NEW YORK STATE TEACHER CERTIFICATION EXAMINATIONS™

FIELD 161: CHEMISTRY

TEST DESIGN AND FRAMEWORK

June 2018

Authorized for Distribution by the New York State Education Department

This test design and framework document is designed to provide information about the content and format of a test for the New York State Teacher Certification Examinations™ (NYSTCE®) program. Education faculty and administrators at teacher preparation institutions may also find the information in this framework useful as they discuss the test with candidates. All test components may differ from those presented here. Furthermore, review of this framework, in whole or in part, does not guarantee an increased likelihood of success on any of the New York State Teacher Certification Examinations. The NYSTCE program is subject to change at the sole discretion of the New York State Education Department, and any changes will fully supersede the information presented in this document. As a reminder, candidates are responsible for contacting their certification officer(s) regarding any changes to the New York State Teacher Certification Examinations.

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FIELD 161: CHEMISTRY

TEST DESIGN

This test consists of selected-response items measuring content knowledge and one extended constructed-response item measuring pedagogical content knowledge. The constructed-response item is scenario-based and requires candidates to describe an instructional strategy to guide all students in achieving a specific learning goal, assess student understanding, and identify students' strengths and needs.

The selected-response items count for 80% of the total test score and the constructed-response item counts for 20% of the total test score, as indicated in the table that follows. Each selected-response item counts the same toward the total test score. The percentage of the total test score derived from the constructed-response item is also indicated in the table that follows.

The total testing time is 195 minutes. Candidates are free to set their own pace during the test administration. The following estimates were used to determine the total test time:

- The selected-response items are designed with the expectation of a response time up to 135 minutes.
- The constructed-response item is designed with the expectation of a response time up to 60 minutes.

Further information regarding the content of each competency can be found in the test framework.

Competency	Selected-Response		Constructed-Response	
	Approximate Number of Items	Approximate Percentage of Test Score	Number of Items	Approximate Percentage of Test Score
0001 Structure of Matter	22	20%	--	--
0002 Properties of Matter	22	20%	--	--
0003 Chemical Reactions	23	20%	--	--
0004 Energy	23	20%	--	--
0005 Pedagogical Content Knowledge	--	--	1	20%
Total	**90**	**80%**	**1**	**20%**

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FIELD 161: CHEMISTRY

TEST FRAMEWORK

Structure of Matter
Properties of Matter
Chemical Reactions
Energy
Pedagogical Content Knowledge

The New York State chemistry teacher has the knowledge and skills necessary to teach effectively in New York State schools. The chemistry teacher understands and applies current education research on how students learn science. The chemistry teacher demonstrates mastery of the content and concepts of chemistry, is a skilled problem solver, and demonstrates strong mathematics and literacy skills. The chemistry teacher applies the three-dimensional approach (i.e., disciplinary core ideas, crosscutting concepts, science and engineering practices) to science instruction in order to explain phenomena, solve real-world problems, and make informed decisions. The chemistry teacher has a broad understanding of the disciplinary core ideas in chemistry and the crosscutting concepts between science disciplines. In addition, the chemistry teacher understands science and engineering practices and applies scientific concepts, principles, and theories to develop and use models; plan and carry out investigations; analyze and interpret data; engage in argument from evidence; and obtain, evaluate, and communicate scientific and technical information from a variety of source types. The chemistry teacher knows, demonstrates, and implements policies and procedures to ensure laboratory safety and ethical practices.

As used in this document, the term "research-based" refers to those practices that have been shown to be effective in improving learner outcomes through systematic observation or experiment, rigorous data analysis, ability to replicate results, and publication in a peer-reviewed journal.

FIELD 161: CHEMISTRY
TEST FRAMEWORK

COMPETENCY 0001—STRUCTURE OF MATTER

Performance Expectations

The New York State chemistry teacher demonstrates understanding of the fundamental atomic structure of matter. The teacher demonstrates knowledge of the characteristics and properties of subatomic constituents and recognizes their significance in identifying elements. The teacher is familiar with contemporary and historical models of atomic structure and understands the historical progression of models of atomic structure. The teacher applies knowledge of atomic structure to explain the organization of the periodic table and the chemical and physical properties of matter. The teacher recognizes the characteristics of different types of chemical bonds and applies this knowledge to predict the types of chemical bonds formed when substances react. The teacher recognizes the relationship between chemical bonding and molecular geometry and predicts the geometry of given molecules. The teacher interprets different representations and models of molecules and compounds. The teacher analyzes the basic composition and structure of organic and inorganic substances. The teacher applies rules of nomenclature. The teacher demonstrates knowledge of natural materials, synthetic materials, and nuclear processes; their applications; and their impact on society and nature. The teacher understands how to plan and safely carry out scientific investigations, understands the process of engineering design in refining a solution to a problem, interprets scientific information, and evaluates specific claims made about scientific phenomena related to the structure of matter. In addition, the teacher applies knowledge of the safe and proper use of equipment and materials in school science investigations.

Performance Indicators

a. recognizes that matter can be understood in terms of the types of atoms present and the interactions both between and within atoms

b. demonstrates knowledge of the subatomic constituents of atoms and their properties

c. recognizes that elements are defined by the number of protons in the atomic nucleus and that isotopes of elements differ in the number of neutrons present

d. distinguishes between mass number and average atomic mass and performs associated calculations

e. demonstrates knowledge of diverse contributions to contemporary and historical models of atomic structure and the evidence used to support the different models

f. demonstrates understanding of the organization and historical development of the periodic table and analyzes patterns in the physical and chemical properties of elements in terms of atomic structure

g. applies knowledge of trends in the periodic table and patterns of chemical properties to predict the types of chemical bonds formed when different substances react and understands factors that affect bond strength

h. demonstrates understanding of molecular geometry and molecular polarity and predicts the geometry of given molecules

i. demonstrates knowledge of chemical bonding in terms of the behavior of electrons and uses electron-dot diagrams to represent valence electron arrangement in elements, compounds, and ions

j. uses models, including structural and condensed structural formulas and particle diagrams, to represent and predict the structure of molecules and compounds

k. demonstrates knowledge of characteristics of ionic bonds, covalent bonds (including multiple covalent bonds), and metallic bonds

l. applies knowledge of the rules of nomenclature for inorganic and organic substances

m. analyzes the chemical composition and basic structure of organic compounds, including isomers, and recognizes common functional groups

n. demonstrates knowledge of and evaluates information about the production of synthetic materials, the chemical and physical properties of synthetic materials, and the impact of synthetic materials on society and nature

o. demonstrates knowledge of the relationship between energy and matter; nuclear processes (i.e., fission, fusion, and radioactive decay); models used to represent these processes; and the applications of nuclear processes, including associated risks and benefits

p. demonstrates knowledge of the engineering design process as related to the structure of matter, including criteria, modeling, use of technology and mathematical thinking, and applications to real-world situations; and evaluates an engineering design or solution, taking into account a range of constraints, including cost, safety, reliability, and aesthetics, and considering social, cultural, and environmental impacts

q. demonstrates knowledge of how to plan, construct, and safely and ethically carry out investigations into the structure of matter (e.g., investigating atomic composition with a physical model or computer simulation, examining molecular structure with ball-and-stick models, analyzing household items for organic compounds)

r. analyzes and draws inferences from scientific and technical texts and graphics; interprets graphs and data; applies mathematical and computational thinking in analyzing data; and evaluates the hypotheses, data, analyses, and conclusions in a scientific or technical text related to the structure of matter

s. demonstrates knowledge of appropriate resources regarding the safe and proper use of scientific equipment and materials (e.g., inventory, handling, storage, disposal), including accurately interpreting provided information; applies knowledge of guidelines for the proper use of materials and scientific equipment in field, laboratory, and classroom settings; and understands proper procedures for maintaining safety and responding to accidents and injuries during school science investigations

FIELD 161: CHEMISTRY
TEST FRAMEWORK

COMPETENCY 0002—PROPERTIES OF MATTER

Performance Expectations

The New York State chemistry teacher demonstrates knowledge of physical and chemical properties of matter and recognizes the connection between atomic structure and the properties of matter. The teacher distinguishes between physical and chemical changes and properties and uses this knowledge to purify and identify chemical substances. The teacher applies knowledge of the characteristics of different types of intermolecular forces to predict the types of intermolecular forces present between molecules. The teacher relates the physical properties of a substance to the types of chemical bonds and intermolecular forces present. The teacher applies knowledge of kinetic molecular theory to predict the behavior of particles and describe the different phases of matter. The teacher applies the gas laws and mathematical thinking to solve problems and analyze data involving gases. The teacher applies knowledge of the properties of solutions. The teacher evaluates information about the properties and functioning of natural and designed materials. In addition, the teacher understands how to plan and safely carry out scientific investigations, understands the process of engineering design in refining a solution to a problem, interprets scientific information, and evaluates specific claims made about scientific phenomena related to the properties of matter.

Performance Indicators

a. demonstrates knowledge that each pure substance has characteristic physical and chemical properties for any bulk quantity under given conditions and uses evidence about the properties of a sample of matter to identify it

b. relates the properties of matter to the arrangement and properties of the atoms that compose the matter

c. demonstrates knowledge of characteristics of ionic bonds, covalent bonds (including multiple covalent bonds), and metallic bonds

d. recognizes that substances undergo physical and chemical changes and recognizes examples of physical and chemical properties and how these properties can be used to identify compounds and to separate components of a mixture

e. relates the physical state of a substance at a given temperature and pressure to the structure and arrangement of its particles and their interactions

f. demonstrates knowledge of the properties of the different phases of matter and their equilibria

g. applies kinetic molecular theory to predict particle arrangement and motion and the temperature and phase of a substance when energy is added or removed

h. demonstrates knowledge of the characteristics of different types of intermolecular forces and predicts the type of intermolecular forces present between given molecules

i. relates the physical properties of substances to their chemical bonding and intermolecular forces, including using evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles

j. demonstrates understanding of the concept of an ideal gas and applies kinetic molecular theory, the gas laws, and mathematical and computational thinking to solve problems and analyze data pertaining to the relationships between volume, pressure, temperature, velocity, and frequency and force of collisions among gas molecules

k. understands and applies knowledge, including associated calculations related to the formation, properties, and behaviors of solutions (e.g., colligative properties, solubility, degree of saturation, equilibrium, conductivity) and common ways of expressing concentration

l. evaluates and interprets scientific and technical information about the properties of materials, including the functioning of designed materials

m. demonstrates knowledge of the engineering design process as related to the properties of matter, including criteria, modeling, use of technology and mathematical thinking, and applications to real-world situations; and evaluates an engineering design or solution, taking into account a range of constraints, including cost, safety, reliability, and aesthetics, and considering social, cultural, and environmental impacts

n. demonstrates knowledge of how to plan, construct, and safely and ethically carry out investigations into the properties of matter (e.g., measuring and recording the chemical and physical properties of an unknown substance to identify it; using a computer simulation to explore the effects of changing the volume, pressure, and temperature of gases; predicting and testing what substances added to water make an electrically conductive solution)

o. analyzes and draws inferences from scientific and technical texts and graphics; interprets graphs and data; applies mathematical and computational thinking in analyzing data; and evaluates the hypotheses, data, analyses, and conclusions in a scientific or technical text related to the properties of matter

FIELD 161: CHEMISTRY
TEST FRAMEWORK

COMPETENCY 0003—CHEMICAL REACTIONS

Performance Expectations

The New York State chemistry teacher applies the principles of conservation of matter, mass, energy, and charge to the analysis of chemical reactions. The teacher demonstrates knowledge of common types of inorganic and organic chemical reactions, acids and bases, and oxidation–reduction reactions and their applications. The teacher demonstrates understanding of the mole concept and stoichiometry and performs calculations based on these concepts. The teacher applies knowledge of chemical kinetics to solve rate problems and predict rate laws and reaction mechanisms. The teacher also demonstrates knowledge of the concept of chemical equilibrium and uses this knowledge to analyze chemical systems under given conditions. In addition, the teacher understands how to plan and safely carry out scientific investigations, understands the process of engineering design in refining a solution to a problem, interprets scientific information, and evaluates specific claims made about scientific phenomena related to chemical reactions.

Performance Indicators

a. demonstrates knowledge of types of evidence that indicate that a chemical reaction has occurred

b. applies the principles of conservation of matter, mass, energy, and charge to chemical reactions

c. demonstrates understanding of the mole concept, stoichiometry, and associated calculations (e.g., balancing chemical equations; determining formula masses, empirical formulas, molecular formulas, percent composition, percent yield)

d. demonstrates knowledge of common types of inorganic and organic chemical reactions (e.g., synthesis, decomposition, replacement, substitution, combustion, polymerization)

e. demonstrates understanding of oxidation–reduction reactions, including half-reactions and net ionic equations, and the principles and applications of electrochemistry, such as voltaic cells and electrolytic cells

f. understands and applies knowledge of acid-base theories and associated calculations (e.g., pH scale, titration, buffers)

g. demonstrates knowledge of chemical kinetics, including collision theory, reaction mechanisms, and factors that affect reaction rates; predicts rate laws from experimental data; and solves rate problems

h. demonstrates knowledge of chemical equilibrium, including factors that affect chemical equilibrium and system stability; solves problems relating to equilibrium; and applies Le Chatelier's principle to analyze chemical systems and refine their design by specifying a change in conditions to produce increased amounts of reactants or products at equilibrium

i. demonstrates knowledge of the engineering design process as related to chemical reactions, including criteria, modeling, use of technology and mathematical thinking, and applications to real-world situations; and evaluates an engineering design or solution, taking into account a range of constraints, including cost, safety, reliability, and aesthetics, and considering social, cultural, and environmental impacts

j. demonstrates knowledge of how to plan, construct, and safely and ethically carry out investigations into chemical reactions (e.g., collecting and analyzing evidence from the interactions of substances to determine whether a chemical reaction has occurred, exploring the pH of common household substances using litmus paper or other indicators, determining the optimal design for and building an electrochemical cell)

k. analyzes and draws inferences from scientific and technical texts and graphics; interprets graphs and data; applies mathematical and computational thinking in analyzing data; and evaluates the hypotheses, data, analyses, and conclusions in a scientific or technical text related to chemical reactions

COMPETENCY 0004—ENERGY

Performance Expectations

The New York State Chemistry teacher demonstrates knowledge of the different manifestations of energy and their shared characteristics. The teacher understands heat and applies that understanding to calorimetry investigations and engineering design solutions. The teacher analyzes the energy changes associated with chemical bonding and chemical reactions and explains physical processes in terms of energy changes. The teacher demonstrates knowledge of entropy and free energy and uses this knowledge to perform mathematical calculations and predict the spontaneity of reactions. The teacher uses knowledge of free energy change to determine equilibrium constants and the voltage of an electrochemical cell. In addition, the teacher understands how to plan and safely carry out scientific investigations, understands the process of engineering design in refining a solution to a problem, interprets scientific information, and evaluates specific claims made about scientific phenomena related to energy in chemical systems.

Performance Indicators

a. demonstrates knowledge of energy as a property that depends on the motion and interactions of matter and internal energy within a system; of the different forms of energy (e.g., thermal, mechanical, chemical, electromagnetic); and that the total energy of a system is ultimately conserved as energy is transferred and transformed between its various forms

b. demonstrates understanding of heat in terms of kinetic molecular theory; temperature as a measure of the average kinetic energy of particles of matter; and how the relationship between the temperature and total energy of a system depends on the types, phases, and amounts of matter

c. applies scientific principles related to energy to design, build, and evaluate devices to meet given criteria, such as minimizing or maximizing thermal energy transfer or converting one form of energy to another

d. demonstrates knowledge of the principles and design of calorimetry investigations, solves calorimetry problems, and interprets the results of calorimetry investigations

e. uses the concepts of kinetic and potential energy to explain physical processes such as fusion (melting), solidification (freezing), vaporization (boiling and evaporation), condensation, sublimation, and deposition and analyzes phase diagrams and heating and cooling curves

f. demonstrates knowledge of the relationship between the release or absorption of energy from a chemical reaction system to changes in total bond energy, analyzes energy changes associated with chemical bonding and chemical reactions, and interprets potential energy diagrams

g. understands the concepts of entropy and free energy and the mathematical calculations associated with these concepts and predicts the spontaneity of given reactions based on enthalpy changes, entropy changes, and temperatures of the systems

h. demonstrates understanding of the relationship between the change in free energy and the voltage of an electrochemical cell and evaluates the design of a given electrochemical cell

i. demonstrates knowledge of the engineering design process as related to energy, including criteria, modeling, use of technology and mathematical thinking, and applications to real-world situations; and evaluates an engineering design or solution, taking into account a range of constraints, including cost, safety, reliability, and aesthetics, and considering social, cultural, and environmental impacts

j. demonstrates knowledge of how to plan, construct, and safely and ethically carry out investigations into energy in chemical systems (e.g., conducting a calorimetry activity to calculate the specific heat of an unknown metal, collecting temperature data to draw conclusions about changes in the total bond energy in a system, generating a heating curve for a substance from experimentally collected data)

k. analyzes and draws inferences from scientific and technical texts and graphics; interprets graphs and data; applies mathematical and computational thinking in analyzing data; and evaluates the hypotheses, data, analyses, and conclusions in a scientific or technical text related to energy in chemical systems

FIELD 161: CHEMISTRY
TEST FRAMEWORK

COMPETENCY 0005—PEDAGOGICAL CONTENT KNOWLEDGE

Performance Expectations

The New York State chemistry teacher effectively applies pedagogical content knowledge to design culturally relevant instruction to guide all students in achieving a specific learning goal using an effective three-dimensional approach (i.e., disciplinary core idea, crosscutting concept, science or engineering practice). The teacher also applies knowledge of current education research on how students learn science in order to develop safe and effective performance tasks that will guide all students, including diverse learners, in achieving a specific learning goal. The teacher appropriately assesses student knowledge and understanding and identifies potential and apparent student strengths and needs.

Performance Indicators

a. demonstrates knowledge of how to assess student readiness for a specific new learning goal related to a chemistry concept or science or engineering practice

b. applies knowledge of how to design culturally relevant instruction using appropriate and effective instructional strategies that connect students' prior understanding and real-world experiences to new knowledge for all students, including diverse learners

c. applies knowledge of how to design appropriate and effective three-dimensional instruction (i.e., disciplinary core ideas, crosscutting concepts, science and engineering practices) to support students in applying and developing understanding of chemistry concepts

d. applies knowledge of appropriate and effective research-based strategies to guide all students to engage safely in chemistry concepts or science and engineering practices

e. applies knowledge of appropriate and effective assessment to evaluate and promote learning and growth for all students, including diverse learners