MICHIGAN TEST FOR TEACHER CERTIFICATION (MTTC)

TEST OBJECTIVES
FIELD 018: CHEMISTRY

Subarea	Approximate Percentage of Questions on Test
Reflecting on and Constructing Scientific Knowledge	25%
Using Inorganic Chemistry	32%
Using Physical Chemistry	27%
Using Organic Chemistry and Biochemistry	16%

I. REFLECTING ON AND CONSTRUCTING SCIENTIFIC KNOWLEDGE

001 Understand the principles and procedures of scientific inquiry.

Includes formulating research questions and investigations in chemistry; developing valid experimental designs for collecting and analyzing data and testing hypotheses; recognizing the need for control groups in experiments; understanding procedures for collecting and interpreting data to minimize bias; recognizing independent and dependent variables and analyzing the role of each in experimental design; identifying the most appropriate method (e.g., graph, table, formula) for presenting data for a given purpose; applying mathematics to investigations in chemistry and the analysis of data; interpreting results presented in different formats; evaluating the validity of conclusions; and assessing the reliability of sources of information.

002 Apply knowledge of methods and equipment used in scientific investigations.

Includes selecting and using appropriate data collection and measurement devices and methods; identifying uncertainties in measurement; evaluating the accuracy and precision of a measurement in a given situation; identifying procedures and sources of information related to the safe use, storage, and disposal of materials and equipment related to chemistry investigations; identifying hazards associated with laboratory practices and materials; and applying procedures for preventing accidents and dealing with emergencies.

003 Understand the nature of scientific thought, inquiry, and history.

Includes demonstrating knowledge of the reliance of scientific investigations on empirical data, verifiable evidence, and logical reasoning; recognizing the effect of researcher bias on scientific investigations and the interpretation of data; demonstrating an awareness of the contributions made to chemistry by individuals of diverse backgrounds and different time periods; and recognizing the dynamic nature of scientific knowledge, including ways in which scientific knowledge is acquired and modified.

004 Understand the relationship of chemistry to contemporary, historical, technological, and societal issues.

Includes recognizing the relationships between science and technology; analyzing historical, political, and social factors that affect developments in chemistry, including current issues related to chemistry research and technology (e.g., alternative fuels, polymers); and evaluating the credibility of scientific claims made in various forums (e.g., mass media, professional journals, advertising).

005 Understand interrelationships among the physical, life, and earth/space sciences and their connections to mathematics and technology.

Includes recognizing major unifying themes and concepts that are common to the various scientific disciplines (e.g., patterns, cause and effect, conservation of energy, entropy); and describing the integration and interdependence of the sciences, mathematics, and technology and their applications in real-world contexts.

II. USING INORGANIC CHEMISTRY

006 Apply the rules of chemical nomenclature and notation.

Includes applying basic rules of nomenclature to identify and name inorganic substances; and interpreting symbols and chemical notation for elements, isotopes, ions, molecules, and compounds.

007 Understand atomic and molecular structure and bonding.

Includes identifying the parts of an atom and their characteristics; comparing historic models of the atom; using the periodic table to predict the properties of a given element; representing atoms, ions, and compounds with electron-dot diagrams; analyzing the characteristics of different types of bonds (covalent, ionic, metallic), including the role of electrons in bonding; predicting physical and chemical properties based on the bonding in a substance; using VSEPR theory to explain molecular geometry and polarity; and identifying types of intermolecular forces and relating them to the physical properties of molecular substances.

008 Apply the mole concept and the principles and methods of stoichiometry.

Includes defining a mole and recognizing the significance of the mole concept; calculating the number of moles in a given mass or volume of a substance; solving problems involving molecular and formula masses and percent composition; determining empirical and molecular formulas; applying the law of conservation of mass to solve problems involving moles, mass, and volume and problems involving solution chemistry; balancing chemical equations; solving problems involving limiting reagents and percent yield; and recognizing net ionic equations.

009 Apply knowledge of chemical equilibrium and reaction rates.

Includes analyzing the effects of concentration, pressure, temperature, and catalysts on chemical equilibrium and applying Le Chatelier's principle to chemical systems; solving problems involving equilibrium constants and reaction quotients; solving problems involving solubility product constants of slightly soluble salts and the common-ion effect; analyzing everyday phenomena in terms of chemical equilibrium; describing how temperature, concentrations, and catalysts affect reaction rates; analyzing potential energy versus reaction coordinate diagrams; identifying first-order and second-order reactions from the rate law for a reaction; determining the rate law of a reaction from experimental data; and recognizing the relationship between a reaction mechanism and the rate law.

010 Understand the principles and applications of acid-base chemistry.

Includes analyzing acids and bases according to acid-base theories (i.e., Arrhenius, Brønsted-Lowry, Lewis); distinguishing between strong and weak acids and bases and identifying conjugate acid-base pairs; calculating the hydronium or hydroxide ion concentration and the pH or pOH of various acid and base solutions; predicting the acid-base properties of various salts; analyzing the composition and function of buffer solutions; applying the principles of acid-base titration, including the selection of indicators, and interpreting the results of acid-base titrations; and identifying applications of acid-base chemistry.

011 Understand the principles and applications of electrochemistry.

Includes interpreting the behavior of common substances in terms of oxidation-reduction reactions; determining oxidation numbers and balancing oxidation-reduction reactions (e.g., half-reaction method); analyzing the feasibility of given reactions based on electrode potentials at standard conditions and nonstandard conditions; analyzing the components, operating principles, and potentials of electrochemical and electrolytic cells; relating cell potentials to spontaneity and equilibrium constants; demonstrating knowledge of methods and applications of electrochemical analysis; and identifying applications of electrochemistry.

012 Understand qualitative analysis.

Includes demonstrating knowledge of various separation techniques (e.g., distillation, filtration, chromatography) and their basic principles; selecting an appropriate separation technique in a given situation; demonstrating knowledge of the methods and equipment used for determining the types of substances present in a sample; and identifying everyday applications of qualitative analysis.

III. USING PHYSICAL CHEMISTRY

013 Understand chemical thermodynamics and thermochemistry.

Includes differentiating among forms of energy (e.g., heat, chemical, nuclear); analyzing how the laws of thermodynamics apply to chemical systems; predicting the spontaneity of given reactions based on enthalpy changes, entropy changes, and temperatures of the systems; analyzing endothermic and exothermic reactions; distinguishing between heat and temperature; demonstrating knowledge of the principles of calorimetry; analyzing the results of calorimetry experiments; and solving enthalpy problems using Hess's law, standard enthalpies of formation, and bond energies.

014 Apply methods for measuring the physical properties of solids, liquids, and gases.

Includes comparing physical properties (e.g., melting point, density, solubility) of solids, liquids, and gases; demonstrating knowledge of methods and equipment used for measuring the physical properties of substances; and using the physical properties of a substance to identify it.

015 Apply knowledge of the kinetic molecular theory to the states of matter, phase changes, and the gas laws.

Includes identifying the basic tenets of the kinetic molecular theory; using the kinetic theory to describe and explain characteristics of the states of matter, including changes of state; explaining the dynamic equilibrium between phases; analyzing heating and cooling curves; analyzing vapor pressure curves and phase diagrams; analyzing the relationships among pressure, temperature, and volume of a gas or mixture of gases; distinguishing between ideal and real gas behavior; and setting up and solving problems involving gas law relationships.

016 Understand characteristics and properties of solutions.

Includes analyzing the colligative properties of solutions; recognizing factors that affect solubility, including intermolecular forces; interpreting solubility curves; solving problems involving concentrations of solutions (e.g., molarity, molality, percent by mass percentage); analyzing the process of dissociation in solution; identifying properties of strong and weak electrolyte solutions; and applying solubility rules of inorganic salts to predict the occurrence of precipitation reactions.

017 Understand quantum mechanics.

Includes identifying basic features of the quantum mechanical model of the atom; recognizing the experimental evidence for the quantum mechanical model of the atom; analyzing the relationships among electron energy levels, photons, and atomic spectra; demonstrating a basic understanding of quantum numbers; describing atomic orbitals; predicting the electron configurations of neutral atoms and ions of given elements; and relating photon energy to the wavelength and frequency of light.

018 Understand the basic principles and methods of spectroscopy.

Includes demonstrating knowledge of the basic principles used in spectroscopy, limited to UV, visible, infrared, and mass spectroscopy; recognizing the kind of information that can be determined using spectroscopic analysis; and identifying everyday applications of spectroscopy.

IV. USING ORGANIC CHEMISTRY AND BIOCHEMISTRY

019 Understand the structure and nomenclature of organic compounds.

Includes classifying hydrocarbons (e.g., alkane, aromatic) based on the type of carbon-carbon bonds; identifying the main families of organic compounds by means of their functional groups; using IUPAC rules to name simple organic compounds; identifying heterocyclic compounds; and recognizing isomers of organic compounds, including stereoisomers.

020 Understand organic reactions of major functional groups.

Includes demonstrating knowledge of the reactions of the major functional groups (addition, condensation, elimination, substitution); identifying the processes by which organic polymers are formed; and identifying everyday applications of organic reactions.

021 Understand the structure and function of biomolecules.

Includes recognizing and distinguishing the structures of the major classes of biomolecules (proteins, lipids, carbohydrates, nucleic acids); identifying the primary functions of the various types of biomolecules and relating these functions to molecular structure; recognizing the role of enzymes in biological systems; recognizing factors that affect enzyme kinetics; and recognizing the importance and role of buffers in biological systems.

022 Understand biochemical reactions and processes.

Includes using chemical principles (including thermodynamics) to analyze important biochemical processes (e.g., synthesis, degradation, electron transport, oxidative phosphorylation); and identifying the overall chemical equations for the metabolic reactions of photosynthesis and respiration.