### Standard 1: Life Science

No standards apply.

### Standard 2: Physical Science

*As a basis for understanding Physical Science, students will develop the following knowledge, skills and understandings:*

#### 2.1 Students understand the structure and properties of matter.

- **2.1.1** Matter can be classified between pure substances (elements and compounds) and mixtures (heterogeneous and homogenous).
  - **2.1.1.1** Differentiate between solutions (homogenous mixtures) and suspensions; including colloids.
  - **2.1.1.2** Separate, purify, and identify pure substance through the process of filtration, chromatography, distillation, and reverse osmosis.
  - **2.1.1.3** Apply the Law of Definite (Constant) Composition when using element symbols to devise chemical formulas.

- **2.1.2** Early and Modern Atomic Theories have impacted current atomic models.
  - **2.1.2.1** Understand Dalton’s Atomic Theory and the major contributions leading up to his theory.
  - **2.1.2.2** Use experimental basis to account for Thomson’s discovery of the electron and Rutherford’s discovery of the nucleus.
  - **2.1.2.3** Understand the experimental basis for the development of the quantum theory of atomic structure including the significance and limitations of the Bohr model, spectral lines and contributions of Planck, DeBroglie, Heisenberg and Schrödinger.

- **2.1.3** Rutherford-Bohr models incorporate protons, neutrons, and electrons in their appropriate locations.
  - **2.1.3.1** Relate the size and mass of the nucleus to the size and mass of the atom; factoring the magnitude of difference.
  - **2.1.3.2** Know the relationship between atomic number (Z), atomic mass number (A), and the existence of isotopes to ultimately determine average atomic masses from abundance data.
  - **2.1.3.3** Know that most elements have two or more isotopes (having little effect on how the atom chemically interacts with others) effecting the mass and stability of the nucleus.
  - **2.1.3.4** Connect the charge of sub atomic particles to the electric force holding the atom together.
  - **2.1.3.5** Calculate the number of electrons in an atom therefore determining whether the atom is electrically neutral or an ion.

- **2.1.4** Modern atomic structure can be derived using information from the periodic table, quantum analysis, and probability.
  - **2.1.4.1** The quantum energy levels of atoms can be used to derive their structure and as a “fingerprint” for identification.
  - **2.1.4.2** Use the relationship among the four quantum numbers (n, l, m, and s) to describe atomic orbitals and electron configurations.
  - **2.1.4.3** Use Aufbau’s Principle, Pauli’s Exclusion Principle, and Hund’s Rule to construct electron spin diagrams differentiating between energy level, sublevel, and orbital.
  - **2.1.4.4** Determine electron configurations for atoms and relate the position of an element in the periodic table to its quantum electron configuration and reactivity with other elements in the table.
### 2.1.5 The periodic table shows how periodicity of the physical and chemical properties of the elements relates to atomic structure.
- **2.1.5.1** Understand the history and development of the periodic table; starting with Mendeleev’s vision.
- **2.1.5.2** Compare and contrast families, groups, periods, and/or series of elements on the Periodic Table.
- **2.1.5.3** Use the periodic table to identify representative and transition elements, metals, nonmetals, metalloids, the alkali metals, alkaline earth metals, halogens, noble gases and lanthanide and actinide series.
- **2.1.5.4** Use the periodic table to identify trends in atomic and ionic radii, ionization energy, electronegativity, and electron affinity; including predicting oxidation states.
- **2.1.5.5** Know the nature and properties of ionic and covalent bonding between atoms and predict, using the periodic table, the general nature of bonding between atoms.

### 2.1.6 Biological, chemical, and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules.
- **2.1.6.1** Know that salt crystals are repeating patterns (lattices) of cations and anions held together by electrostatic attractions.
- **2.1.6.2** Using ionization energies and electronegativity data, predict bond formation.
- **2.1.6.3** Use electronegativity to predict bond polarity.
- **2.1.6.4** Explain the nature of network covalent and metallic bonding.
- **2.1.6.5** Explain the general characteristics of compounds found by ionic, covalent, metallic and network covalent bonds.
- **2.1.6.6** Identify and explain inter-particle forces of attraction such as hydrogen bonding, dipole-dipole attractions, and van der Waals forces including London dispersion forces.
- **2.1.6.7** Draw Lewis dot structures to predict the shape and polarity of molecules (VSEPR).
- **2.1.6.8** Understand the need for resonance and sp³ hybridization to explain molecular structure.
- **2.1.6.9** Predict the boiling and melting temperatures of solids, liquids, and gases using knowledge of the relationship between the types of inter-particle attractions involved.
- **2.1.6.10** Use bond energies to predict heats of reaction.
- **2.1.6.11** Use concepts of resonance and hybridization to explain molecular structure (VB).
- **2.1.6.12** Use concepts of hybridization to explain sigma and pi bonding in molecules
- **2.1.6.13** Distinguish among structural, cis-trans and optical isomerism in simple organic molecules.

### 2.1.7 The chemical nomenclature system is used to descriptively name binary ionic, binary covalent, polyatomic, and acidic compounds.

### 2.1.8 Nuclear Processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes, nuclear fissions, and nuclear fusion.
- **2.1.8.1** Know that protons and neutrons in the nucleus are held together by nuclear forces that overcome proton-proton repulsions.
- **2.1.8.2** Know that the energy release in fission and fusion reactions is several magnitudes greater than energy releases in chemical and physical processes.
- **2.1.8.3** Identify the three most common forms of radioactive decay (alpha, beta, & gamma) and understand how the nucleus changes in each type of decay; including balancing nuclear equations.
### 2.1.8.4 Understand that alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrating effects.
### 2.1.8.5 Calculate the amount of radioactive substance remaining after a specific integral number of half-lives have passed.
### 2.1.8.6 Know neutrons and protons are made up of even smaller constituents.

#### 2.1.9 Students understand organic chemistry.
- **2.1.9.1** The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the biochemical basis of life.
- **2.1.9.2** Recognize the difference between carbon compounds that are classified as organic and those that are classified inorganic.
- **2.1.9.3** Identify monomers for some common polymers.
- **2.1.9.4** Organic nomenclature is a system based on structures for simple (C₁ to C₁₀) alkanes, alkenes, alkynes and aromatics; and their isomers.
- **2.1.9.5** Alkanes, alkenes and alkynes differ in their properties and reactivities.
- **2.1.9.6** Organic functional groups have specific reactive characteristics.

#### 2.2 Students understand chemical reactions.
- **2.2.1** Chemical reactions are processes in which reactants are re-arranged into products (different combinations of atoms).
  - **2.2.1.1** Identify synthesis, decomposition, single replacement, double replacement, precipitation, acid-base, and oxidation-reduction reactions.
  - **2.2.1.2** Identify reacting ionic and/or molecular species in chemical reactions; predicting their products, and balancing chemical reaction equations.
  - **2.2.1.3** Identify reactions that involve oxidation-reduction processes and balance redox reaction equations using oxidation numbers and half-reactions.
  - **2.2.1.4** Use standard oxidation and reduction potentials to predict redox reactions.
  - **2.2.1.5** Classify relevant chemicals into Acids and Bases and predict the Salts (based on their ions) formed when they neutralize in a water solution.
  - **2.2.1.6** Distinguish among acid-base models of Arrhenius, Brønsted-Lowry, and Lewis.
- **2.2.2** The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants; stoichiometry.
  - **2.2.2.1** Understand how Avogadro’s hypothesis is integral to the mole concept.
  - **2.2.2.2** Determine molar mass of representative particles from chemical formulas.
  - **2.2.2.3** Convert among mass, volume at STP, Avogadro’s number of particles and moles.
  - **2.2.2.4** Calculate percentage composition and determine both empirical and molecular formulas.
  - **2.2.2.5** Calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.
  - **2.2.2.6** Determine limiting reactants in chemical reactions and calculate percentage yields.
2.2.3 Chemical Equilibrium is a dynamic process at the molecular level.
2.2.3.1 Apply Le Chatelier’s Principle and relate shifts in chemical systems at equilibrium to the stresses applied such as change in temperature, change in concentration or reactants, and change in pressure of gases.
2.2.3.2 Write and calculate equilibrium constants and use K values to predict and explain the equilibrium.
2.2.3.3 Calculate $K_a$ and $K_b$ for acid-base reactions and use equilibrium constants to determine $pK_a$ and pH.
2.2.3.4 Formulate buffer solutions and understand how buffers stabilize pH in acid-base reactions.
2.2.3.5 Predict hydrolysis reactions and use hydrolysis reactions to determine pH, and $K_a$ values.
2.2.3.6 Use the Henderson-Hasselbalch formula to determine pH of buffer solutions.
2.2.3.7 Understand the concept of $K_{sp}$ and its application in predicting precipitation reactions.

2.3 Students understand the sources and properties of energy (in structure, reactions, phases, and solutions).
2.3.1 Energy can be considered either potential, kinetic, or contained by a field (electromagnetic fields).
2.3.1.1 Interpret potential energy diagrams describing chemical bonding.
2.3.1.2 Understand how electric forces hold atoms and molecules together.
2.3.1.3 Apply intermolecular attractive forces when explaining how solid and liquid materials are held together.

2.3.2 Each kind of atom or molecule can gain or lose energy only in particular discrete amounts.
2.3.2.1 Know the arrangement of the electromagnetic spectrum.
2.3.2.2 Know that energy in electromagnetic waves is carried in packets called photons.

2.3.3 Energy is exchanged or transformed in all chemical reactions and physical changes of matter.
2.3.3.1 Understand chemical reaction rates depend on factors that influence the frequency of collision of reactant molecules such as concentration, temperature and pressure.
2.3.3.2 Interpret the relationship between temperature and reaction rates using graphical data.
2.3.3.3 Explain the role of activation energy in chemical reactions.
2.3.3.4 Explain the role of a catalyst in chemical reactions; including metallic surfaces and enzymes
2.3.3.5 Determine reaction rate orders, rate constants, and reaction rates from experimental data (differential rate laws)
2.3.3.6 Evaluate proposed reaction mechanisms given appropriate data.

2.3.4 The Kinetic Molecular Theory describes the motion of atoms and molecules; specifically temperature and heat.
2.3.4.1 Distinguish between exothermic and endothermic processes.
2.3.4.2 Determine heats of fusion, heats of vaporization, or heats of reaction through calorimetry, both at constant pressure and at constant volume.
2.3.4.3 Use Hess’ Law to determine enthalpy changes in chemical reactions.
2.3.5 Phase diagrams interpret changes of state under different conditions.
  2.3.5.1 Relate vapor pressure and temperature.
  2.3.5.2 Relate energetics of phase changes to attractive forces between representative particles.

2.3.6 The Kinetic Molecular Theory explains the properties of gases.
  2.3.6.1 Know the random motion of gas particles and their collisions with a surface create observable pressure on that surface.
  2.3.6.2 Know the values and understand the meanings of standard temperature and pressure (STP).
  2.3.6.3 Apply the gas laws (including the Ideal Gas Law and Dalton’s Law) to relations between the pressure, temperature, volume, and amount of ideal gas or any mixture of ideal gases.
  2.3.6.4 Interpret the ideal gas laws using the Kinetic Molecular Theory.
  2.3.6.5 Relate conditions of pressure and temperature that minimize deviations of ideal gas behavior.
  2.3.6.6 Understand how the kinetic molecular theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms.
  2.3.6.7 Describe the characteristics of condensed states of matter using the kinetic molecular theory.

2.3.7 Solutions are homogenous mixtures of two or more substances.
  2.3.7.1 Describe the dissolving process at the molecular level using concepts of molecular motions and attractive forces between solute and solvent.
  2.3.7.2 Qualify and quantify colligative properties in terms of electrolytes and non-electrolytes.
  2.3.7.3 Understand how structural, temperature, pressure and surface area affect the dissolving process.
  2.3.7.4 Calculate the concentration of a solute in solution in terms of solubility, molarity, and mole fraction.

2.3.8 Nature and technological systems use physical, chemical, and nuclear change to produce nuclear energy.

2.4 Students understand forces and motion.

2.5 Students understand waves and optics.

2.6 Students understand electricity and magnetism.

Standard 3: Earth and Space Science

No standards apply.
Standard 4: Nature of Science

As a basis for understanding the nature of science as it relates to scientific knowledge, scientific inquiry, and scientific enterprise and to address content in the other standards students will:

4.1 Apply proper scientific measures when solving problems.
   4.1.1 Know and employ metric units when measuring and problem solving:
       4.1.1.1 Identify the seven major SI and laboratory metric units, i.e., meter, kilogram, second, ampere, Kelvin, and mole.
       4.1.1.2 Convert between prefixes nano to tera within the metric system.
       4.1.1.3 Differentiate and convert between the two temperature scales; Celsius and Kelvin.
       4.1.1.4 Contribute and solve derived values (volume and density) using correct SI units.
   4.1.2 Use problem solving strategies (including dimensional analysis) to solve mathematical problems
       4.1.2.1 Identify the potentially important information given in a problem when choosing an appropriate solution.
       4.1.2.2 Determine the true question and/or conceptual premise; applying appropriate units when applicable
       4.1.2.3 Properly manipulate conversion factors to dimensional analysis questions
   4.1.3 Reason unavoidable sources of error when discussing accuracy and precision (uncertainty) of results; examples include human, instrumental, systematic, and random errors
       4.1.3.1 Reason the number of significant digits, accuracy, and precision in problems and laboratory tools.
       4.1.3.2 Answer mathematical operations using scientific notation
   4.1.4 Demonstrate safety procedures within lab situations:
       4.1.4.1 Demonstrate proper lab safety.
       4.1.4.2 Locate and explain how to properly use safety equipment in the lab.
   4.1.5 Use technology and mathematics (e.g. measurement, formulas, charts, graphs) to perform accurate scientific investigations and communications
       4.1.5.1 Select and use appropriate lab tools, measuring devices, calculators, computers, probe ware, etc. correctly during investigations
       4.1.5.2 Utilize appropriate measurements, formulas, charts, graphs, etc. when analyzing laboratory data

4.2 Investigate the natural world using scientific inquiry.
   4.2.1 Effectively contribute to a collaborative group; including accepting roles, following norms, and successfully communicating.
   4.2.2 Design and conduct open ended scientific investigations; confirming scientific laws, theories, and models; or to explore new aspects of the natural world and new areas of science.
   4.2.3 Devise investigations that:
       4.2.3.1 Identify a focused problem or research question
       4.2.3.2 Formulate testable hypotheses that is related to the research question; supporting it quantitatively when appropriate
       4.2.3.3 Select relevant independent and dependent variables
4.2.3.4 Identify and clarify the method and controls; using appropriate apparatus
4.2.3.5 Demonstrate competence in using laboratory equipment (seeking assistance when required); paying attention to safety issues
4.2.3.6 Adapt to new and unforeseen circumstances while following instructions.
4.2.3.7 Employ methods that collect sufficient and relevant quantitative and/or qualitative data; using appropriate units.
4.2.3.8 Organize and display raw data for easier interpretation and analysis data.
4.2.3.9 Determine errors, their quantitative/qualitative effects they have on results, and calculate percent error when possible.
4.2.3.10 Formulate a conclusion based on interpretation of results with an explanation, and, where appropriate, compare results with literature values.
4.2.3.11 Receive critical response from others

4.2.4 Reason that when conditions of an investigation cannot be controlled, it may be necessary to discern patterns by observing a wide range of natural occurrences.

4.2.5 Know that conceptual principles and knowledge guide scientific inquiries; historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.

4.2.6 Comprehend why scientists conduct investigations:
4.2.6.1 To discover new aspects of the natural world
4.2.6.2 To explain recently observed phenomena
4.2.6.3 To test the conclusions of prior investigations
4.2.6.4 To test predictions of current theories

4.2.7 Appreciate that investigations and public communication among scientists must meet specific criteria in order to be accepted as new knowledge and methods:
4.2.7.1 Strive for certainty of proposed solutions using experimental standards.
4.2.7.2 Pursue arguments that are logical and do demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge.
4.2.7.3 Convey explanations with logical structure and rules of evidence.
4.2.7.4 Show commitment to making public their methods, procedures, and conclusions.
4.2.7.5 Report methods and procedures used to obtain evidence to enhance opportunities for further research.
4.2.7.6 Understand the logical and empirical communication among scientists and the public leads to new accountable information.
4.2.7.7 Continually test, revise, and occasionally discard theories to allow for critical response from others.
4.2.7.8 Know that all current scientific knowledge in principle is subject to change as new evidence become available.

4.2.8 Understand the Nature of Science Inquiry is driven by the desire to understand the natural world and seeks to answer questions that may or may not directly influence humans.

4.3 Evaluate the acquisition, development, and modification of scientific knowledge in the past, present, and future.

4.3.1 Know ways in which science distinguishes itself from other bodies of knowledge, through use of empirical standards and logical arguments.

4.3.2 Be aware that scientific explanations must meet certain criteria to be considered valid:
4.3.2.1 Must be consistent with experimental and observational evidence about nature
4.3.2.2 Make accurate predictions about systems being studied

Adapted from National (NSES), McRel and California State Science Standards Sub-standards in gray are not addressed in this course
Adopted by the Board on January 29, 2009

Singapore American School, revised August 2012
4.4 Examine how science and its enterprises impact society.

4.4.1 Compare and contrast science and technology
4.4.2 Reflect that throughout history, diverse cultures have developed scientific ideas and solved human problems through technology
4.4.3 Understand that individuals and teams contribute to scientific knowledge and understanding at different levels of complexity:
   4.4.3.1 Conducting basic field studies or improving advanced technology
   4.4.3.2 Creating new technologies
   4.4.3.3 Solving technological problems
   4.4.3.4 Collaborating on a major scientific question or technological problem
4.4.4 Comprehend the free and rapid interplay of theoretical ideas and experiments results in published scientific literature maintains crucial links between scientific fields
4.4.5 Develop information and technology skills which are essential in modern scientific endeavors
4.4.6 Appreciate that progress in Science/Technology can relate to social issues and challenges
4.4.7 Understand that there are ethical traditions associated with the scientific enterprise:
   4.4.7.1 Be committed to peer review.
   4.4.7.2 Report truthfully about methods and outcomes of investigations.
   4.4.7.3 Publish results of work with the expectation of peer review.
   4.4.7.4 Scientists who violate these traditions are censored by their peers
4.4.8 Consider that scientists and engineers can only conduct research on human subjects or stem cells if they have the consent of the subjects or governing bodies.
4.4.9 Accept that technology is often driven by the desire to help meet human needs, solve human problems, and fulfill human aspirations
4.4.10 Be able to assess a proposal from a scientific enterprise; including questions about: alternatives, risks, costs, benefits, with consideration of who benefits, who suffers, who pays, who gains, and who bears the risks
4.4.11 Validate that credible technological resources come from professional presentations, journal publications, and data bases
4.4.12 Understand that science and technology are essential social enterprises, but can only indicate what can happen, not what should happen
4.4.13 Acknowledge science is interdependent on different fields of study in different disciplines.
High School Science Curriculum: Accelerated Chemistry

4.4.13.1 Scientists in different disciplines ask different questions, use different methods of investigation and accept different types of evidence to support their explanations.

4.4.13.2 Many scientific investigations require the contributions of individuals from different disciplines

4.4.13.3 New disciplines of science often emerge at the interface of older disciplines

4.4.14 Undergo searches for current areas where data, information, and understanding are incomplete; therefore providing the best opportunity for students to advance in the science related career opportunities.

4.4.15 Comprehends that creativity, imagination, and a good knowledge base are all required in the work of science and engineering

4.5 Students understand the connections among science, global issues and sustainable solutions.

As a basis for this, students will understand:

4.5.1 Climate Change (Global Warming)
4.5.2 Biodiversity and Ecosystem Losses
4.5.3 Fisheries Depletion
4.5.4 Deforestation
4.5.5 Water Deficits
4.5.6 Air, Water and Soil Pollution
4.5.7 Global Infectious Diseases
4.5.8 Natural Disaster Prevention and Mitigation
4.5.9 Human Population Dynamics
4.5.10 Unsustainable Land Use
4.5.11 Solid Waste Management
4.5.12 Energy Conservation, alternative energy, alternative fuels