

# Chemistry

## [27.160]

In addition to the standards for all science teachers that are set forth in Section 27.140 of this Part, those who specialize in the teaching of chemistry shall be required to meet the standards described in this Section.

### STANDARD 1

**The competent chemistry teacher possesses basic scientific and mathematical skills, utilizes safe laboratory practices, and is aware of issues of public concern.**

**Knowledge Indicators** - *The competent chemistry teacher:*

- 1A. understands the appropriate mathematical skills to solve problems; is aware of methods used in collecting, analyzing, and reporting data, including basic statistical and computational concepts, and the use of technology in the learning process.
- 1B. understands the appropriate experimental procedures and common scientific equipment for measurement and determination of chemical reactions and properties.
- 1C. understands chemical hygiene plans, safe and proper use of equipment, and materials commonly used in chemistry laboratories, including proper waste disposal and procedures for preventing and dealing with accidents and injuries in the laboratory.
- 1D. understands the role of chemistry in daily life, including ways in which basic research and the development of new technology affect society.

**Performance Indicators** - *The competent chemistry teacher:*

- 1E. solves simple algebraic operations, uses scientific notation, plots and interprets graphs.
- 1F. uses computer programs to organize data and indicate relationships.
- 1G. selects appropriate instrumentation and methods of chemical analysis.
- 1H. implements an appropriate chemical hygiene plan as part of the process of setting up and running a safe and effective chemistry laboratory course.
- 1I. relates chemistry and technology to issues of societal importance.

### STANDARD 2

**The competent chemistry teacher understands and applies the concepts of the nature of matter at the atomic level.**

**Knowledge Indicators** - *The competent chemistry teacher:*

- 2A. understands the chemical constitution of matter as elements, compounds, and mixtures and the distinction between physical and chemical changes.
- 2B. understands the development and central concepts of atomic theory and atomic structure, including the quantum mechanical model.
- 2C. understands the names and electronic structure of common elements and their ions.
- 2D. understands the periodic nature of the elements and the relationship between their electron configuration and the periodic table.

- 2E. understands the description of the energy of an electron in an atom or ion in terms of the four quantum numbers.
- 2F. understands the properties of an atomic nucleus that affect its stability.
- 2G. understands nuclear decay sequences and products.

**Performance Indicators - *The competent chemistry teacher:***

- 2H. applies basic separation techniques based on differences in properties of matter.
- 2I. describes the historical progression in the development of the theory of the atom, including the contributions of Dalton, Thomson, Rutherford, and Bohr.
- 2J. uses applicable principles to show the ground state electronic configuration of the elements and their ions.
- 2K. explains the chemical and physical properties of the elements in terms of electron configuration.
- 2L. explains the stability versus instability of specified nuclei and their decay products.
- 2M. shows strategies for writing and balancing equations for nuclear reactions.

### STANDARD 3

**The competent chemistry teacher understands the combination of elements to form bonds and the geometry and properties of the resulting compounds.**

**Knowledge Indicators - *The competent chemistry teacher:***

- 3A. understands the transfer of electrons in the formation of ionically bonded materials, the sharing of electrons in covalently bonded compounds, and the polarity of compounds in terms of electro negativity differences.
- 3B. understands the concepts of hybridization, Valence Shell Electron Pair Repulsion, and Lewis structures to describe molecular geometry and bonding.
- 3C. understands general features and properties of compounds of metals, nonmetals, and transition elements and materials derived from them.
- 3D. understands general features of three-dimensional structures, bonding, molecular properties, and reactivity of organic molecules.

**Performance Indicators - *The competent chemistry teacher:***

- 3E. categorizes compounds as ionic, polar covalent, and nonpolar covalent.
- 3F. draws Lewis structures and describes the geometry of specified compounds.
- 3G. describes geometry of coordination compounds based on hybridization of the central atom.
- 3H. uses molecular models and predicts properties of organic molecules based on bonding and structure.

### STANDARD 4

**The competent chemistry teacher understands the nature and properties of molecules in the gaseous, liquid, and solid states.**

**Knowledge Indicators - *The competent chemistry teacher:***

- 4A. understands the kinetic molecular theory and its description of solids, liquids, and gases.
- 4B. understands the combined gas laws, the ideal gas law, Dalton's Law of Partial Pressures, and Graham's Law of Diffusion.

- 4C. understands intermolecular forces that explain physical properties of elements and compounds in all states of matter, classifying by type of unit attraction.

**Performance Indicators - *The competent chemistry teacher:***

- 4D. explains the transitions between solids, liquids, and gases using phase diagrams.  
4E. describes the behavior of gases and demonstrates proper and effective lab techniques for working with gases under various conditions.  
4F. explains liquid properties in terms of intermolecular forces.  
4G. classifies unknown solids as molecular, metallic, ionic, and covalent network solids according to their physical and chemical properties.

## STANDARD 5

### The competent chemistry teacher understands interactions of particles in solution.

**Knowledge Indicators - *The competent chemistry teacher:***

- 5A. understands concentrations and appropriate procedures for preparing solutions.  
5B. understands the mechanisms of the solution process, including effects of temperature and pressure on solubility of liquids and gases.  
5C. understands the colligative properties of solutions.

**Performance Indicators - *The competent chemistry teacher:***

- 5D. prepares solutions of specific concentrations (molality, molarity, normality, mole fraction, and percent by weight).  
5E. selects appropriate solvents for dissolution or purification of solid compounds.  
5F. applies colligative properties to practical solutions of technological problems.

## STANDARD 6

### The competent chemistry teacher understands acid-base chemistry.

**Knowledge Indicators - *The competent chemistry teacher:***

- 6A. understands Arrhenius, Bronsted-Lowry, and Lewis concepts of acids and bases.  
6B. understands the relationship between acid and base strength and molecular structure.  
6C. understands how chemical equilibrium of weak acids explains buffered solutions.

**Performance Indicators - *The competent chemistry teacher:***

- 6D. uses the Arrhenius, Bronsted-Lowry, and Lewis concepts to explain the pH of various solutions.  
6E. prepares standardized solutions and conducts acid/base titrations.  
6F. explains how to prepare a buffer of a specified pH if given a list of the  $K_a$  of various acids, and a standardized NaOH solution.

## STANDARD 7

**The competent chemistry teacher understands the laws of thermodynamics and can apply them to chemical systems.**

**Knowledge Indicators** - *The competent chemistry teacher:*

- 7A. understands the relationships between enthalpy, entropy, Gibbs free energy, and the equilibrium constant.
- 7B. understands the kinetic and thermodynamic dynamics that move a reversible reaction to a position of chemical equilibrium.
- 7C. understands LeChatelier's Principle and its application to a reversible reaction.
- 7D. understands oxidation/reduction reactions and their relationship to standard reduction potentials.
- 7E. understands electrolysis reactions.

**Performance Indicators** - *The competent chemistry teacher:*

- 7F. evaluates the energy potential of a variety of fuels in terms of maximum possible useful work.
- 7G. evaluates the thermodynamic feasibility of various reactions and performs appropriate thermodynamic calculations.
- 7H. demonstrates the implications of LeChatelier's Principle on a variety of aqueous and gaseous equilibria.
- 7I. balances redox equations.
- 7J. devises and builds an electrochemical cell.

## STANDARD 8

**The competent chemistry teacher understands the mechanisms of chemical reactions and the theory and practical applications of reaction rates.**

**Knowledge Indicators** - *The competent chemistry teacher:*

- 8A. understands the classification of types of chemical reactions.
- 8B. understands common rate terms and experimental determination of reaction rates as a function of concentration and time.
- 8C. understands the basics of collision and transition-state theories and significance of the Arrhenius equation.
- 8D. understands rate laws and their importance to mechanisms; rate laws associated with common reactions and catalyzed reactions.

**Performance Indicators** - *The competent chemistry teacher:*

- 8E. writes balanced equations to describe chemical reactions.
- 8F. experimentally determines and analyzes rate data and applies them to mechanisms.
- 8G. explains how reactions occur, what factors are involved in determining how fast a reaction proceeds, and the effects of temperature on rates.
- 8H. uses kinetics to determine reaction mechanisms and explains catalysis.

## STANDARD 9

**The competent chemistry teacher understands major aspects of organic chemistry.**

### **Knowledge Indicators - *The competent chemistry teacher:***

- 9A. understands the functional group classification and nomenclature of organic compounds and general characteristics and reactions of each group.
- 9B. understands the concepts and mechanisms of substitution, addition, elimination, and other reactions of organic molecules.
- 9C. understands the importance and use of chromatography in the separation and spectroscopy in the characterization of organic molecules.
- 9D. understands the general structure, properties and uses of organic polymers, pharmaceuticals, pesticides, and other practical products.
- 9E. understands the structure, properties, and function of common biological molecules (carbohydrates, lipids, proteins and nucleic acids) and how these biomolecules are used in processes necessary for life.

### **Performance Indicators - *The competent chemistry teacher:***

- 9F. recognizes functional groups and predicts reactions thereof.
- 9G. writes simple mechanisms of organic reactions.
- 9H. sets up appropriate separation, purification, and identification schemes for organic molecules.
- 9I. demonstrates and discusses practical organic materials.
- 9J. explains the overall biological function of common types of biomolecules.