

The State Board of Education (SBOE) proposes new §§112.41-112.45, concerning Texas Essential Knowledge and Skills (TEKS) for science. The proposed new sections would provide updated standards for Biology, Chemistry, Physics, and Integrated Physics and Chemistry to ensure they remain current.

BACKGROUND INFORMATION AND JUSTIFICATION: In accordance with statutory requirements that the SBOE by rule identify the essential knowledge and skills of each subject in the required curriculum, the SBOE follows a board-approved cycle to review and revise the essential knowledge and skills for each subject.

At the September 2019 meeting, SBOE members were asked to designate content advisors for the review and revision of the science TEKS. In December 2019, applications to serve on science TEKS review work groups were posted on the Texas Education Agency (TEA) website. Additionally in December 2019, TEA distributed a survey to collect information from educators regarding the review and revision of the science TEKS. TEA staff provided applications for the science review work groups to SBOE members on a monthly basis from December 2019 to June 2020. At the January 2020 SBOE meeting, the SBOE provided specific guidance for the TEKS review work groups.

Also in January 2020, science TEKS review content advisors met in a face-to-face meeting to develop consensus recommendations regarding revisions to the science TEKS to share with future work groups. At that time, the content advisors met with representatives from Work Group A to discuss the consensus recommendations. Work Group A convened in February 2020 to review survey results, content advisor consensus recommendations, and the SBOE's guidance to work groups to develop recommendations for how science TEKS review work groups can address these areas. Work Group B was convened virtually in June and July 2020 to develop recommendations for four high school science courses: Biology, Chemistry, Physics, and Integrated Physics and Chemistry. Additionally, in July 2020, members from Work Group B met with Work Group C to discuss vertical alignment of the high school and middle school TEKS.

The proposed new sections would introduce revised standards for Biology, Chemistry, Physics, and Integrated Physics and Chemistry as well as related implementation language. The revised standards would ensure that the requirements for these courses remain current. The proposed new sections would be implemented beginning with the 2023-2024 school year.

The SBOE approved the proposed new sections for first reading and filing authorization at its September 11, 2020 meeting.

FISCAL IMPACT: Monica Martinez, associate commissioner for standards and support services, has determined that for the first five years the proposal is in effect (2021-2025), there are no fiscal implications to the state. However, in fiscal years 2019 and 2020, there was a fiscal impact to TEA to reimburse committee members for travel to review the science TEKS. For fiscal year 2020, the estimated cost to TEA was \$23,609. There will also be implications for the TEA if the state develops professional development to help teachers and administrators understand the revised TEKS. Any professional development that is created would be based on whether the TEA received an appropriation for professional development in the next biennium.

There may be fiscal implications for school districts and charter schools to implement the proposed revisions to the TEKS, which may include the need for professional development and revisions to district-developed databases, curriculum, and scope and sequence documents. Since curriculum and instruction decisions are made at the local district level, it is difficult to estimate the fiscal impact on any given district.

LOCAL EMPLOYMENT IMPACT: The proposal has no effect on local economy; therefore, no local employment impact statement is required under Texas Government Code, §2001.022.

SMALL BUSINESS, MICROBUSINESS, AND RURAL COMMUNITY IMPACT: The proposal has no direct adverse economic impact for small businesses, microbusinesses, or rural communities; therefore, no regulatory flexibility analysis specified in Texas Government Code, §2006.002, is required.

COST INCREASE TO REGULATED PERSONS: The proposal does not impose a cost on regulated persons, another state agency, a special district, or a local government and, therefore, is not subject to Texas Government Code, §2001.0045.

TAKINGS IMPACT ASSESSMENT: The proposal does not impose a burden on private real property and, therefore, does not constitute a taking under Texas Government Code, §2007.043.

GOVERNMENT GROWTH IMPACT: TEA staff prepared a Government Growth Impact Statement assessment for this proposed rulemaking. During the first five years the proposed rulemaking would be in effect, it would create new regulations by proposing revised science TEKS required to be offered by school districts and charter schools.

The proposed rulemaking would not create or eliminate a government program; would not require the creation of new employee positions or elimination of existing employee positions; would not require an increase or decrease in future legislative appropriations to the agency; would not require an increase or decrease in fees paid to the agency; would not expand, limit, or repeal an existing regulation; would not increase or decrease the number of individuals subject to its applicability; and would not positively or adversely affect the state's economy.

PUBLIC BENEFIT AND COST TO PERSONS: Ms. Martinez has determined that for each year of the first five years the proposal is in effect, the public benefit anticipated as a result of enforcing the proposal would be better alignment of the TEKS and coordination of the standards with the adoption of instructional materials. There is no anticipated economic cost to persons who are required to comply with the proposal.

DATA AND REPORTING IMPACT: The proposal would have no new data and reporting impact.

PRINCIPAL AND CLASSROOM TEACHER PAPERWORK REQUIREMENTS: TEA has determined that the proposal would not require a written report or other paperwork to be completed by a principal or classroom teacher.

PUBLIC COMMENTS: The public comment period on the proposal begins October 9, 2020, and ends November 13, 2020. A form for submitting public comments is available on the TEA website at [https://tea.texas.gov/About_TEA/Laws_and_Rules/SBOE_Rules_\(TAC\)/Proposed_State_Board_of_Education_Rules/](https://tea.texas.gov/About_TEA/Laws_and_Rules/SBOE_Rules_(TAC)/Proposed_State_Board_of_Education_Rules/). The SBOE will take registered oral and written comments on the proposal at the appropriate committee meeting in November 2020 in accordance with the SBOE board operating policies and procedures. A public hearing on the proposal will be held as part of the November 2020 SBOE meeting.

STATUTORY AUTHORITY. The new sections are proposed under Texas Education Code (TEC), §7.102(c)(4), which requires the State Board of Education (SBOE) to establish curriculum and graduation requirements; TEC, §28.002(a), which identifies the subjects of the required curriculum; TEC, §28.002(c), which requires the SBOE to by rule identify the essential knowledge and skills of each subject in the required curriculum that all students should be able to demonstrate and that will be used in evaluating instructional materials and addressed on the state assessment instruments; TEC, §28.002(j), which allows the SBOE to require laboratory instruction in secondary science courses and require a specific amount or percentage of time in a secondary science course that must be laboratory instruction; TEC, §28.002(n), which allows the SBOE to by rule develop and implement a plan designed to incorporate foundation curriculum requirements into the career and technical education curriculum required in TEC, §28.002; and TEC, §28.025(a), which requires the SBOE to by rule determine the curriculum requirements for the foundation high school graduation program that are consistent with the required curriculum under TEC, §28.002.

CROSS REFERENCE TO STATUTE. The new sections implement Texas Education Code, §§7.102(c)(4); 28.002(a), (c), (j), and (n); and 28.025(a).

<rule>

§112.41. Implementation of Texas Essential Knowledge and Skills for Science, High School, Adopted 2020.

- (a) The provisions of §§112.42-112.45 of this subchapter shall be implemented by school districts.
- (b) No later than July 31, 2022, the commissioner of education shall determine whether instructional materials funding has been made available to Texas public schools for materials that cover the essential knowledge and skills for science as adopted in §§112.42-112.45 of this subchapter.

- (c) If the commissioner makes the determination that instructional materials funding has been made available under subsection (b) of this section, §§112.42-112.45 of this subchapter shall be implemented beginning with the 2023-2024 school year and apply to the 2023-2024 and subsequent school years.
- (d) If the commissioner does not make the determination that instructional materials funding has been made available under subsection (b) of this section, the commissioner shall determine no later than July 31 of each subsequent school year whether instructional materials funding has been made available. If the commissioner determines that instructional materials funding has been made available, the commissioner shall notify the State Board of Education and school districts that §§112.42-112.45 of this subchapter shall be implemented for the following school year.
- (e) Sections 112.34, 112.35, 112.38, and 112.39 of this subchapter shall be superseded by the implementation of §§112.42-112.45 of this subchapter.

§112.42. Biology (One Credit), Adopted 2020.

- (a) General requirements. Students shall be awarded one credit for successful completion of this course. This course is recommended for students in Grades 9-11.
- (b) Introduction.
 - (1) Biology. Students in Biology focus on patterns, processes, and relationships of living organisms through four main concepts: biological structures, functions, and processes; mechanisms of genetics; biological evolution; and interdependence within environmental systems. 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. 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.
- (c) Knowledge and skills.
- (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:
- (A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;
 - (B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;
 - (C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;
 - (D) use appropriate tools such as microscopes, slides, Petri dishes, laboratory glassware, metric rulers, digital balances, pipets, filter paper, micropipettes, gel electrophoresis and polymerase chain reaction (PCR) apparatuses, microcentrifuges, water baths, incubators, thermometers, hot plates, data collection probes, test tube holders, lab notebooks or journals, hand lenses, and models, diagrams, or samples of biological specimens or structures;
 - (E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;
 - (F) organize quantitative and qualitative data using scatter plots, line graphs, bar graphs, charts, data tables, digital tools, diagrams, scientific drawings, and student-prepared models;
 - (G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and
 - (H) distinguish among scientific hypotheses, theories, and laws.
- (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:
- (A) identify advantages and limitations of models such as their size, scale, properties, and materials;
 - (B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;
 - (C) use mathematical calculations to assess quantitative relationships in data; and

- (D) evaluate experimental and engineering designs.
- (3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:
- (A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;
 - (B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and
 - (C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.
- (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:
- (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;
 - (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
 - (C) research and explore connections between grade-level appropriate science concepts and science, technology, engineering, and mathematics (STEM) careers.
- (5) Science concepts--biological structures, functions, and processes. The student knows that biological structures at multiple levels of organization perform specific functions and processes that affect life. The student is expected to:
- (A) relate the functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids, to the structure and function of a cell;
 - (B) compare and contrast prokaryotic and eukaryotic cells, including their complexity, and compare and contrast scientific explanations for cellular complexity;
 - (C) investigate homeostasis through the cellular transport of molecules; and
 - (D) compare the structures of viruses to cells and explain how viruses spread and cause disease.
- (6) Science concepts--biological structures, functions, and processes. The student knows how an organism grows and the importance of cell differentiation. The student is expected to:
- (A) explain the importance of the cell cycle to the growth of organisms, including stages of the cell cycle and deoxyribonucleic acid (DNA) replication models;
 - (B) explain the process of cell specialization through cell differentiation, including the role of environmental factors; and
 - (C) relate disruptions of the cell cycle to how they lead to the development of diseases such as cancer.
- (7) Science concepts--mechanisms of genetics. The student knows the role of nucleic acids in gene expression. The student is expected to:
- (A) identify components of DNA, explain how the nucleotide sequence specifies some traits of an organism, and examine scientific explanations for the origin of DNA;
 - (B) describe the significance of gene expression and explain the process of protein synthesis using models of DNA and ribonucleic acid (RNA);

- (C) identify and illustrate changes in DNA and evaluate the significance of these changes; and
 - (D) describe the function of molecular technologies such as polymerase chain reaction (PCR), gel electrophoresis, and genetic engineering that are applicable in current research and engineering practices.
- (8) Science concepts--mechanisms of genetics. The student knows the role of nucleic acids and the principles of inheritance and variation of traits in Mendelian and non-Mendelian genetics. The student is expected to:
- (A) analyze the significance of chromosome reduction, independent assortment, and crossing-over during meiosis in increasing diversity in populations of organisms that reproduce sexually; and
 - (B) predict possible outcomes of various genetic combinations using monohybrid and dihybrid crosses, including non-Mendelian traits of incomplete dominance, codominance, sex-linked traits, and multiple alleles.
- (9) Science concepts--biological evolution. The student knows evolutionary theory is a scientific explanation for the unity and diversity of life that has multiple lines of evidence. The student is expected to:
- (A) analyze and evaluate how evidence of common ancestry among groups is provided by the fossil record, biogeography, and homologies, including anatomical, molecular, and developmental; and
 - (B) examine scientific explanations for varying rates of change such as gradualism, abrupt appearance, and stasis in the fossil record.
- (10) Science concepts--biological evolution. The student knows evolutionary theory is a scientific explanation for the unity and diversity of life that has multiple mechanisms. The student is expected to:
- (A) analyze and evaluate how natural selection produces change in populations and not in individuals;
 - (B) analyze and evaluate how the elements of natural selection, including inherited variation, the potential of a population to produce more offspring than can survive, and a finite supply of environmental resources, result in differential reproductive success;
 - (C) analyze and evaluate how natural selection may lead to speciation; and
 - (D) analyze evolutionary mechanisms other than natural selection, including genetic drift, gene flow, mutation, and genetic recombination, on the gene pool of a population.
- (11) Science concepts--biological structures, functions, and processes. The student knows the significance of matter cycling, energy flow, and enzymes in living organisms. The student is expected to:
- (A) explain how matter is conserved and energy is transferred during photosynthesis and cellular respiration using models, including chemical equations; and
 - (B) identify and investigate the role of enzymes in facilitating cellular processes.
- (12) Science concepts--biological structures, functions, and processes. The student knows that multicellular organisms are composed of multiple systems that interact to perform complex functions. The student is expected to:
- (A) analyze the interactions that occur among systems that perform the functions of regulation, nutrient absorption, reproduction, and defense from injury or illness in animals; and

- (B) explain how the functions of transport, reproduction, and response in plants are facilitated by their structures.
- (13) Science concepts--interdependence within environmental systems. The student knows that interactions at various levels of organization occur within an ecosystem to maintain stability. The student is expected to:
- (A) investigate and evaluate how ecological relationships, including predation, parasitism, commensalism, mutualism, and competition, influence ecosystem stability;
- (B) analyze how ecosystem stability is affected by disruptions to the cycling of matter and flow of energy through trophic levels using models;
- (C) explain the significance of the carbon and nitrogen cycles to ecosystem stability and analyze the consequences of disrupting these cycles; and
- (D) explain how environmental change, including change due to human activity, affects biodiversity and analyze how changes in biodiversity impact ecosystem stability.

§112.43. Chemistry (One Credit), Adopted 2020.

- (a) General requirements. Students shall be awarded one credit for successful completion of this course. Prerequisites: one credit of high school science and Algebra I. Recommended prerequisite: completion of or concurrent enrollment in a second year of mathematics. This course is recommended for students in Grades 10-12.
- (b) 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. Student learning for different types of investigations includes 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.

(c) Knowledge and skills.

(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:

(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;

(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;

(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;

(E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;

(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;

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(H) distinguish between scientific hypotheses, theories, and laws.

(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:

- (A) identify advantages and limitations of models such as their size, scale, properties, and materials;
 - (B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;
 - (C) use mathematical calculations to assess quantitative relationships in data; and
 - (D) evaluate experimental and engineering designs.
- (3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:
- (A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;
 - (B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and
 - (C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.
- (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:
- (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;
 - (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
 - (C) research and explore connections between grade-level appropriate science concepts and science, technology, engineering, and mathematics (STEM) careers.
- (5) Science concepts. The student understands the development of the Periodic Table and applies 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;
 - (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
 - (C) analyze and interpret elemental data, including atomic radius, atomic mass, electronegativity, ionization energy, and reactivity to identify periodic trends.
- (6) Science concepts. The student understands the development of atomic theory and applies it to real-world phenomena. 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;
 - (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;
 - (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;
 - (D) 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.
- (7) 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;
- (B) name and write the chemical formulas for ionic and covalent compounds using International Union of Pure and Applied Chemistry (IUPAC) nomenclature rules;
- (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
- (D) analyze the properties of ionic, covalent, and metallic substances in terms of intramolecular and intermolecular forces.
- (8) Science concepts. The student understands how matter is accounted for in chemical substances. The student is expected to:
- (A) define mole and apply the concept of molar mass to convert between moles and grams;
- (B) calculate the number of atoms or molecules in a sample of material using Avogadro's number;
- (C) calculate percent composition of compounds; and
- (D) differentiate between empirical and molecular formulas.
- (9) Science concepts. The student understands how matter is accounted for in chemical reactions. The student is expected to:
- (A) interpret, write, and balance chemical equations, including synthesis, decomposition, single replacement, double replacement, and combustion reactions using the law of conservation of mass;
- (B) differentiate among acid-base reactions, precipitation reactions, and oxidation-reduction reactions;
- (C) perform stoichiometric calculations, including determination of mass relationships, gas volume relationships, and percent yield; and
- (D) 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:
- (A) describe the postulates of the kinetic molecular theory;
- (B) describe and calculate the relationships among volume, pressure, number of moles, and temperature for an ideal gas; 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:
- (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;
- (C) investigate factors that influence solid and gas solubilities such as temperature using solubility curves and rates of dissolution such as temperature, agitation, and surface area;

- (D) investigate the general rules regarding solubility and predict the products of a double replacement reaction;
 - (E) calculate the concentration of solutions in units of molarity; and
 - (F) 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:
- (A) name and write the chemical formulas for acids and bases using IUPAC nomenclature rules;
 - (B) define acids and bases and distinguish between Arrhenius and Bronsted-Lowry definitions;
 - (C) differentiate between strong and weak acids and bases;
 - (D) 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.
- (13) 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;
 - (B) investigate the process of heat transfer using calorimetry;
 - (C) classify processes as exothermic or endothermic and represent energy changes that occur in chemical reactions using thermochemical equations or graphical analysis; and
 - (D) perform calculations involving heat, mass, temperature change, and specific heat.
- (14) 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;
 - (B) compare fission and fusion reactions; and
 - (C) give examples of applications of nuclear phenomena such as nuclear stability, radiation therapy, diagnostic imaging, solar cells, and nuclear power.

§112.44. Integrated Physics and Chemistry (One Credit), Adopted 2020.

- (a) General requirements. Students shall be awarded one credit for successful completion of this course. This course is recommended for students in Grades 9 and 10.
- (b) Introduction.
 - (1) Integrated Physics and Chemistry. In Integrated Physics and Chemistry, students conduct laboratory and field investigations, use engineering practices, use scientific practices during investigation, and make informed decisions using critical thinking and scientific problem solving. This course integrates the disciplines of physics and chemistry in the following topics: force, motion, energy, and matter. 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. 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.
- (c) Knowledge and skills.
- (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:
 - (A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;
 - (B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;
 - (C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;
 - (D) use appropriate tools such as data-collecting probes, software applications, the internet, standard laboratory glassware, metric rulers, meter sticks, spring scales, multimeters,

Gauss meters, wires, batteries, light bulbs, switches, magnets, electronic balances, mass sets, Celsius thermometers, hot plates, an adequate supply of consumable chemicals, lab notebooks or journals, timing devices, models, and diagrams;

- (E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;
 - (F) organize quantitative and qualitative data using labeled drawings and diagrams, graphic organizers, charts, tables, and graphs;
 - (G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and
 - (H) distinguish between scientific hypotheses, theories, and laws.
- (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:
- (A) identify advantages and limitations of models such as their size, scale, properties, and materials;
 - (B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;
 - (C) use mathematical calculations to assess quantitative relationships in data; and
 - (D) evaluate experimental and engineering designs.
- (3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:
- (A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;
 - (B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and
 - (C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.
- (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:
- (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;
 - (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
 - (C) research and explore connections between grade-level appropriate science concepts and science, technology, engineering, and mathematics (STEM) careers.
- (5) Science concepts. The student knows the relationship between force and motion in everyday life. The student is expected to:
- (A) investigate, analyze, and model motion in terms of position, velocity, acceleration, and time using tables, graphs, and mathematical relationships;
 - (B) analyze data to explain the relationship between mass and acceleration in terms of the net force on an object in one dimension using force diagrams, tables, and graphs;

- (C) apply the concepts of momentum and impulse to design, evaluate, and refine a device to minimize the net force on objects during collisions such as those that occur during vehicular accidents, sports activities, or the dropping of personal electronic devices;
 - (D) describe the nature of the four fundamental forces: gravitation; electromagnetic; the strong and weak nuclear forces, including fission and fusion; and mass-energy equivalency; and
 - (E) construct and communicate an explanation based on evidence for how changes in mass, charge, and distance affect the strength of gravitational and electrical forces between two objects.
- (6) Science concepts. The student knows the impact of energy transfer and energy conservation in everyday life. The student is expected to:
- (A) design and construct series and parallel circuits that model real-world circuits such as in-home wiring, automobile wiring, and simple electrical devices to evaluate the transfer of electrical energy;
 - (B) design, evaluate, and refine a device that generates electrical energy through the interaction of electric charges and magnetic fields;
 - (C) plan and conduct an investigation to provide evidence that energy is conserved within a closed system;
 - (D) investigate and demonstrate the movement of thermal energy through solids, liquids, and gases by convection, conduction, and radiation such as weather, living, and mechanical systems;
 - (E) plan and conduct an investigation to evaluate the transfer of energy or information through different materials by different types of waves such as wireless signals, ultraviolet radiation, and microwaves;
 - (F) construct and communicate an evidence-based explanation for how wave interference, reflection, and refraction are used in technology such as medicine, communication, and scientific research; and
 - (G) evaluate evidence from multiple sources to critique the advantages and disadvantages of various renewable and nonrenewable energy sources and their impact on society and the environment.
- (7) Science concepts. The student knows that relationships exist between the structure and properties of matter. The student is expected to:
- (A) model basic atomic structure and relate an element's atomic structure to its bonding, reactivity, and placement on the Periodic Table;
 - (B) use patterns within the Periodic Table to predict the relative physical and chemical properties of elements;
 - (C) explain how physical and chemical properties of substances are related to their usage in everyday life such as in sunscreen, cookware, industrial applications, and fuels;
 - (D) explain how electrons can transition from a high energy level to a low energy state, emitting photons at different frequencies for different energy transitions;
 - (E) explain how atomic energy levels and emission spectra present evidence for the wave particle duality; and
 - (F) plan and conduct an investigation to provide evidence that the rate of reaction or dissolving is affected by multiple factors such as particle size, stirring, temperature, and concentration.

- (8) Science concepts. The student knows that changes in matter affect everyday life. The student is expected to:
- (A) investigate how changes in properties are indicative of chemical reactions such as hydrochloric acid with a metal, oxidation of metal, combustion, and neutralizing an acid with a base;
 - (B) develop and use models to balance chemical equations and support the claim that atoms, and therefore mass, are conserved during a chemical reaction;
 - (C) research and communicate the uses, advantages, and disadvantages of nuclear reactions in current technologies; and
 - (D) construct and communicate an evidence-based explanation of the environmental impact of the end-products of chemical reactions such as those that may result in degradation of water, soil, air quality, and global climate change.

§112.45. Physics (One Credit), Adopted 2020.

- (a) General requirements. Students shall be awarded one credit for successful completion of this course. Recommended prerequisite or corequisite: Algebra I. This course is recommended for students in Grades 9-12.
- (b) Introduction.
- (1) Physics. In Physics, 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: laws of motion, changes within physical systems and conservation of energy and momentum, forces, characteristics and behavior of waves, and electricity and magnetism. Students will apply conceptual knowledge and collaborative skills to experimental design, implementation, and interpretation. 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. 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.
- (c) Knowledge and skills.
 - (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:
 - (A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;
 - (B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations, and use engineering practices to design solutions to problems;
 - (C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;
 - (D) use appropriate tools such as balances, ballistic carts or equivalent, batteries, computers, constant velocity cars, convex lenses, copper wire, discharge tubes with power supply (H, He, Ne, Ar), data acquisition probes and software, dynamics and force demonstration equipment, electrostatic generators, electrostatic kits, friction blocks, graph paper, graphing technology, hand-held visual spectrometers, inclined planes, iron filings, lab masses, laser pointers, magnets, magnetic compasses, metric rulers, motion detectors, multimeters (current, voltage, resistance), optics bench, optics kit, photogates, plane mirrors, prisms, protractors, pulleys, resistors, rope or string, scientific calculators, stopwatches, springs, spring scales, switches, tuning forks, wave generators, or other equipment and materials that will produce the same results;
 - (E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;
 - (F) organize quantitative and qualitative data using bar charts, line graphs, scatter plots, data tables, labeled diagrams, and conceptual mathematical relationships;
 - (G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and
 - (H) distinguish among scientific hypotheses, theories, and laws.

- (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:
- (A) identify advantages and limitations of models such as their size, scale, properties, and materials;
 - (B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;
 - (C) use mathematical calculations to assess quantitative relationships in data; and
 - (D) evaluate experimental and engineering designs.
- (3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:
- (A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;
 - (B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and
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- (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:
- (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;
 - (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
 - (C) research and explore connections between grade-level appropriate science concepts and science, technology, engineering, and mathematics (STEM) careers.
- (5) Science concepts. The student knows and applies the laws governing motion in a variety of situations. The student is expected to:
- (A) analyze different types of motion by generating and interpreting position versus time, velocity versus time, and acceleration versus time using hand graphing and real-time technology such as motion detectors, photogates, or digital applications;
 - (B) define scalar and vector quantities related to one- and two-dimensional motion and combine vectors using both graphical vector addition and the Pythagorean theorem;
 - (C) describe and analyze motion in one dimension using equations with the concepts of distance, displacement, speed velocity, frames of reference, and acceleration;
 - (D) describe and analyze acceleration in uniform circular and horizontal projectile motion in two dimensions using equations;
 - (E) explain and apply the concepts of equilibrium and inertia as represented by Newton's first law of motion using relevant real-world examples such as rockets, satellites, and automobile safety devices;
 - (F) calculate the effect of forces on objects, including tension, friction, normal, gravity, centripetal, and applied forces, using free body diagrams and the relationship between force and acceleration as represented by Newton's second law of motion;

- (G) illustrate and analyze the simultaneous forces between two objects as represented in Newton's third law of motion using free body diagrams and in an experimental design scenario; and
 - (H) describe and calculate, using scientific notation, how the magnitude of force between two objects depends on their masses and the distance between their centers, and predict the effects on objects in linear and orbiting systems using Newton's law of universal gravitation.
- (6) Science concepts. The student knows the nature of forces in the physical world. The student is expected to:
- (A) use scientific notation and predict how the magnitude of the electric force between two objects depends on their charges and the distance between their centers using Coulomb's law;
 - (B) identify and describe examples of electric and magnetic forces and fields in everyday life such as generators, motors, and transformers;
 - (C) investigate and describe conservation of charge during the processes of induction, conduction, and polarization using different materials such as electroscopes, balloons, rods, fur, silk, and Van der Graaf generators;
 - (D) analyze, design, and construct series and parallel circuits using schematics and materials such as switches, wires, resistors, lightbulbs, batteries, voltmeters, and ammeters; and
 - (E) calculate current through, potential difference across, resistance of, and power used by electric circuit elements connected in both series and parallel circuits using Ohm's law.
- (7) Science concepts. The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to:
- (A) calculate and explain work and power in one dimension and identify when work is and is not being done by or on a system;
 - (B) investigate and calculate mechanical, kinetic, and potential energy of a system;
 - (C) apply the concept of conservation of energy using the work-energy theorem, energy diagrams, and energy transformation equations, including transformations between kinetic, potential, and thermal energy;
 - (D) calculate and describe the impulse and momentum of objects in physical systems such as automobile safety features, athletics, and rockets; and
 - (E) analyze the conservation of momentum qualitatively in inelastic and elastic collisions in one dimension using models, diagrams, and simulations.
- (8) Science concepts. The student knows the characteristics and behavior of waves. The student is expected to:
- (A) examine and describe simple harmonic motion such as springs and pendulums and wave energy propagation in various types of media such as surface waves on a body of water and ropes;
 - (B) compare the characteristics of transverse and longitudinal waves, including electromagnetic and sound waves;
 - (C) investigate and analyze characteristics of waves, including velocity, frequency, amplitude, and wavelength, and calculate using the relationships between wave speed, frequency, and wavelength;
 - (D) investigate behaviors of waves, including reflection, refraction, diffraction, interference, standing wave, the Doppler effect and polarization and superposition; and

- (E) compare the different applications of the electromagnetic spectrum, including radio telescopes, microwaves, and x-rays;
 - (F) investigate the emission spectra produced by various atoms and explain the relationship to the electromagnetic spectrum; and
 - (G) describe and predict image formation as a consequence of reflection from a plane mirror and refraction through a thin convex lens.
- (9) Science concepts. The student knows examples of quantum phenomena and their applications. The student is expected to:
- (A) describe the photoelectric effect and emission spectra produced by various atoms and how both are explained by the photon model for light;
 - (B) investigate Malus's Law and describe examples of applications of wave polarization, including 3-D movie glasses and LCD computer screens;
 - (C) compare and explain how superposition of quantum states is related to the wave-particle duality nature of light; and
 - (D) give examples of applications of quantum phenomena, including the Heisenberg uncertainty principle, quantum computing, and cybersecurity.