# NEW YORK STATE TEACHER CERTIFICATION EXAMINATIONS™

## FIELD 07: CHEMISTRY
## TEST FRAMEWORK

**June 2003**
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# New York State Teacher Certification Examinations™

## FIELD 07: CHEMISTRY
## TEST FRAMEWORK
## June 2003

| Subarea | | Range of Objectives |
|---|---|---|
| | **Selected-Response** | |
| I. | Foundations of Scientific Inquiry | 0001–0006 |
| II. | Matter and Atomic Structure | 0007–0011 |
| III. | Energy, Chemical Bonds, and Molecular Structure | 0012–0016 |
| IV. | Chemical Reactions | 0017–0021 |
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Foundations of Scientific Inquiry
Matter and Atomic Structure
Energy, Chemical Bonds, and Molecular Structure
Chemical Reactions
Stoichiometry and Solutions
Interactions of Chemistry and the Environment
Foundations of Scientific Inquiry: Constructed-Response Assignment

The New York State chemistry educator has the knowledge and skills necessary to teach effectively in New York State public schools. The chemistry teacher is a skilled problem solver who understands the historical development of ideas in science and the connections among science, mathematics, and technology. The chemistry teacher knows how to access, generate, process, and transfer information using appropriate technologies and can apply knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions. Most importantly, the chemistry teacher understands the process of scientific inquiry and applies chemistry concepts, principles, and theories to pose questions, seek answers, and communicate explanations of natural phenomena.

## SUBAREA I—FOUNDATIONS OF SCIENTIFIC INQUIRY

**0001 Understand the relationships and common themes that connect mathematics, science, and technology.**

For example:

- applying chemical theory to various systems (e.g., geological, biological, astronomical)
- analyzing the use of chemistry, mathematics, and other sciences in the design of a technological solution to a given problem
- analyzing the role of technology in the advancement of scientific knowledge
- using a variety of software (e.g., spreadsheets, graphing utilities, molecular modeling and visualization software, statistical packages, simulations) and information technologies to model and solve problems in mathematics, science, and technology

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**0002 Understand the historical and contemporary contexts of the study of chemistry.**

For example:

- analyzing the significance of key events, theories, experiments, and individuals in the history of chemistry
- recognizing the impact of society on the study of chemistry (e.g., growing demands for nonpolluting fuels, detergents, and refrigerants; biomedical advances; expanding markets for drugs and recyclable products)
- assessing the implications for society of recent developments in chemistry (e.g., synthetic materials, pharmaceuticals, alternative fuels)

**0003 Understand the process of scientific inquiry and the role of observation and experimentation in explaining natural phenomena.**

For example:

- analyzing processes by which new scientific knowledge and hypotheses are generated
- analyzing ethical issues related to the process of scientific inquiry
- assessing the appropriateness of a specified experimental design to test a given chemical hypothesis
- assessing the role of communication among scientists in promoting scientific progress

**0004 Understand the processes of gathering, organizing, reporting, and interpreting scientific data, and apply this understanding in the context of chemistry investigations.**

For example:

- assessing the appropriateness, validity, and reliability of a given method or procedure for collecting data for a specified purpose
- selecting an appropriate and effective graphic representation (e.g., chart, table, graph) for organizing, reporting, and analyzing given experimental data
- applying procedures and criteria for sharing and formally reporting experimental procedures and data, including percent error
- analyzing relationships between factors (e.g., inverse, direct, linear) as indicated by experimental data

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**0005 Understand principles and procedures of measurement used in chemistry.**

For example:

- evaluating the appropriateness of units of measurement, measuring devices, or methods of measurement for given situations
- analyzing likely sources of error in given measurements in chemistry experiments and their consequences in subsequent calculations
- using significant figures and scientific notation in expressing measurements, making calculations, and reporting data
- distinguishing between accuracy and precision in scientific measurements

**0006 Understand equipment, materials, and chemicals used in chemistry investigations; and apply procedures for their proper, safe, and legal use.**

For example:

- identifying laboratory glassware and equipment and making appropriate selections for specific experiments
- analyzing the principles upon which given laboratory instruments are based (e.g., pH meters, gas chromatographs)
- applying proper methods for storing, identifying, and dispensing given chemicals and the legal guidelines for disposing of chemicals
- applying proper procedures for safety in the laboratory (e.g., use of goggles, fume hoods)
- applying proper procedures for dealing with accidents and injuries in the chemistry laboratory (e.g., use of fire blankets, fire extinguishers)
- applying information from material safety data sheets (MSDS) and chemical hygiene plans (CHP)

## SUBAREA II—MATTER AND ATOMIC STRUCTURE

**0007 Understand the concept of matter, and analyze chemical and physical properties of and changes in matter.**

For example:

- differentiating among elements, compounds, and mixtures
- using the physical and chemical properties of an unknown substance to identify it
- identifying the methods by which chemical properties of matter are determined
- distinguishing between physical and chemical changes in matter

**0008 Understand the various models of atomic structure, the principles of quantum theory, and the properties and interactions of subatomic particles.**

For example:

- identifying major features of models of atomic structure (e.g., Bohr, Rutherford, Heisenberg, Schrödinger) and the supporting evidence for these models (e.g., gold foil experiment, emission spectra)
- relating interactions among electrons, protons, and neutrons to their properties
- analyzing the relationships among electron energy levels, photons, and atomic spectra
- analyzing the electron configurations of atoms and ions
- predicting and interpreting Lewis dot symbols of atoms and ions

**0009 Understand the organization of the periodic table.**

For example:

- analyzing the organization of the periodic table in terms of atomic number and properties of the elements
- analyzing trends (e.g., ionization energies, covalent atomic radii) within periods and groups in the periodic table
- predicting physical and chemical properties of given elements based on their positions in the periodic table
- using the periodic table to gain information (e.g., relative reactivity) about given elements

**0010 Understand the kinetic molecular theory, the nature of phase changes, and the gas laws.**

For example:

- comparing arrangements and movements of particles in solids, liquids, and gases
- analyzing basic principles of the kinetic molecular theory (e.g., particles of matter are in continual motion, real versus ideal gas behavior)
- analyzing heating and cooling curves qualitatively and quantitatively
- analyzing phase diagrams
- setting up and solving problems involving relationships among temperature, pressure, and volume of a gas

**0011 Understand the process of nuclear transformation.**

For example:

- comparing characteristics (e.g., mass, penetrating power) of the different types of emanations from the decay of radioactive elements
- analyzing the processes of natural radioactivity and artificial transmutation
- solving problems involving half-life of radioactive particles
- calculating nuclear mass defect and nuclear binding energy

## SUBAREA III—ENERGY, CHEMICAL BONDS, AND MOLECULAR STRUCTURE

**0012 Understand the principles of calorimetry.**

For example:

- differentiating among forms of energy (e.g., heat, chemical, nuclear)
- analyzing the results of calorimetry experiments
- distinguishing between heat and temperature

**0013 Understand thermodynamics and energy relationships in chemical bonding and chemical reactions.**

For example:

- analyzing the three laws of thermodynamics and their applications to chemical systems
- predicting the spontaneity of given reactions based on enthalpy changes, entropy changes, and temperatures of the systems
- analyzing energy changes due to the formation or breaking of chemical bonds
- solving problems involving energy changes during chemical reactions (e.g., heat of combustion, heat of formation)
- interpreting potential-energy diagrams of chemical reactions

**0014 Understand the types of bonds between atoms (ionic, covalent, and metallic bonds), the formation of these bonds, and properties of substances containing the different bonds.**

For example:

- comparing the characteristics of various types of bonds between atoms (e.g., bond strength, polarity)
- analyzing chemical bonding in terms of electron behavior (e.g., interpreting Lewis structures, predicting molecular geometry)
- analyzing factors that affect bond strength (e.g., electronegativity, electron affinity)
- predicting properties of a substance based on the type of bonds holding the atoms together

**0015 Understand the types of intermolecular forces and properties of substances containing the different forces between molecules.**

For example:

- comparing the characteristics of various types of intermolecular forces
- predicting the kind of force between molecules of a given structure
- relating the physical properties of substances to their intermolecular forces
- relating the unique properties of water to its molecular structure and intermolecular forces

**0016 Understand the nomenclature and structure of inorganic and organic compounds.**

For example:

- applying the IUPAC rules of nomenclature
- distinguishing among inorganic structures (e.g., ionic solids, network solids, metallic solids)
- analyzing the chemical composition and basic structure of organic compounds (e.g., saturated, unsaturated, and aromatic hydrocarbons; halogen, oxygen, and nitrogen derivatives)
- distinguishing among functional groups of organic compounds
- distinguishing among structural, geometric, and optical isomers

## SUBAREA IV—CHEMICAL REACTIONS

**0017 Understand factors that affect reaction rates and methods of measuring reaction rates.**

For example:

- applying collision theory to situations involving factors that influence reaction rates
- relating experimental measurements to reaction rates and rate laws
- relating reaction mechanisms to rate laws
- determining order of reactions and rate constants and solving first-order rate problems

**0018 Understand the principles of chemical equilibrium.**

For example:

- analyzing the effects of concentration, pressure, temperature, and catalysts on chemical equilibrium
- applying Le Chatelier's principle to chemical systems
- solving problems involving equilibrium constants (e.g., $K_a$, $K_b$, $K_{eq}$, $K_p$, $K_{sp}$, $K_w$)

**0019 Understand the theories, principles, and applications of acid-base chemistry.**

For example:

- analyzing acids and bases according to operational and conceptual definitions (i.e., Arrhenius, Brønsted-Lowry, Lewis)
- analyzing the principles and applications of acid-base titration
- determining the hydronium ion concentration and the pH for various acid, base, and salt solutions
- comparing the relative strengths of given acids based on periodic relationships
- analyzing buffer solutions qualitatively and quantitatively

**0020 Understand redox reactions and electrochemistry.**

For example:

- analyzing processes that occur during redox reactions
- determining oxidation numbers and balancing redox equations
- determining standard and nonstandard electrode potentials
- predicting whether given redox reactions will occur
- analyzing the components (e.g., anode, cathode) and operating principles of electrochemical cells

**0021 Understand the nature of organic reactions.**

For example:

- recognizing the relationship between the rates of reactions involving organic compounds and bond types
- analyzing common types of reactions (i.e., combustion, addition, substitution, polymerization, oxidation, esterification)
- recognizing applications of organic reactions

## SUBAREA V—STOICHIOMETRY AND SOLUTIONS

**0022 Understand the mole concept.**

For example:

- relating the mole to Avogadro's number
- relating the gram-atomic mass of an element to the mass of one mole of the element
- calculating the number of moles in a given mass or volume of a substance
- demonstrating knowledge of how the mass of a single atom or molecule can be calculated

**0023 Understand the relationship between the mole concept and chemical formulas.**

For example:

- solving problems involving molecular and formula masses
- solving percent-composition problems
- determining empirical and molecular formulas

**0024 Understand the relationships expressed in chemical equations.**

For example:

- interpreting chemical notation
- recognizing various types of reactions and predicting their products
- balancing equations
- recognizing net ionic equations
- solving stoichiometric problems involving moles, mass, and volume (including limiting reactant and percent yield)

**0025 Understand the properties of solutions and colloidal suspensions, and analyze factors that affect solubility.**

For example:

- analyzing the colligative properties of solutions (i.e., freezing point depression, boiling point elevation, osmotic pressure, vapor pressure lowering)
- solving problems involving concentrations of solutions (e.g., molarity, molality, percent by mass)
- analyzing factors (e.g., temperature, pressure, molecular structure, surface area) that affect solubility
- interpreting solubility curves

## SUBAREA VI—INTERACTIONS OF CHEMISTRY AND THE ENVIRONMENT

**0026 Understand industrial and household chemistry.**

For example:

- analyzing industrial processes (e.g., processes by which petroleum is separated into fractions)
- analyzing chemical processes in the home (e.g., organic reactions involving leavening agents and fermentation)
- recognizing safety issues related to industrial and household chemistry (e.g., mixing household chemicals, acceptable disposal methods)

**0027 Understand the applications of nuclear reactions.**

For example:

- analyzing the use of radioisotopes (e.g., in the life sciences, in geological and archaeological dating)
- analyzing the role of the components of a nuclear reactor and the issue of waste disposal
- assessing the risks and benefits of nuclear technology
- identifying sources of radioactive emissions in the environment and analyzing the risks and benefits they pose for humans

**0028 Understand factors and processes related to the release of chemicals into the environment.**

For example:

- analyzing the chemical processes related to the release of chemicals into the atmosphere (e.g., acid rain, greenhouse effect, ozone depletion, photochemical smog, photosynthesis, nitrogen cycle)
- analyzing the chemical processes related to the release of chemicals into aquatic and terrestrial environments (e.g., eutrophication, groundwater contamination, water purification, fluoridation)
- analyzing methods for preventing and reversing environmental damage resulting from the release of chemicals into the environment (e.g., recycling, sewage treatment plants, pollution control devices, biomediation)

## SUBAREA VII—FOUNDATIONS OF SCIENTIFIC INQUIRY: CONSTRUCTED-RESPONSE ASSIGNMENT

The content to be addressed by the constructed-response assignment is described in Subarea I, Objectives 01–06.