of the English Development Standards Kindergarten-Grade 12* resource guide and can be accessed at www.wida.us

Model Performance Indicator Example

SOL Strand and Bullet: SOL Strand and Bullet:

CH.1 The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include:

a) designated laboratory techniques;
b) safe use of chemicals and equipment;
e) accurate recording, organization, and analysis of data through repeated trials;
g) mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis;

Example Context for Language Use: Students will conduct investigations and experiments on a variety of topics. Throughout this process, they will work in small groups to draw on prior knowledge as they discuss information presented by the teacher as they share among themselves and record the information. As they conduct their investigations, students will discuss examples of mathematical manipulations and their uses; explore the accurate recording, organization, and analysis of data through the use of multiple sources of information; and write about laboratory equipment, chemicals, and safety issues.

COGNITIVE FUNCTION: Students at all levels of English proficiency **INVESTIGATE** scientific processes, resources, and tools.

	Level 1 Entering	**Level 2 Emerging**	**Level 3 Developing**	**Level 4 Expanding**	**Level 5 Bridging**	**Level 6-Reaching**
LISTENING	Match oral descriptions to visuals representing the process of accurately recording, organizing, and analyzing data using a graphic organizer with a partner	Match and categorize oral descriptions of visuals representing the process of accurately recording, organizing, and analyzing data in a small group	Categorize oral descriptions representing the process of accurately recording, organizing, and analyzing data in a small group with a partner	Evaluate the accuracy of oral descriptions representing the process of recording, organizing, and analyzing data using a model with a partner	Analyze the effectiveness of oral descriptions in representing the process of recording, organizing, and analyzing data with a partner	
SPEAKING	Point to and name examples of mathematical manipulations (SI units, scientific notation, and linear equations) using visual supports with a partner	Orally identify mathematical manipulations (including examples of SI units, scientific notation, and linear equations) using a word bank and visual supports	Respond to questions and comments about mathematical manipulations (including SI units, scientific notation, and linear equations) using a graphic organizer with a partner	Describe the uses of mathematical manipulations including SI units, scientific notation, and linear equations in a small group	Explain with elaboration the uses of mathematical manipulations (including SI units, scientific notation, and linear equations) using a sentence starter ("____ is used for ______ because…")	

READING	Match words with images depicting accurate recording, organization, and analysis of data through repeated trials using a word bank	Make connections among a series of words and phrases about accurate recording, organization, and analysis of data through repeated trials using a graphic organizer	Verify information about accurate recording, organization, and analysis of data through repeated trials with a partner	Categorize information on accurate recording, organization, and analysis of data through repeated trials using a graphic organizer	Interpret information on accurate recording, organization, and analysis of data through repeated trials with a partner	**Level 6-Reaching**
WRITING	Label images of laboratory chemicals and equipment with names and safety alerts and/or cautions using a word bank and a dictionary	Label images of laboratory chemicals and equipment with names and safety alerts and/or cautions using a dictionary	List names and safety alerts and/or cautions associated with laboratory chemicals and equipment using a model	Compose a short paragraph about laboratory chemicals, equipment, and safety alerts, cautions, or concerns with a partner	Write an extended paragraph about laboratory chemicals, equipment, and safety alerts, cautions, or concerns using a model	

TOPIC-RELATED LANGUAGE: Students at all levels of English language proficiency interact with grade-level words and expressions, such as: investigate, experiment, variable, observations, verifiable data, laboratory techniques, equipment, emergency, mathematical manipulations, SI units, scientific notation, linear equations, ratio and proportion, dimensional analysis, analyze, evaluate, produce, analysis, graphing, significant digits, match, process, record, organize, categorize, evaluate, name, identify, respond, explain, elaborate, elaboration, connect, make connections, verify, interpret, accurate, accuracy, label, chemicals, safety, alert, caution, concern, laboratory, extend, extended, extensive

K-12 Safety in the Science Classroom

In implementing the *Science Standards of Learning*, teachers must be certain that students know how to follow safety guidelines, demonstrate appropriate laboratory safety techniques, and use equipment safely while working individually and in groups.

Safety must be given the highest priority in implementing the K-12 instructional program for science. Correct and safe techniques, as well as wise selection of experiments, resources, materials, and field experiences appropriate to age levels, must be carefully considered with regard to the safety precautions for every instructional activity. Safe science classrooms require thorough planning, careful management, and constant monitoring of student activities. Class enrollment should not exceed the designed capacity of the room.

Teachers must be knowledgeable of the properties, use, and proper disposal of all chemicals that may be judged as hazardous prior to their use in an instructional activity. Such information is referenced through Materials Safety Data Sheets (MSDS). The identified precautions involving the use of goggles, gloves, aprons, and fume hoods must be followed as prescribed.

While no comprehensive list exists to cover all situations, the following should be reviewed to avoid potential safety problems. Appropriate safety procedures should be used in the following situations:

- observing wildlife; handling living and preserved organisms; and coming in contact with natural hazards, such as poison ivy, ticks, mushrooms, insects, spiders, and snakes;
- engaging in field activities in, near, or over bodies of water;
- handling glass tubing and other glassware, sharp objects, and labware;
- handling natural gas burners, Bunsen burners, and other sources of flame/heat;
- working in or with direct sunlight (sunburn and eye damage);
- using extreme temperatures and cryogenic materials;
- handling hazardous chemicals including toxins, carcinogens, and flammable and explosive materials;
- producing acid/base neutralization reactions/dilutions;
- producing toxic gases;
- generating/working with high pressures;
- working with biological cultures including their appropriate disposal and recombinant DNA;
- handling power equipment/motors;
- working with high voltage/exposed wiring; and
- working with laser beam, UV, and other radiation.

The use of human body fluids or tissues is generally prohibited for classroom lab activities. Further guidance from the following sources may be referenced:

OSHA (Occupational Safety and Health Administration);

ISEF (International Science and Engineering Fair) rules; and

public health departments’ and school divisions’ protocols.

For more detailed information about safety in science, consult the *LCPS Science Safety Manual*.

The Role of Instructional Technology in the Science Classroom

The use of current and emerging technologies is essential to the K-12 science instructional program. Specifically, technology must accomplish the following:

- Assist in improving every student's functional literacy. This includes improved communication through reading/information retrieval (the use of telecommunications), writing (word processing), organization and analysis of data (databases, spreadsheets, and graphics programs), presentation of one's ideas (presentation software), and resource management (project management software).
- Be readily available and regularly used as an integral and ongoing part of the delivery and assessment of instruction.
- Include instrumentation oriented toward the instruction and learning of science concepts, skills, and processes. Technology, however, should not be limited to traditional instruments of science, such as microscopes, labware, and data-collecting apparatus, but should also include computers, robotics, video-microscopes, graphing calculators, probeware, geospatial technologies, online communication, software and appropriate hardware, as well as other emerging technologies.

In most cases, the application of technology in science should remain "transparent" unless it is the actual focus of the instruction. One must expect students to "do as a scientist does" and not simply hear about science if they are truly expected to explore, explain, and apply scientific concepts, skills, and processes.

As computer/technology skills are essential components of every student's education, it is important that teaching these skills is a shared responsibility of teachers of all disciplines and grade levels.

Internet Safety

The Internet allows students to learn from a wide variety of resources and communicate with people all over the world. Students should develop skills to recognize valid information, misinformation, biases, or propaganda. Students should know how to protect their personal information when interacting with others and about the possible consequences of online activities such as social networking, e-mail, and instant messaging.

- Students need to know that not all Internet information is valid or appropriate.
- Students should be taught specifically how to maximize the Internet's potential while protecting themselves from potential abuse.
- Internet messages and the people who send them are not always what or who they seem.
- Predators and cyberbullies anonymously use the Internet to manipulate students. Students must learn how to avoid dangerous situations and get adult help.

Cybersafety should be addressed when students research online resources or practice other skills through interactive sites. Science teachers should address underlying principles of cybersafety by reminding students that the senses are limited when communicating via the Internet or other electronic devices and that the use of reasoning and logic can extend to evaluating online situations.

Listed below are Earth Science Virginia Standards of Learning which lend themselves to integrating Internet safety with a brief explanation of how the two can be connected.

CH.1 - Teachers can help students understand that data collected and presented on the Internet may be flawed due to many variables, including equipment malfunction, human bias, or presentation mechanisms.

CH.1 - If students are using online tools for written communications, address the general safety issues appropriate for this age group.

Additional information about Internet safety may be found on the Virginia Department of Education's Website at
http://www.doe.virginia.gov/support/safety_crisis_management/internet_safety/index.shtml

Chemistry Standards of Learning

The Chemistry standards are designed to provide students with a detailed understanding of the interaction of matter and energy. This interaction is investigated through the use of laboratory techniques, manipulation of chemical quantities, and problem-solving applications. Scientific methodology is employed in experimental and analytical investigations, and concepts are illustrated with current practical applications that should include examples from environmental, nuclear, organic, and biochemistry content areas.

Technology, including graphing calculators, computers, and probeware, are employed where feasible. Students will understand and use safety precautions with chemicals and equipment. The standards emphasize qualitative and quantitative study of substances and the changes that occur in them. In meeting the chemistry standards, students will be encouraged to share their ideas, use the language of chemistry, discuss problem-solving techniques, and communicate effectively.

The Chemistry standards continue to focus on student growth in understanding the **nature of science**. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.

Standard CH.1

The Chemistry Standards of Learning are listed successively in the pages that follow. See the *At A Glance* page at the beginning of this document for pacing and teaching sequence.

CH.1 The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include

a) designated laboratory techniques;
b) safe use of chemicals and equipment;
c) proper response to emergency situations;
d) manipulation of multiple variables, using repeated trials;
e) accurate recording, organization, and analysis of data through repeated trials;
f) mathematical and procedural error analysis;
g) mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis;
h) use of appropriate technology including computers, graphing calculators, and probeware, for gathering data, communicating results, and using simulations to model concepts;
i) construction and defense of a scientific viewpoint; and
j) the use of current applications to reinforce chemistry concepts.

Essential Understandings	Essential Knowledge and Skills
The concepts developed in this standard include the following: • The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world. The nature of science includes the following concepts a) the natural world is understandable; b) science is based on evidence - both observational and experimental; c) science is a blend of logic and innovation; d) scientific ideas are durable yet subject to change as new data are collected; e) science is a complex social endeavor; and f) scientists try to remain objective and engage in peer review to help avoid bias. • Techniques for experimentation involve the identification and the proper use of chemicals, the description of equipment, and the recommended statewide framework for high school laboratory safety.	In order to meet this standard, it is expected that students will • make connections between components of the nature of science and their investigations and the greater body of scientific knowledge and research. • demonstrate safe laboratory practices, procedures, and techniques. • demonstrate the following basic lab techniques: filtering, using chromatography, and lighting a gas burner. • understand Material Safety Data Sheet (MSDS) warnings, including handling chemicals, lethal dose (LD), hazards, disposal, and chemical spill cleanup. • identify the following basic lab equipment: beaker, Erlenmeyer flask, graduated cylinder, test tube, test tube rack, test tube holder, ring stand, wire gauze, clay triangle, crucible with lid, evaporating dish, watch glass, wash bottle, and dropping pipette. • make the following measurements, using the specified equipment: - volume: graduated cylinder, volumetric flask, buret - mass: triple beam and electronic balances

Standard CH.1

• Measurements are useful in gathering data about chemicals and how they behave. • Repeated trials during experimentation ensure verifiable data. • Data tables are used to record and organize measurements. • Mathematical procedures are used to validate data, including percent error to evaluate accuracy. • Measurements of quantity include length, volume, mass, temperature, time, and pressure to the correct number of significant digits. Measurements must be expressed in International System of Units (SI) units. • Scientific notation is used to write very small and very large numbers. • Algebraic equations represent relationships between dependent and independent variables. • Graphs are used to summarize the relationship between the independent and dependent variable. • Graphed data give a picture of a relationship. • Ratios and proportions are used in calculations. • Significant digits of a measurement are the number of known digits together with one estimated digit. • The last digit of any valid measurement must be estimated and is therefore uncertain. • Dimensional analysis is a way of translating a measurement from one unit to another unit. • Graphing calculators can be used to manage the mathematics of chemistry. • Scientific questions drive new technologies that allow discovery of additional data and generate better questions. New tools and instruments provide an increased understanding of matter at the atomic, nano, and molecular scale. • Constant reevaluation in the light of new data is essential to keeping scientific knowledge current. In this fashion, all forms of scientific	- temperature: thermometer and/or temperature probe - pressure: barometer and/or pressure probe. • identify, locate, and know how to use laboratory safety equipment, including aprons, goggles, gloves, fire extinguishers, fire blanket, safety shower, eye wash, broken glass container, and fume hood. • design and perform controlled experiments to test predictions, including the following key components: hypotheses, independent and dependent variables, constants, controls, and repeated trials. • predict outcome(s) when a variable is changed. • read measurements and record data, reporting the significant digits of the measuring equipment. • demonstrate precision (reproducibility) in measurement. • recognize accuracy in terms of closeness to the true value of a measurement. • determine the mean of a set of measurements. • use data collected to calculate percent error. • discover and eliminate procedural errors. • use common SI prefixes and their values (milli-, centi-, kilo-) in measurements and calculations. • demonstrate the use of scientific notation, using the correct number of significant digits with powers of ten notation for the decimal place. • graph data utilizing the following: - independent variable (horizontal axis) - dependent variable (vertical axis) - scale and units of a graph - regression line (best fit curve). • calculate mole ratios, percent composition, conversions, and average atomic mass. • perform calculations according to significant digits rules. • convert measurements using dimensional analysis. • use graphing calculators to solve chemistry problems.

knowledge remain flexible and may be revised as new data and new ways of looking at existing data become available.	• read a measurement from a graduated scale, stating measured digits plus the estimated digit. • use appropriate technology for data collection and analysis, including probeware interfaced to a graphing calculator and/or computer and computer simulations. • summarize knowledge gained through gathering and appropriate processing of data in a report that documents background, objective(s), data collection, data analysis and conclusions. • explain the emergence of modern theories based on historical development. For example, students should be able to explain the origin of the atomic theory beginning with the Greek atomists and continuing through the most modern quantum models.

Standard CH.1

Resources	Teacher Notes
Text: World of Chemistry. McDougall Littell. 2002. Virginia Standards of Learning Supplement *to accompany* World of Chemistry. McDougall Littell. 2002 Sample Lesson Plans from the VA Department of Education Science Enhanced Scope and Sequence. http://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml Use of Significant Digits in Chemistry – Technical Assistance Document from the Virginia Department of Education, December 2012. http://www.doe.virginia.gov/instruction/science/resources/tech_assistance_significant_digits.pdf	

Standard CH.2

CH.2	The student will investigate and understand that the placement of elements on the periodic table is a function of their atomic structure. The periodic table is a tool used for the investigations of a) average atomic mass, mass number, and atomic number; b) isotopes, half lives, and radioactive decay; c) mass and charge characteristics of subatomic particles; d) families or groups; e) periods; f) trends including atomic radii, electronegativity, shielding effect, and ionization energy; g) electron configurations, valence electrons, and oxidation numbers; h) chemical and physical properties; and i) historical and quantum models.

Essential Understandings	Essential Knowledge and Skills
The concepts developed in this standard include the following: • The periodic table is arranged in order of increasing atomic numbers. • The atomic number of an element is the same as the number of protons. In a neutral atom, the number of electrons is the same as the number of protons. All atoms of an element have the same number of protons. • The average atomic mass for each element is the weighted average of that element's naturally occurring isotopes. • The mass number of an element is the sum of the number of protons and neutrons. It is different for each element's isotopes. • An isotope is an atom that has the same number of protons as another atom of the same element but has a different number of neutrons. Some isotopes are radioactive; many are not. • Half-life is the length of time required for half of a given sample of a radioactive isotope to decay. • Electrons have little mass and a negative (–) charge. They are located in electron clouds or probability clouds outside the nucleus. • Protons have a positive (+) charge. Neutrons have no charge. Protons and neutrons are located in the nucleus of the atom and comprise most of its mass. Quarks are also located in the nucleus of the atom.	In order to meet this standard, it is expected that students will • determine the atomic number, atomic mass, the number of protons, and the number of electrons of any atom of a particular element using a periodic table. • determine the number of neutrons in an isotope given its mass number. • perform calculations to determine the "weighted" average atomic mass. • perform calculations involving the half-life of a radioactive substance. • differentiate between alpha, beta, and gamma radiation with respect to penetrating power, shielding, and composition. • differentiate between the major atom components (proton, neutron and electron) in terms of location, size, and charge. • distinguish between a group and a period. • identify key groups, periods, and regions of elements on the periodic table. • identify and explain trends in the periodic table as they relate to ionization energy, electronegativity, shielding effect, and relative

Standard CH.2

- The names of groups and periods on the periodic chart are alkali metals, alkaline earth metals, transition metals, halogens, and noble gases.
- Metalloids have properties of metals and nonmetals. They are located between metals and nonmetals on the periodic table. Some are used in semiconductors.
- Periods and groups are named by numbering columns and rows. Horizontal rows called periods have predictable properties based on an increasing number of electrons in the outer energy levels. Vertical columns called groups or families have similar properties because of their similar valence electron configurations.
- The Periodic Law states that when elements are arranged in order of increasing atomic numbers, their physical and chemical properties show a periodic pattern.
- Periodicity is regularly repeating patterns or trends in the chemical and physical properties of the elements arranged in the periodic table.
- Atomic radius is the measure of the distance between radii of two identical atoms of an element. Atomic radius decreases from left to right and increases from top to bottom within given groups.
- Electronegativity is the measure of the attraction of an atom for electrons in a bond. Electronegativity increases from left to right within a period and decreases from top to bottom within a group.
- Shielding effect is constant within a given period and increases within given groups from top to bottom.
- Ionization energy is the energy required to remove the most loosely held electron from a neutral atom. Ionization energies generally increase from left to right and decrease from top to bottom of a given group.
- Electron configuration is the arrangement of electrons around the nucleus of an atom based on their energy level.
- Electrons are added one at a time to the lowest energy levels first (Aufbau Principle). Electrons occupy equal-energy orbitals so that a maximum number of unpaired electrons results (Hund's Rule).
- Energy levels are designated 1–7. Orbitals are designated s, p, d, and f according to their shapes and relate to the regions of the Periodic Table.

sizes.

- compare an element's reactivity to the reactivity of other elements in the table.
- relate the position of an element on the periodic table to its electron configuration.
- determine the number of valence electrons and possible oxidation numbers from an element's electron configuration.
- write the electron configuration for the first 20 elements of the periodic table.
- distinguish between physical and chemical properties of metals and nonmetals.
- differentiate between pure substances and mixtures and between homogeneous and heterogeneous mixtures.
- identify key contributions of principal scientists including:
  - *atomos*, initial idea of atom – Democritus
  - first atomic theory of matter, solid sphere model – John Dalton
  - discovery of the electron using the cathode ray tube experiment, plum pudding model – J. J. Thomson
  - discovery of the nucleus using the gold foil experiment, nuclear model – Ernest Rutherford
  - discovery of charge of electron using the oil drop experiment – Robert Millikan
  - energy levels, planetary model – Niels Bohr
  - periodic table arranged by atomic mass – Dmitri Mendeleev
  - periodic table arranged by atomic number – Henry Moseley
  - quantum nature of energy – Max Planck
  - uncertainty principle, quantum mechanical model – Werner Heisenberg
  - wave theory, quantum mechanical model – Louis de Broglie.
- differentiate between the historical and quantum models of the atom.

Standard CH.2

An orbital can hold a maximum of two electrons (Pauli Exclusion Principle). • Atoms can gain, lose, or share electrons within the outer energy level. • Loss of electrons from neutral atoms results in the formation of an ion with a positive charge (cation). Gain of electrons by a neutral atom results in the formation of an ion with a negative charge (anion). • Transition metals can have multiple oxidation states. • Matter occurs as elements (pure), compounds (pure), and mixtures, which may be homogeneous (solutions) or heterogeneous. Some elements, such as oxygen, hydrogen, fluorine, chlorine, bromine, iodine, and nitrogen, naturally occur as diatomic molecules. • Matter is classified by its chemical and physical properties. • Physical properties refer to the condition or quality of a substance that can be observed or measured without changing the substance's composition. Important physical properties are density, conductivity, melting point, boiling point, malleability, and ductility. • Chemical properties refer to the ability of a substance to undergo chemical reaction and form a new substance. • Reactivity is the tendency of an element to enter into a chemical reaction. • Discoveries and insights related to the atom's structure have changed the model of the atom over time. Historical models have included solid sphere, plum pudding, nuclear, and planetary models. The modern atomic theory is called the quantum mechanical model.	

Standard CH.2

Resources	Teacher Notes
Text: World of Chemistry. McDougall Littell. 2002. Virginia Standards of Learning Supplement *to accompany* World of Chemistry. McDougall Littell. 2002 Sample Lesson Plans from the VA Department of Education Science Enhanced Scope and Sequence. http://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml	

Standard CH.3

CH.3	The student will investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations. Key concepts include a) nomenclature; b) balancing chemical equations; c) writing chemical formulas; d) bonding types; e) reaction types; and f) reaction rates, kinetics, and equilibrium.

Essential Understandings	Essential Knowledge and Skills
The concepts developed in this standard include the following: • Chemical formulas are used to represent compounds. Subscripts represent the relative number of each type of atom in a molecule or formula unit. The International Union of Pure and Applied Chemistry (IUPAC) system is used for naming compounds. • When pairs of elements form two or more compounds, the masses of one element that combine with a fixed mass of the other element form simple, whole-number ratios (Law of Multiple Proportions). • Compounds have different properties than the elements from which they are composed. • Conservation of matter is represented in balanced chemical equations. A coefficient is a quantity that precedes a reactant or product formula in a chemical equation and indicates the relative number of particles involved in the reaction. • The empirical formula shows the simplest whole-number ratio in which the atoms of the elements are present in the compound. The molecular formula shows the actual number of atoms of each element in one molecule of the substance. • Lewis dot diagrams are used to represent valence electrons in an element. Structural formulas show the arrangements of atoms and bonds in a molecule and are represented by Lewis dot structures. • Bonds form between atoms to achieve stability. Covalent bonds involve	In order to meet this standard, it is expected that students will • name binary covalent/molecular compounds. • name binary ionic compounds (using the Roman numeral system where appropriate). • predict, draw, and name molecular shapes (bent, linear, trigonal planar, tetrahedral, and trigonal pyramidal). • transform word equations into chemical equations and balance chemical equations. • write the chemical formulas for certain common substances, such as ammonia, water, carbon monoxide, carbon dioxide, sulfur dioxide, and carbon tetrafluoride. • use polyatomic ions for naming and writing formulas of ionic compounds, including carbonate, sulfate, nitrate, hydroxide, phosphate, and ammonium. • draw Lewis dot diagrams to represent valence electrons in elements and draw Lewis dot structures to show covalent bonding. • use valence shell electron pair repulsion (VSEPR) model to draw and name molecular shapes (bent, linear, trigonal planar, tetrahedral, and trigonal pyramidal). • recognize polar molecules and non-polar molecules.

Standard CH.3

Essential Understandings	Essential Knowledge and Skills
the sharing of electrons between atoms. Ionic bonds involve the transfer of electrons between ions. Elements with low ionization energy form positive ions (cations) easily. Elements with high ionization energy form negative ions (anions) easily. Polar bonds form between elements with very different electronegativities. Non-polar bonds form between elements with similar electronegativities. • Polar molecules result when electrons are distributed unequally. • Major types of chemical reactions are - synthesis ($A+B \rightarrow AB$) - decomposition ($BC \rightarrow B+C$) - single replacement ($A+BC \rightarrow B+AC$) - double replacement ($AC+BD \rightarrow AD+BC$) - neutralization ($HX+MOH \rightarrow H_2O + MX$) - combustion ($C_xH_y + O_2 \rightarrow CO_2 + H_2O$). • Kinetics is the study of reaction rates. Several factors affect reaction rates, including temperature, concentration, surface area, and the presence of a catalyst. • Reaction rates/kinetics are affected by activation energy, catalysis, and the degree of randomness (entropy). Catalysts decrease the amount of activation energy needed. • Chemical reactions are exothermic reactions (heat producing) and endothermic reactions (heat absorbing). • Reactions occurring in both forward and reverse directions are reversible. Reversible reactions can reach a state of equilibrium, where the reaction rates of both the forward and reverse reactions are constant. Le Chatelier's Principle indicates the qualitative prediction of direction of change with temperature, pressure, and concentration.	• classify types of chemical reactions as synthesis, decomposition, single replacement, double replacement, neutralization, and/or combustion. • recognize that there is a natural tendency for systems to move in a direction of randomness (entropy). • recognize equations for redox reactions and neutralization reactions. • distinguish between an endothermic and exothermic process. • interpret reaction rate diagrams. • identify and explain the effect the following factors have on the rate of a chemical reaction: catalyst, temperature, concentration, size of particles. • distinguish between irreversible reactions and those at equilibrium. • predict the shift in equilibrium when a system is subjected to a stress (Le Chatelier's Principle) and identify the factors that can cause a shift in equilibrium (temperature, pressure, and concentration.)

Standard CH.3

Resources	Teacher Notes
Text: World of Chemistry. McDougall Littell. 2002. Virginia Standards of Learning Supplement *to accompany* World of Chemistry. McDougall Littell. 2002 Sample Lesson Plans from the VA Department of Education Science Enhanced Scope and Sequence. http://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml	

Standard CH.4

CH.4	The student will investigate and understand that chemical quantities are based on molar relationships. Key concepts include a) Avogadro's principle and molar volume; b) stoichiometric relationships; c) solution concentrations; and d) acid/base theory; strong electrolytes, weak electrolytes, and nonelectrolytes; dissociation and ionization; pH and pOH; and the titration process.

Essential Understandings	Essential Knowledge and Skills
The concepts developed in this standard include the following: • Atoms and molecules are too small to count by usual means. A mole is a way of counting any type of particle (atoms, molecules, and formula units). • Avogadro's number = 6.02×10^{23} particles per mole. • Molar mass of a substance is its average atomic mass in grams from the Periodic Table. • Molar volume = 22.4 L/mole for any gas at standard temperature and pressure (STP). • Stoichiometry involves quantitative relationships. Stoichiometric relationships are based on mole quantities in a balanced equation. • Total grams of reactant(s) = total grams of product(s). • Molarity = moles of solute/L of solution. • [ ] refers to molar concentration. • When solutions are diluted, the moles of solute present initially remain. • The saturation of a solution is dependent on the amount of solute present in the solution. • Two important classes of compounds are acids and bases. Acids and bases are defined by several theories. According to the Arrhenius theory, acids are characterized by their sour taste, low pH, and the fact that they turn litmus paper red. According to the Arrhenius theory,	In order to meet this standard, it is expected that students will • perform conversions between mass, volume, particles, and moles of a substance. • perform stoichiometric calculations involving the following relationships: - mole-mole; - mass-mass; - mole-mass; - mass-volume; - mole-volume; - volume-volume; - mole-particle; - mass-particle; and - volume-particle. • identify the limiting reactant (reagent) in a reaction. • calculate percent yield of a reaction. • perform calculations involving the molarity of a solution, including dilutions. • interpret solubility curves. • differentiate between the defining characteristics of the Arrhenius theory of acids and bases and the Bronsted-Lowry theory of acids and bases. • identify common examples of acids and bases, including vinegar and ammonia.

Standard CH.4

Essential Understandings	Essential Knowledge and Skills
bases are characterized by their bitter taste, slippery feel, high pH, and the fact that they turn litmus paper blue. According to the Bronsted-Lowry theory, acids are proton donors, whereas bases are proton acceptors. Acids and bases dissociate in varying degrees. • Strong electrolytes dissociate completely. Weak electrolytes dissociate partially. Non-electrolytes do not dissociate. • pH is a number scale ranging from 0 to 14 that represents the acidity of a solution. The pH number denotes hydrogen (hydronium) ion concentration. The pOH number denotes hydroxide ion concentration. The higher the hydronium [H_3O^+] concentration, the lower the pH. • pH + pOH = 14 • Strong acid-strong base titration is the process that measures [H^+] and [OH^-]. • Indicators show color changes at certain pH levels.	• compare and contrast the differences between strong, weak, and non-electrolytes. • relate the hydronium ion concentration to the pH scale. • perform titrations in a laboratory setting using indicators.

Standard CH.4

Resources	Teacher Notes
Text: World of Chemistry. McDougall Littell. 2002. Virginia Standards of Learning Supplement *to accompany* World of Chemistry. McDougall Littell. 2002 Sample Lesson Plans from the VA Department of Education Science Enhanced Scope and Sequence. http://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml	

Standard CH.5

CH.5	The student will investigate and understand that the phases of matter are explained by kinetic theory and forces of attraction between particles. Key concepts include a) pressure, temperature, and volume; b) partial pressure and gas laws; c) vapor pressure; d) phase changes; e) molar heats of fusion and vaporization; f) specific heat capacity; and g) colligative properties.

Essential Understandings	Essential Knowledge and Skills
The concepts developed in this standard include the following: • Atoms and molecules are in constant motion. • The phase of a substance depends on temperature and pressure. • Temperature is a measurement of the average kinetic energy in a sample. There is a direct relationship between temperature and average kinetic energy. • The kinetic molecular theory is a model for predicting and explaining gas behavior. • Gases have mass and occupy space. Gas particles are in constant, rapid, random motion and exert pressure as they collide with the walls of their containers. Gas molecules with the lightest mass travel fastest. Relatively large distances separate gas particles from each other. • Equal volumes of gases at the same temperature and pressure contain an equal number of particles. Pressure units include atm, kPa, and mm Hg. • An ideal gas does not exist, but this concept is used to model gas behavior. A real gas exists, has intermolecular forces and particle volume, and can change states. The Ideal Gas Law states that $PV = nRT$. • The pressure and volume of a sample of a gas at constant temperature are inversely proportional to each other (Boyle's Law: $P_1V_1 = P_2V_2$). • At constant pressure, the volume of a fixed amount of gas is directly proportional to its absolute temperature (Charles' Law: $V_1/T_1 = V_2/T_2$).	In order to meet this standard, it is expected that students will • explain the behavior of gases and the relationship between pressure and volume (Boyle's Law), and volume and temperature (Charles' Law). • solve problems and interpret graphs involving the gas laws. • identify how hydrogen bonding in water plays an important role in many physical, chemical, and biological phenomena. • interpret vapor pressure graphs. • graph and interpret a heating curve (temperature vs. time). • interpret a phase diagram of water. • calculate energy changes, using molar heat of fusion and molar heat of vaporization. • calculate energy changes, using specific heat capacity. • examine the polarity of various solutes and solvents in solution formation.

Standard CH.5

Essential Understandings	Essential Knowledge and Skills
• The Combined Gas Law ($P_1V_1/T_1 = P_2V_2/T_2$) relates pressure, volume, and temperature of a gas. • The sum of the partial pressures of all the components in a gas mixture is equal to the total pressure of a gas mixture (Dalton's law of partial pressures). • Forces of attraction (intermolecular forces) between molecules determine their state of matter at a given temperature. Forces of attraction include hydrogen bonding, dipole-dipole attraction, and London dispersion (van der Waals) forces. • Vapor pressure is the pressure of the vapor found directly above a liquid in a closed container. When the vapor pressure equals the atmospheric pressure, a liquid boils. Volatile liquids have high vapor pressures, weak intermolecular forces, and low boiling points. Nonvolatile liquids have low vapor pressures, strong intermolecular forces, and high boiling points. • Solid, liquid, and gas phases of a substance have different energy content. Pressure, temperature, and volume changes can cause a change in physical state. Specific amounts of energy are absorbed or released during phase changes. • A fourth phase of matter is plasma. Plasma is formed when a gas is heated to a temperature at which its electrons dissociate from the nuclei. • A heating curve graphically describes the relationship between temperature and energy (heat). It can be used to identify a substance's phase of matter at a given temperature as well as the temperature(s) at which it changes phase. It also shows the strength of the intermolecular forces present in a substance. • Molar heat of fusion is a property that describes the amount of energy needed to convert one mole of a substance between its solid and liquid states. Molar heat of vaporization is a property that describes the amount of energy needed to convert one mole of a substance between its liquid and gas states. Specific heat capacity is a property of a substance that tells the amount of energy needed to raise one gram of a substance by one degree Celsius. The values of these properties are related to the strength of their intermolecular forces.	

Standard CH.5

Essential Understandings	Essential Knowledge and Skills
• Solutions can be a variety of solute/solvent combinations: gas/gas, gas/liquid, liquid/liquid, solid/liquid, gas/solid, liquid/solid, or solid/solid. • Polar substances dissolve ionic or polar substances; nonpolar substances dissolve nonpolar substances. The number of solute particles changes the freezing point and boiling point of a pure substance. • A liquid's boiling point and freezing point are affected by changes in atmospheric pressure. A liquid's boiling point and freezing point are affected by the presence of certain solutes.	

Resources	Teacher Notes
Text: World of Chemistry. McDougall Littell. 2002. Virginia Standards of Learning Supplement *to accompany* World of Chemistry. McDougall Littell. 2002 Sample Lesson Plans from the VA Department of Education Science Enhanced Scope and Sequence. http://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml	

Standard CH.6

CH.6	The student will investigate and understand how basic chemical properties relate to organic chemistry and biochemistry. Key concepts include a) unique properties of carbon that allow multi-carbon compounds; and b) uses in pharmaceuticals and genetics, petrochemicals, plastics and food.

Essential Understandings	Essential Knowledge and Skills
It is expected that the content of this SOL is incorporated into the appropriate SOL as that content is being taught (i.e., bonding types, shapes, etc.) and not isolated as a discrete unit. The concepts developed in this standard include the following: • The bonding characteristics of carbon contribute to its stability and allow it to be the foundation of organic molecules. These characteristics result in the formation of a large variety of structures such as DNA, RNA and amino acids. • Carbon-based compounds include simple hydrocarbons, small carbon-containing molecules with functional groups, complex polymers, and biological molecules. • Petrochemicals contain hydrocarbons, including propane, butane, and octane. • There is a close relationship between the properties and structure of organic molecules. • Common pharmaceuticals that are organic compounds include aspirin, vitamins, and insulin. • Small molecules link to make large molecules called polymers that have combinations with repetitive subunits. Natural polymers include proteins and nucleic acids. Human-made (synthetic) polymers include polythene, nylon and Kevlar.	In order to meet this standard, it is expected that students will • describe how saturation affects shape and reactivity of carbon compounds. • draw Lewis dot structures, identify geometries, and describe polarities of the following molecules: CH_4, C_2H_6, C_2H_4, C_2H_2, CH_3CH_2OH, CH_2O, C_6H_6, CH_3COOH. • recognize that organic compounds play a role in natural and synthetic pharmaceuticals. • recognize that nucleic acids and proteins are important natural polymers. • recognize that plastics formed from petrochemicals are organic compounds that consist of long chains of carbons. • conduct a lab that exemplifies the versatility and importance of organic compounds (e.g., aspirin, an ester, a polymer).

Standard CH.6

Resources	Teacher Notes
Text: World of Chemistry. McDougall Littell. 2002. Virginia Standards of Learning Supplement *to accompany* World of Chemistry. McDougall Littell. 2002 Sample Lesson Plans from the VA Department of Education Science Enhanced Scope and Sequence. http://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml	

Appendix A – Chemistry Focal Points

Foundations
- Scientific Investigation & Experimental Design
- Measurement & Math Review
- Lab Safety & Equipment
- Percent Error
- Precision /Accuracy
- SI Units, Density
- Graphing, Probeware

Matter
- Classification
- Phases And Changes
- Separation
- Phase Diagrams
- Physical & Chemical Properties
- Specific Heat
- Calorimetry

Atoms
- Atomic #, Atomic Mass
- Subatomic Particles
- History / Models
- Isotopes, Ions, Nuclear (Fission / Fusion, Half-Life, Alpha, Beta, Gamma)

Periodic Table
- Families / Groups
- Periods
- Metals / Nonmetals
- Trends
- Oxidation Numbers
- Shielding

Modern Atomic Theory
- Electron Configurations (Atoms And Ions), Valence
- Electrons, Quantum Numbers
- Orbital Notations, Uncertainty Principle
- Hunds, Pauli, Aufbau
- Light, Noble Gas Notation, Shielding

Bonding
- Ionic and Covalent (Types)
- Lewis Structures
- VSEPR, Resonance
- Polarity
- Hybrid Orbitals, Energies

Nomenclature
- Naming Compounds & Writing Formulas
- Ionic and Covalent
- Polyatomic Ions

Reactions
- Types (5 Main Types)
- Balancing
- Driving Forces
- Net Ionic Equations
- Redox & Electrochemistry

Moles
- Mole Conversions (Mass, Volume, Number)
- Percent Composition
- Empirical & Molecular Formula
- Formula Mass

Stoichiometry
- Calculations
- Percent Yield
- Limiting Reaction

Gases
- KMT, Pressure
- Gas Laws, STP
- Kelvin Scale
- Gas Densities

Solids and Liquids
- Intermolecular Forces
- Heat of Fusion & Heat of Vaporization
- Vapor Pressure

Solutions
- Molarity, Molality, %
- Preparation, Dilution & Saturation
- Solubility Curves
- Electrolytes
- Rates of Solution
- Solubility Process
- Colligative Properties

Equilibrium / Kinetics
- LeChatlier, K_{eg}
- Reaction Rates
- Reaction Pathways
- Endothermic & Exothermic
- Catalysts
- Enthalpy, Entropy

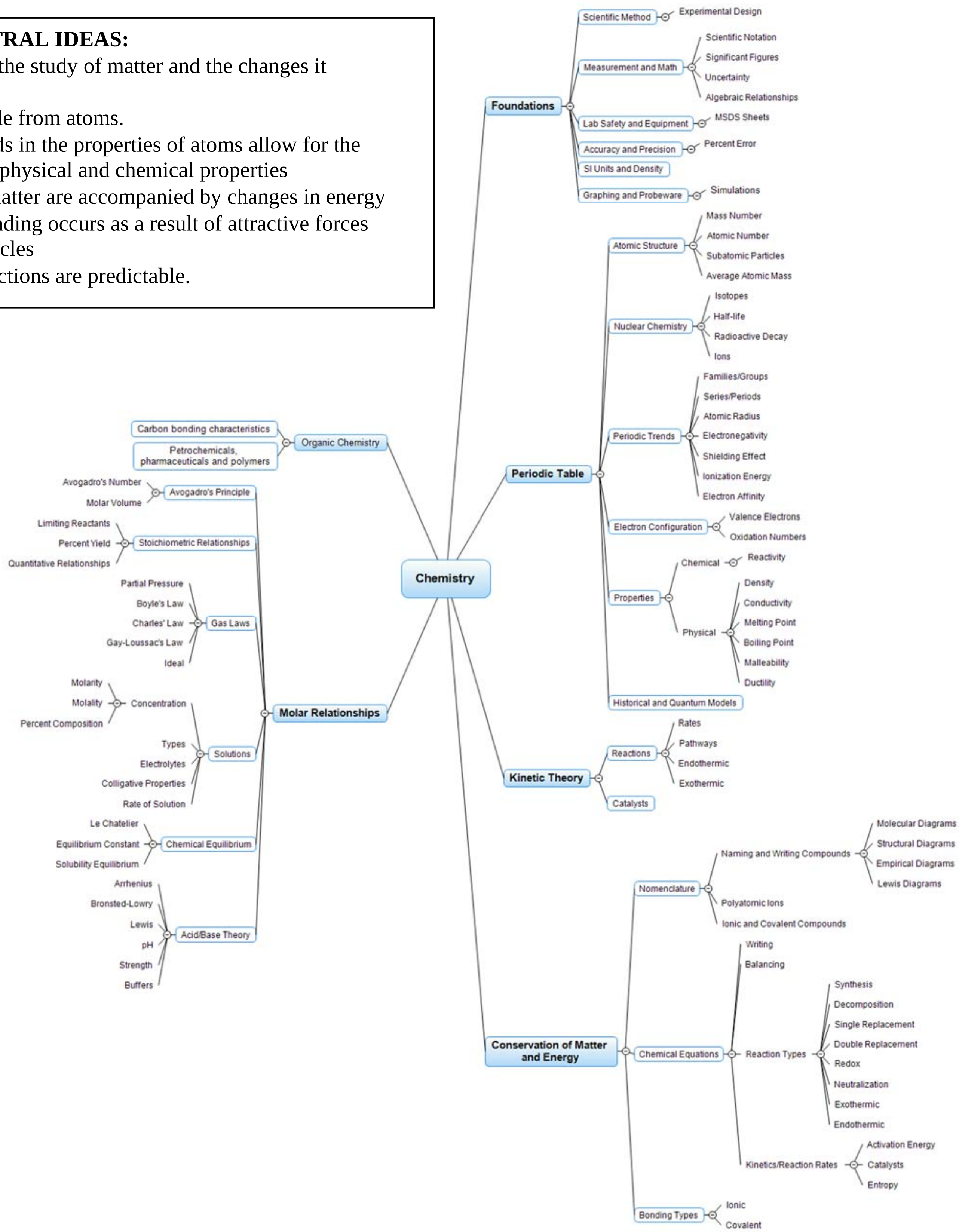
Acids and Bases
- Neutralization, Kw
- pH, Titration
- Properties, Strengths Indicators
- 3 Types, Buffers

Organic/Biochemistry
- Nomenclature
- Bonding Properties
- Lewis dot structures
- Geometries
- Polarity
- Pharmaceuticals
- Polymers
- Uses

Appendix B – Chemistry Central Ideas and Concept Map

COURSE CENTRAL IDEAS:

- Chemistry is the study of matter and the changes it undergoes.
- Matter is made from atoms.
- Periodic trends in the properties of atoms allow for the prediction of physical and chemical properties
- Changes in matter are accompanied by changes in energy
- Chemical bonding occurs as a result of attractive forces between particles
- Chemical reactions are predictable.



Appendix C – Vertical Alignment of Standards by Learning Strands

Scientific Investigation, Reasoning, and Logic

Grade Six	6.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which a) observations are made involving fine discrimination between similar objects and organisms; b) precise and approximate measurements are recorded; c) scale models are used to estimate distance, volume, and quantity; d) hypotheses are stated in ways that identify the independent and dependent variables; e) a method is devised to test the validity of predictions and inferences; f) one variable is manipulated over time, using many repeated trials; g) data are collected, recorded, analyzed, and reported using metric measurements and tools; h) data are analyzed and communicated through graphical representation; i) models and simulations are designed and used to illustrate and explain phenomena and systems; and j) current applications are used to reinforce science concepts.
Life Science	LS.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which a) data are organized into tables showing repeated trials and means; b) a classification system is developed based on multiple attributes; c) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and probeware are used to gather data; d) models and simulations are constructed and used to illustrate and explain phenomena; e) sources of experimental error are identified; f) dependent variables, independent variables, and constants are identified; g) variables are controlled to test hypotheses, and trials are repeated; h) data are organized, communicated through graphical representation, interpreted, and used to make predictions; i) patterns are identified in data and are interpreted and evaluated; and j) current applications are used to reinforce life science concepts.
Physical Science	PS.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which a) chemicals and equipment are used safely; b) length, mass, volume, density, temperature, weight, and force are accurately measured; c) conversions are made among metric units, applying appropriate prefixes; d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data; e) numbers are expressed in scientific notation where appropriate; f) independent and dependent variables, constants, controls, and repeated trials are identified; g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted; h) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted; i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted; j) valid conclusions are made after analyzing data; k) research methods are used to investigate practical problems and questions; l) experimental results are presented in appropriate written form; m) models and simulations are constructed and used to illustrate and explain phenomena; and n) current applications of physical science concepts are used.
Earth Science	ES.1 The student will plan and conduct investigations in which a) volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools; b) technologies, including computers, probeware, and geospatial technologies, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions; c) scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted; d) maps and globes are read and interpreted, including location by latitude and longitude; e) variables are manipulated with repeated trials; and f) current applications are used to reinforce Earth science concepts.

Appendix C – Vertical Alignment of Standards by Learning Strands

Biology	BIO.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which a) observations of living organisms are recorded in the lab and in the field; b) hypotheses are formulated based on direct observations and information from scientific literature; c) variables are defined and investigations are designed to test hypotheses; d) graphing and arithmetic calculations are used as tools in data analysis; e) conclusions are formed based on recorded quantitative and qualitative data; f) sources of error inherent in experimental design are identified and discussed; g) validity of data is determined; h) chemicals and equipment are used in a safe manner; i) appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions; j) research utilizes scientific literature; k) differentiation is made between a scientific hypothesis, theory, and law; l) alternative scientific explanations and models are recognized and analyzed; and m) current applications of biological concepts are used.
Chemistry	CH.1 The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include a) designated laboratory techniques; b) safe use of chemicals and equipment; c) proper response to emergency situations; d) manipulation of multiple variables, using repeated trials; e) accurate recording, organization, and analysis of data through repeated trials; f) mathematical and procedural error analysis; g) mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis; h) use of appropriate technology including computers, graphing calculators, and probeware, for gathering data, communicating results, and using simulations to model concepts; i) construction and defense of a scientific viewpoint; and the use of current applications to reinforce chemistry concepts
Physics	PH.1 The student will plan and conduct investigations using experimental design and product design processes. Key concepts include a) the components of a system are defined; b) instruments are selected and used to extend observations and measurements; c) information is recorded and presented in an organized format; d) the limitations of the experimental apparatus and design are recognized; e) the limitations of measured quantities are recognized through the appropriate use of significant figures or error ranges; f) models and simulations are used to visualize and explain phenomena, to make predictions from hypotheses, and to interpret data; and g) appropriate technology, including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results.

Appendix C – Vertical Alignment of Standards by Learning Strands

Matter

Grade Six	6.4 The student will investigate and understand that all matter is made up of atoms. Key concepts include a) atoms consist of particles, including electrons, protons, and neutrons; b) atoms of a particular element are alike but are different from atoms of other elements; c) elements may be represented by chemical symbols; d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds); e) compounds may be represented by chemical formulas; f) chemical equations can be used to model chemical changes; and g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere. 6.5 The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include a) water as the universal solvent; b) the properties of water in all three phases.
Physical Science	PS.2 The student will investigate and understand the nature of matter. Key concepts include a) the particle theory of matter; b) elements, compounds, mixtures, acids, bases, and salts; c) solids, liquids, and gases; d) physical properties; e) chemical properties; and f) characteristics of types of matter based on physical and chemical properties. PS.3 The student will investigate and understand the modern and historical models of atomic structure. Key concepts include a) the contributions of Dalton, Thomson, Rutherford, and Bohr in understanding the atom; and b) the modern model of atomic structure. PS.4 The student will investigate and understand the organization and use of the periodic table of elements to obtain information. Key concepts include a) symbols, atomic numbers, atomic mass, chemical families (groups), and periods; b) classification of elements as metals, metalloids, and nonmetals; and c) formation of compounds through ionic and covalent bonding. PS.5 The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include a) physical changes; b) chemical changes; and c) nuclear reactions.