



## GACE® Chemistry Assessment

### *Test at a Glance*

Updated May 2017

See the GACE® Chemistry Assessment Study Companion for practice questions and preparation resources.

Assessment Name	Chemistry
Grade Level	6–12
Test Code	Test I: 028 Test II: 029 Combined Test I and Test II: 528
Testing Time	Test I: 2 hours Test II: 2 hours Combined Test I and Test II: 4 hours
Test Duration	Test I: 2.5 hours Test II: 2.5 hours Combined Test I and Test II: 5 hours
Test Format	Computer delivered
Number of Selected-response Questions	Test I: 60 Test II: 60 Combined Test I and Test II: 120
Question Format	The test consists of a variety of short-answer questions such as selected-response questions, where you select one answer choice or multiple answer choices (depending on what the question asks for), questions where you enter your answer in a text box, and other types of questions. You can review the possible question types in the <b><i>Guide to Taking a GACE Computer-delivered Test</i></b> .
Number of Constructed-response Questions	Test I: 0 Test II: 0 Combined Test I and Test II: 0

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## About this Assessment

The GACE Chemistry assessment is designed to measure the professional knowledge of prospective teachers of secondary school Chemistry in the state of Georgia.

This assessment includes two tests. You may take either test individually or the full assessment in a single session. The testing time is the amount of time you will have to answer the questions on the test. Test duration includes time for tutorials and directional screens that may be included in the test.

The questions in this assessment assess both basic knowledge across content areas and the ability to apply principles.

The total number of questions that are scored is typically smaller than the total number of questions on the test. Most tests that contain selected-response questions also include embedded pretest questions, which are not used in calculating your score. By including pretest questions in the assessment, ETS is able to analyze actual test-taker performance on proposed new questions and determine whether they should be included in future versions of the test.

## Content Specifications

Each test in this assessment is organized into content **subareas**. Each subarea is further defined by a set of **objectives** and their **knowledge statements**.

- The objectives broadly define what an entry-level educator in this field in Georgia public schools should know and be able to do.
- The knowledge statements describe in greater detail the knowledge and skills eligible for testing.
- Some tests also include content material at the evidence level. This content serves as descriptors of what each knowledge statement encompasses.

See a breakdown of the subareas and objectives for the tests in this assessment on the following pages.

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## Test I Subareas

Subarea	Approx. Percentage of Test
I. Scientific Inquiry, Processes, Technology, and Society	32%
II. Nature of Matter and Energy	40%
III. Nomenclature, Chemical Composition, and Bonding and Structure	28%

## Test I Objectives

### Subarea I: Scientific Inquiry, Processes, Technology, and Society

*Objective 1: Understands scientific inquiry and technology, and the relationship to society and the environment*

The beginning Chemistry teacher:

- A. Understands the processes involved in scientific inquiry
  - Formulating problems
  - Forming and testing hypotheses
  - Development of theories, models, postulates, assumptions, and laws
  - Process skills, including observing, concluding, comparing, inferring, categorizing, and generalizing
- B. Understands experimental design
  - Testing hypotheses
  - Significance of controls
  - Use and identification of variables
  - Data collection planning
- C. Understands the nature of scientific knowledge
  - Subject to change
  - Consistent with experimental evidence
  - Reproducibility
  - Unifying concepts and processes, including systems, models, constancy and change, equilibrium, and form and function
  - Communicating experimental findings
  - Undergoes peer review

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- D. Understands the major historical developments in chemistry and the contributions of major historical figures
- How current chemical principles and models developed over time
  - Major developments in chemistry such as the atomic model and gas laws, including major historical figures
- E. Understands the impact of chemistry and technology on the environment
- Acid rain
  - Air and water pollution
  - Greenhouse gases
  - Ozone layer depletion
  - Waste disposal and recycling
  - Green chemistry
- F. Understands applications of chemistry in daily life
- Plastics, soaps, batteries, fuel cells, and other consumer products
  - Water purification
  - Chemical properties of household products
  - Pharmaceuticals
  - Medical imaging
- G. Understands the advantages and disadvantages associated with various types of energy production
- Renewable and nonrenewable energy resources
  - Conservation, recycling, and sustainability
  - Pros and cons of power generation based on various sources, such as fossil and nuclear fuel, hydropower, wind power, solar power, and geothermal power

*Objective 2: Understands how to conduct laboratory processes, including the collection and analysis of data*

The beginning Chemistry teacher:

- A. Understands how to collect, evaluate, manipulate, interpret, and report data
- Significant figures in collected data and calculations
  - Organization and presentation of data
  - Interpret and draw conclusions from data presented in tables, graphs, and charts
  - Note trends in data and relationships between variables
  - Make predictions and conclusions based on data

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- B. Understands units of measurement, notation systems, conversions, and mathematics used in chemistry
- Standard units of measurement
  - Unit conversion and dimensional analysis
  - Scientific notation
  - Measurement equipment
- C. Understands basic error analysis
- Determining mean
  - Accuracy and precision
  - Identifying sources and effects of error
  - Percent error
- D. Understands the appropriate preparation, use, storage, and disposal of materials in the laboratory
- Appropriate use
  - Safe disposal
  - Appropriate storage
  - Preparation for classroom use
  - Safe procedures and safety precautions
- E. Understands the appropriate use and need for maintenance and calibration of laboratory equipment
- Appropriate use
  - Appropriate storage
  - Maintenance
  - Calibration
  - Preparation for classroom use
  - Safety procedures and precautions when using equipment
- F. Understands safety procedures and precautions for the high school chemistry laboratory
- Location and use of standard safety equipment, such as eyewash stations and showers
  - Laboratory safety rules for students
  - Appropriate apparel and conduct in the laboratory, such as wearing goggles
  - Emergency procedures

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## Subarea II: Nature of Matter and Energy

### *Objective 1: Understands basic principles of matter and energy*

The beginning Chemistry teacher:

- A. Understands the organization of matter
  - Pure substances (elements and compounds)
  - Mixtures (homogeneous, heterogeneous, solutions, suspensions)
  - States of matter (solid, liquid, gas, plasma)
  - Atoms, ions, molecules
- B. Understands the differences between chemical and physical properties/changes
  - Chemical versus physical properties
  - Chemical versus physical changes
  - Intensive versus extensive properties
  - Conservation of matter
- C. Understands different forms of energy and conservation of energy
  - Kinetic and potential energy
  - Chemical, electrical, electromagnetic, nuclear, and thermal energy
  - Conversions between different forms of energy within chemical systems
  - Law of conservation of energy
- D. Understands kinetic molecular theory, including ideal gases
  - Assumptions of the kinetic molecular theory
  - Ideal gases and the ideal gas laws
  - Ideal versus real gas behavior

### *Objective 2: Understands the atomic model of matter*

The beginning Chemistry teacher:

- A. Understands the current model of atomic structure
  - Description of atomic model, including subatomic particles, orbitals/quantum numbers (energy levels and sublevels; s, p, d, ...)
  - Experimental basis, including the gold foil experiment and spectral lines
  - Isotopes (mass number, average atomic mass)
- B. Understands the electron configuration of the elements based on the periodic table
  - Aufbau principle, Hund's rule, Pauli exclusion principle
  - Correlation between electron configuration and the periodic table

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- Relationship between electron configuration and chemical and physical properties

C. Understands radioactivity

- Characteristics of alpha particles, beta particles, and gamma radiation
- Radioactive decay processes
- Half-life
- Fission and fusion
- Balancing nuclear reactions and identifying products of nuclear reactions

D. Understands how the electronic absorption and emission spectra of elements are related to electron energy levels

- Electronic energy transitions in atoms; e.g., ground state, excited states, emission/absorption of energy
- Energy of electronic absorption/emission spectral lines in various regions of the electromagnetic spectrum
- Relationship between energy, frequency, and wavelength

*Objective 3: Understands the basic principles of thermodynamics*

The beginning Chemistry teacher:

A. Understands temperature, thermal energy, and heat capacity, including temperature scales, units of energy, and calculations involving these concepts

- Temperature and temperature scales
- Thermal energy and units of energy
- Heat transfer
- Heat capacity and specific heat
- Calorimetry calculations

B. Understands concepts and calculations involving phase transitions between the various states of matter

- Phase transitions
- Phase diagrams (triple point)
- Heats of vaporization, fusion, and sublimation
- Heating curves

C. Understands the energetics of chemical reactions

- Exothermic and endothermic reactions
- Bond energy
- Hess's law

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- D. Understands how the laws of thermodynamics relate to chemical reactions and phase changes
- Laws of thermodynamics (first, second, third)
  - Spontaneous processes and reversible processes
  - Change in enthalpy and entropy in chemical/physical processes

**Subarea III: Nomenclature, Chemical Composition, and Bonding and Structure**

*Objective 1: Understands the nomenclature of compounds and their chemical composition*

The beginning Chemistry teacher:

- A. Understands the systematic names and chemical formulas of simple inorganic compounds
- Binary compounds
  - Acids, bases, and salts
  - Hydrates
- B. Understands the names of common organic compounds based on their functional groups
- Alkanes, alkenes, and alkynes
  - Alcohols, ethers, ketones, aldehydes, amines
- C. Understands the mole concept and how it applies to chemical composition
- Avogadro's number, molar mass, and mole conversions
  - Calculation of empirical and molecular formulas
  - Percent composition

*Objective 2: Understands various types of bonding, the structure of molecules, and intermolecular forces*

The beginning Chemistry teacher:

- A. Understands types of bonds and their properties
- Relative bond lengths
  - Relative bond strengths
  - Covalent bonding
  - Ionic bonding
  - Metallic bonding
- B. Understands structural formulas and molecular geometry (shape)
- Lewis structures, including formal charges

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- Resonance structures
  - Molecular geometry (shape and approximate bond angles)
  - Polar and nonpolar molecules
- C. Understands intermolecular interactions
- Hydrogen bonding
  - London forces (instantaneous induced dipole-dipole)
  - Dipole-dipole
  - Dipole-induced dipole
- D. Understands how bonding and molecular geometry correlate with physical properties
- Boiling points
  - Melting points
  - Solubility
  - Equilibrium vapor pressure

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## Test II Subareas

Subarea	Approx. Percentage of Test
I. Periodicity and Chemical Reactions	52%
II. Solutions and Solubility; and Acid-Base Chemistry	48%

## Test II Objectives

### Subarea I: Periodicity and Chemical Reactions

*Objective 1: Understands how to use the periodic table and the periodic trends in the properties of the elements*

The beginning Chemistry teacher:

- A. Understands the basis of the periodic table and general layout
  - Arranged in groups and periods
  - Atomic number and mass
  - Symbols of the elements
  - Metals, nonmetals, metalloids
  - Transition elements
- B. Understands the periodic trends in physical and chemical properties of the elements
  - Atomic/ionic radius
  - Ionization energy
  - Electron affinity
  - Electronegativity
  - Physical properties, such as boiling/melting points and conductivity
  - Chemical reactivity

*Objective 2: Understands how equations represent chemical reactions and are used to do stoichiometric calculations*

The beginning Chemistry teacher:

- A. Understands how to identify, write, and predict products of simple reaction types
  - Combustion
  - Neutralization
  - Decomposition

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- Synthesis
  - Dehydration
  - Single and double replacement
  - Oxidation-reduction
- B. Understands how to balance chemical equations
- Simple chemical equations
  - Chemical equations involving oxidation-reduction
- C. Understands how to perform stoichiometric calculations
- Simple calculations based on balanced chemical equations involving moles, mass, and volume
  - Limiting reagent calculations and percent yield
- D. Understands important biochemical compounds
- Carbohydrates, including simple sugars
  - Lipids
  - Proteins and amino acids
  - DNA and RNA
  - Products of photosynthesis and respiration
- E. Understands common organic compounds; i.e., is able to identify functional groups
- Alcohols
  - Ketones and aldehydes
  - Alkanes, alkenes, and alkynes
  - Ethers
  - Carboxylic acids
  - Amines
  - Benzene

*Objective 3: Understands chemical equilibrium, reaction kinetics, and oxidation-reduction chemistry*

The beginning Chemistry teacher:

- A. Understands chemical reaction equilibrium
- Equilibrium constants and equilibrium expressions for simple reactions
  - Le Chatelier's principle

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- B. Understands basic chemical kinetics
- Simple rate laws, rate constants, and reaction order
  - Activation energy and reaction mechanisms, including catalysts
  - Factors affecting reaction rate, such as concentration, surface area, and temperature
- C. Understands oxidation-reduction reactions and how to determine oxidation states
- Oxidation states
  - Identify oxidation-reduction reactions and half-reactions
  - Standard reduction potentials
  - Electrochemical reactivity series
  - Electrochemical cells

### **Subarea II: Solutions and Solubility; and Acid-Base Chemistry**

*Objective 1: Understands properties of solutions, including concentration, solubility, dissolution, and equilibrium*

The beginning Chemistry teacher:

- A. Understands solution terminology and calculations
- Dilute, concentrated, saturated, unsaturated, supersaturated
  - Solvent, solute
  - Concentration units
  - Preparation of solutions of varying concentrations
- B. Understands factors affecting solubility and dissolution rate
- Effect of temperature, pressure, surface area, and agitation on rate of dissolving
  - Effect of temperature and pressure on solubility
  - Solubility curves
- C. Understands solution phenomena based on colligative properties
- Freezing point depression
  - Boiling point elevation
  - Vapor pressure effects
  - Osmotic pressure
- D. Understands common applications of equilibrium in ionic solutions
- Solubility of ionic compounds, including solubility rules and slightly soluble compounds

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- $K_{sp}$  calculations, including percent dissociation and precipitation
  - Common ion effect
  - Electrolytes, nonelectrolytes, and electrical conductivity

*Objective 2: Understands acid-base chemistry, including pH calculations, titrations, and equilibrium*

The beginning Chemistry teacher:

- A. Understands how to define and identify acids and bases
  - Arrhenius acids and bases
  - Brønsted-Lowry acids and bases
  - Neutralization and equivalence point
- B. Understands the pH scale and can perform calculations involving pH and pOH
  - pH scale
  - Calculation of pH and pOH
  - Calculation of  $[H^+]$  and  $[OH^-]$
- C. Understands concepts and calculations involving acid-base titrations
  - Use and selection of indicators (e.g., phenolphthalein, litmus paper)
  - Endpoint determination
  - Calculations based on titrations
- D. Understands the equilibrium relationships in acid-base chemistry
  - Strong/weak acids and bases, including common examples
  - Monoprotic and polyprotic acids
  - $K_a$ ,  $K_b$ ,  $K_w$ , and percent dissociation
  - Buffer solutions