2021 Introduction

(1) Chemistry. In Chemistry, students conduct laboratory and field investigations, use scientific practices during investigations, and make informed decisions using critical thinking and scientific problem solving. Students study a variety of topics that include characteristics of matter, use of the Periodic Table, development of atomic theory, chemical bonding, chemical stoichiometry, gas laws, solution chemistry, acid-base chemistry, thermochemistry, and nuclear chemistry. Students investigate how chemistry is an integral part of our daily lives. By the end of Grade 12, students are expected to gain sufficient knowledge of the scientific and engineering practices across the disciplines of science to make informed decisions using critical thinking and scientific problem solving

(2) Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.

(3) Scientific hypotheses and theories. Students are expected to know that

- **(A)** hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and

- **(B)** scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.

(4) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked.

2017 Introduction

(1) *Chemistry. In Chemistry, students conduct laboratory and field investigations, use scientific practices during investigations, and make informed decisions using critical thinking and scientific problem solving. Students study a variety of topics that include characteristics of matter, use of the Periodic Table, development of atomic theory and chemical bonding, chemical stoichiometry, gas laws, solution chemistry, thermochemistry, and nuclear chemistry. Students will investigate how chemistry is an integral part of our daily lives.*

(2) *Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.*

(3) *Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world. Scientific practices of investigation can be experimental, descriptive, or comparative. The method chosen should be appropriate to the question being asked.*

(4) *Science and social ethics. Scientific decision making is a way of answering questions about the natural world. Students should be able to distinguish between scientific decision-making methods and ethical and social decisions that involve the application of scientific information.*

(5) *Scientific systems. A system is a collection of cycles, structures, and processes that interact. All systems have basic properties that can be described in terms of space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment..*

(6) *Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.*

2021 Introduction (continued)	2017 Introduction (continued)
Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified. **(A)** Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models. **(B)** Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models. **(5)** Science and social ethics. Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information). **(6)** Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide a tool for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment. **(7)** Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.	

2021	2017
Scientific and Engineering Practices	**Scientific Processes**
(1) Scientific and engineering practices. The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to answer questions, explain phenomena, or design solutions using appropriate tools and models. The student is expected to:	***(1)*** *Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:*
(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;	*NEW*
(B) use scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;	*(2)(E) plan and implement descriptive, comparative, and experimental investigations, including asking questions, formulating testable hypotheses, and selecting equipment and technology;*
(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency approved safety standards;	*(1)(A) demonstrate safe practices during laboratory and field investigations; and*
(D) use appropriate tools such as Safety Data Sheets (SDS), scientific or graphing calculators, computers and probes, electronic balances, an adequate supply of consumable chemicals, and sufficient scientific glassware such as beakers, Erlenmeyer flasks, pipettes, graduated cylinders, volumetric flasks, and burettes;	*(1)(B) know specific hazards of chemical substances such as flammability, corrosiveness, and radioactivity as summarized on the Safety Data Sheets (SDS);*
(E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;	*(2)(F) collect data and make measurements with accuracy and precision*
(F) organize quantitative and qualitative data using oral or written lab reports, labeled drawings, particle diagrams, charts, tables, graphs, journals, summaries, or technology based reports;	*(2)(I) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphs, journals, summaries, oral reports, and technology-based reports.*
(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and	*NEW*
(H) distinguish among scientific hypotheses, theories, and laws	*(2)(D) distinguish between scientific hypotheses and scientific theories;*
	REMOVED *(1)(C) demonstrate an understanding of the use and conservation of resources and the proper disposal of recycling materials.*

2021	2017
(2) Scientific and engineering practices. The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:	***(2) Scientific processes. The student uses scientific practices to solve investigative questions. The student is expected to:***
(A) identify advantages and limitations of models such as their size, scale, properties, and materials;	*NEW*
(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;	*(2)(H) organize, analyze, evaluate, make inferences, and predict trends from data; and*
(C) use mathematical calculations to assess quantitative relationships in data; and	*(2)(G) express and manipulate chemical quantities using scientific conventions and mathematical procedures, including dimensional analysis, scientific notation, and significant figures;*
(D) evaluate experimental and engineering designs.	*NEW*
	REMOVED *(2)(A) know the definition of science and understand that is has limitations, as specified in subsection (b)(2) of this section;* *(2)(B) know that hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories.* *(2)(C) know scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.*
(3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:	***(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:***
(A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;	*NEW*
(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and	*(2)(I) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.*

2021	2017
(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.	*NEW*
(4) Scientific and engineering practices. The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to:	***NEW***
(A) analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student;	*(3)(A) analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student;*
(B) relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as related to the content; and	*(3)(D) evaluate the impact of scientific research on society and the environment;*
(C) research and explore resources such as museums, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field in order to investigate STEM careers.	*(3)(F) research and describe the history of biology and contributions of scientists.*
	REMOVED *(3)(B) communicate and apply scientific information extracted from various sources such as current events, published journal articles, and marketing materials.* *(3)(C) draw inferences based on data related to promotional materials for products and services.*
Science Concepts	***Science Concepts***
	Characteristics of Matter ***(4) Science concepts. The student knows the characteristics of matter and can analyze the relationships between chemical and physical changes and properties. The student is expected to:***
	REMOVED *(4)(A) differentiate between physical and chemical changes and properties;* *(4)(B) identify extensive properties such as mass and volume and intensive properties such as density and melting point;*

2021	2017
	REMOVED continued *(4)(C) compare solids, liquids, and gases in terms of compressibility, structure, shape, and volume; and* *(4)(D) classify matter as pure substances or mixtures through investigation of their properties.*
Periodic Table **(5) Science concepts. The student understands the development of the Periodic Table and applies its predictive power. The student is expected to:**	***(5) Science concepts. The student understands the historical development of the Periodic Table and can apply its predictive power. The student is expected to:***
(A) explain the development of the Periodic Table over time using evidence such as chemical and physical properties;	*(5)(A) explain the use of chemical and physical properties in the historical development of the Periodic Table;*
(B) predict the properties of elements in chemical families, including alkali metals, alkaline earth metals, halogens, noble gases, and transition metals, based on valence electrons patterns using the Periodic Table; and	*(5)(B) identify and explain the properties of chemical families, including alkali metals, alkaline earth metals, halogens, noble gases, and transition metals, using the Periodic Table; and*
(C) analyze and interpret elemental data, including atomic radius, atomic mass, electronegativity, ionization energy, and reactivity to identify periodic trends	*(5)(C) interpret periodic trends, including atomic radius, electronegativity, and ionization energy, using the Periodic Table.*
Atomic Theory **(6) Science concepts. The student understands the development of atomic theory and applies it to real-world phenomena. The student is expected to:**	***(6) Science concepts. The student knows and understands the historical development of atomic theory. The student is expected to:***
(A) construct models using Dalton's Postulates, Thomson's discovery of electron properties, Rutherford's nuclear atom, Bohr's nuclear atom, and Heisenberg's Uncertainty Principle to show the development of modern atomic theory over time;	*(6)(A) describe the experimental design and conclusions used in the development of modern atomic theory, including Dalton's Postulates, Thomson's discovery of electron properties, Rutherford's nuclear atom, and Bohr's nuclear atom;*
(B) describe the structure of atoms and ions, including the masses, electrical charges, and locations of protons and neutrons in the nucleus and electrons in the electron cloud;	*NEW*
(C) investigate the mathematical relationship between energy, frequency, and wavelength of light using the electromagnetic spectrum and relate it to the quantization of energy in the emission spectrum;	*(6)(B) describe the mathematical relationships between energy, frequency, and wavelength of light using the electromagnetic spectrum;*

2021	2017
(D) calculate average atomic mass of an element using isotopic composition; and	*(6)(C) calculate average atomic mass of an element using isotopic composition; and*
(E) construct models to express the arrangement of electrons in atoms of representative elements using electron configurations and Lewis dot structures.	*(6)(D) express the arrangement of electrons in atoms of representative elements using electron configurations and Lewis valence electron dot structures.*
Bonding	
(7) Science concepts. The student knows how atoms form ionic, covalent, and metallic bonds. The student is expected to:	***(8) Science concepts. The student knows how atoms form ionic, covalent, and metallic bonds. The student is expected to:***
(A) construct an argument to support how periodic trends such as electronegativity can predict bonding between elements;	*NEW*
(B) name and write the chemical formulas for ionic and covalent compounds using International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules;	*(7)(A) name ionic compounds containing main group or transition metals, covalent compounds, acids, and bases using International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules;* *(7)(B) write the chemical formulas of ionic compounds containing representative elements, transition metals and common polyatomic ions, covalent compounds, and acids and bases;*
(C) classify and draw electron dot structures for molecules with linear, bent, trigonal planar, trigonal pyramidal, and tetrahedral molecular geometries as explained by Valence Shell Electron Pair Repulsion (VSEPR) theory; and	*(7)(E) classify molecular structure for molecules with linear, trigonal planar, and tetrahedral electron pair geometries as explained by Valence Shell Electron Pair Repulsion (VSEPR) theory.*
(D) analyze the properties of ionic, covalent, and metallic substances in terms of intramolecular and intermolecular forces.	*(7)(C) construct electron dot formulas to illustrate ionic and covalent bonds;* *(7)(D) describe metallic bonding and explain metallic properties such as thermal and electrical conductivity, malleability, and ductility; and*
Matter	
(8) Science concepts. The student understands how matter is accounted for in chemical substances. The student is expected to:	***(8) Science concepts. The student can quantify the changes that occur during chemical reactions. The student is expected to:***
(A) define mole and apply the concept of molar mass to convert between moles and grams;	*(8)(A) define and use the concept of a mole;*
(B) calculate the number of atoms or molecules in a sample of material using Avogadro's number;	*(8)(B) calculate the number of atoms or molecules in a sample of material using Avogadro's number;*
(C) calculate percent composition of compounds; and	*(8)(C) calculate percent composition of compounds;*
(D) differentiate between empirical and molecular formulas.	*(8)(D) differentiate between empirical and molecular formulas;*

2021	2017
(9) Science concepts. The student understands how matter is accounted for in chemical reactions. The student is expected to:	***NEW***
(A) interpret, write, and balance chemical equations, including synthesis, decomposition, single replacement, double replacement, and combustion reactions using the law of conservation of mass;	*(8)(E) write and balance chemical equations using the law of conservation of mass;*
(B) differentiate among acid-base reactions, precipitation reactions, and oxidation-reduction reactions;	*(8)(F) differentiate among double replacement reactions, including acid-base reactions and precipitation reactions, and oxidation-reduction reactions such as synthesis, decomposition, single replacement, and combustion reactions;*
(C) perform stoichiometric calculations, including determination of mass relationships, gas volume relationships, and percent yield; and	*(8)(G) perform stoichiometric calculations, including determination of mass and gas volume relationships between reactants and products and percent yield; and*
(D) describe the concept of limiting reactants in a balanced chemical equation.	*(8)(H) describe the concept of limiting reactants in a balanced chemical equation.*
(10) Science concepts. The student understands the principles of the kinetic molecular theory and ideal gas behavior. The student is expected to:	***(9) Science concepts. The student understands the principles of ideal gas behavior, kinetic molecular theory, and the conditions that influence the behavior of gases. The student is expected to:***
(A) describe the postulates of the kinetic molecular theory;	*(9)(B) describe the postulates of kinetic molecular theory.*
(B) describe and calculate the relationships among volume, pressure, number of moles, and temperature for an ideal gas; and	*(9)(A) describe and calculate the relations between volume, pressure, number of moles, and temperature for an ideal gas as described by Boyle's law, Charles' law, Avogadro's law, Dalton's law of partial pressure, and the ideal gas law; and*
(C) define and apply Dalton's law of partial pressure.	
(11) Science concepts. The student understands and can apply the factors that influence the behavior of solutions. The student is expected to:	***(10) Science concepts. The student understands and can apply the factors that influence the behavior of solutions. The student is expected to:***
(A) describe the unique role of water in solutions in terms of polarity;	*(10)(A) describe the unique role of water in solutions in terms of polarity;*
(B) distinguish among types of solutions, including electrolytes and nonelectrolytes and unsaturated, saturated, and supersaturated solutions;	*(10)(E) distinguish among types of solutions such as electrolytes and nonelectrolytes; unsaturated, saturated, and supersaturated solutions; and strong and weak acids and bases;*
(C) investigate how solid and gas solubilities are influenced by temperature using solubility curves and how rates of dissolution are influenced by temperature, agitation, and surface area;	*(10)(F) investigate factors that influence solid and gas solubilities and rates of dissolution such as temperature, agitation, and surface area;*

2021	2017
(D) investigate the general rules regarding solubility and predict the solubility of the products of a double replacement reaction;	*(10)(B) apply the general rules regarding solubility through investigations with aqueous solutions;*
(E) calculate the concentration of solutions in units of molarity; and	*(10)(C) calculate the concentration of solutions in units of molarity;*
(F) calculate the dilutions of solutions using molarity.	*(10)(D) calculate the dilutions of solutions using molarity;*
(12) Science concepts. The student understands and applies various rules regarding acids and bases. The student is expected to:	***NEW***
(A) name and write the chemical formulas for acids and bases using IUPAC nomenclature rules;	*(7)(A) name ionic compounds containing main group or transition metals, covalent compounds, acids, and bases using International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules;* *(7)(B) write the chemical formulas of ionic compounds containing representative elements, transition metals and common polyatomic ions, covalent compounds, and acids and bases;*
(B) define acids and bases and distinguish between Arrhenius and Bronsted-Lowry definitions;	*(10(G) define acids and bases and distinguish between Arrhenius and Bronsted-Lowry definitions and predict products in acid-base reactions that form water; and*
(C) differentiate between strong and weak acids and bases;	*(10)(E) distinguish among types of solutions such as electrolytes and nonelectrolytes; unsaturated, saturated, and supersaturated solutions; and strong and weak acids and bases;*
(D) predict products in acid-base reactions that form water; and	*(10(G) define acids and bases and distinguish between Arrhenius and Bronsted-Lowry definitions and predict products in acid-base reactions that form water; and*
(E) define pH and calculate the pH of a solution using the hydrogen ion concentration.	*(10)(H) define pH and calculate the pH of a solution using the hydrogen ion concentration*
(13) Science concepts. The student understands the energy changes that occur in chemical reactions. The student is expected to:	***(11) Science concepts. The student understands the energy changes that occur in chemical reactions. The student is expected to:***
(A) explain everyday examples that illustrate the four laws of thermodynamics;	*NEW*
(B) investigate the process of heat transfer using calorimetry;	*(11)(B) describe the law of conservation of energy and the processes of heat transfer in terms of calorimetry;*
(C) classify processes as exothermic or endothermic and represent energy changes that occur in chemical reactions using thermochemical equations or graphical analysis; and	*(11)(C) classify reactions as exothermic or endothermic and represent energy changes that occur in chemical reactions using thermochemical equations or graphical analysis; and*

2021	2017
(D) perform calculations involving heat, mass, temperature change, and specific heat.	*(11)(D) perform calculations involving heat, mass, temperature change, and specific heat.*
	REMOVED *(11)(A) describe energy and its forms, including kinetic, potential, chemical, and thermal energies*
(14) Science concepts. The student understands the basic processes of nuclear chemistry. The student is expected to:	***(12) Science concepts. The student understands the basic processes of nuclear chemistry. The student is expected to:***
(A) describe the characteristics of alpha, beta, and gamma radioactive decay processes in terms of balanced nuclear equations;	*(12)(A) describe the characteristics of alpha, beta, and gamma radioactive decay processes in terms of balanced nuclear equations; and*
(B) compare fission and fusion reactions; and	*(12)(B) compare fission and fusion reactions.*
(C) give examples of applications of nuclear phenomena such as nuclear stability, radiation therapy, diagnostic imaging, solar cells, and nuclear power.	NEW