MICHIGAN TEST FOR TEACHER CERTIFICATION (MTTC)

TEST OBJECTIVES
FIELD 097: PHYSICAL SCIENCE

Subarea	Approximate Percentage of Questions on Test
Foundations of Scientific Inquiry	20%
Concepts and Principles of Chemistry	40%
Concepts and Principles of Physics	40%

I. FOUNDATIONS OF SCIENTIFIC INQUIRY

001 Understand the principles and procedures of scientific inquiry.

Includes formulating research questions and investigations in physical science; developing valid experimental designs for collecting and analyzing data and testing hypotheses; recognizing the need for controlled experiments; understanding procedures for collecting and interpreting data to maintain objectivity; recognizing independent and dependent variables and constants, and analyzing the role of each in experimental design; identifying an appropriate method (e.g., graph, table, equation) for presenting data for a given purpose; applying mathematics to investigations in physical science 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 measurement devices and methods for collecting data; evaluating the accuracy and precision of measurement in a given situation; identifying uncertainties in measurements and results; identifying procedures and sources of information related to the safe use, storage, and disposal of materials and equipment related to physical science investigations; identifying hazards associated with laboratory practices and materials (e.g., chemical safety, heat sources, electricity); and applying procedures for preventing accidents and dealing with emergencies.

003 Understand the development of scientific thought and inquiry.

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 key contributions made to physical science by prominent groups and individuals of diverse cultures and from different time periods; and recognizing the dynamic nature of scientific knowledge, including ways in which scientific knowledge changes.

004 Understand the relationships of physical science to technological and social issues, both contemporary and historical.

Includes analyzing the role of science in human affairs; recognizing the relationships between science and technology; identifying political and social factors that influence developments in physical science, including current issues and controversies related to physical science research and technology (e.g., energy sources and use, applications and effects of various types of radiation); and evaluating the credibility of scientific claims made in various forums (e.g., the Internet, professional journals, advertising).

005 Understand interrelationships among the physical, life, and earth/space sciences.

Includes recognizing major unifying themes and concepts that are common to the various scientific disciplines (e.g., patterns, cause and effect, conservation laws, entropy); and demonstrating knowledge of the integration and interdependence of the sciences, the interdisciplinary connections among the sciences, and their applications in real-world contexts.

II. CONCEPTS AND PRINCIPLES OF CHEMISTRY

006 Understand chemical properties of matter.

Includes using atomic and molecular structure to explain chemical behavior; relating atomic structure to the structure and organization of the periodic table; differentiating among elements, compounds, and mixtures; identifying the structures of various types of compounds (e.g., acids, bases, polymers, aromatic and aliphatic hydrocarbons); identifying the structure and reactivity of major functional groups; demonstrating basic knowledge of isomers (e.g., stereoisomers, geometric isomers, optical isomers); and recognizing the structure and function of biomolecules (e.g., carbohydrates, proteins, lipids).

TEST OBJECTIVES
FIELD 097: PHYSICAL SCIENCE

007 Understand the physical properties of matter.

Includes demonstrating knowledge of the physical characteristics of matter (e.g., density, mass, atomic structure); applying knowledge of the characteristics of the states of matter; applying the kinetic theory of matter; analyzing phase changes; demonstrating knowledge of the physical properties of common materials (e.g., metals, nonmetals, water); identifying colligative properties of solutions; relating the structure of substances to physical properties (e.g., melting point, conductivity, solubility); comparing the physical properties of mixtures and solutions; and demonstrating knowledge of the gas laws and their relationship to the ideal gas law.

008 Understand the properties and characteristics of chemical bonds.

Includes relating the electron configuration of an atom to its chemical reactivity; comparing and contrasting the character and properties of covalent, metallic, and ionic bonds; identifying the nature of intermolecular and intramolecular forces; analyzing the relationship between intermolecular forces and the physical properties of a given substance; analyzing chemical bonds in terms of electronegativity, electron affinity, and oxidation state; and analyzing energy changes in the formation and dissociation of chemical bonds.

009 Understand the types and characteristics of chemical reactions.

Includes analyzing common chemical changes (e.g., acid-base reactions, oxidation-reduction reactions, aliphatic and alicyclic reactions); analyzing the effects of concentration, pressure, temperature, and catalysts on chemical equilibrium and applying Le Chatelier's principle to chemical systems; analyzing electrochemical reactions in electrochemical cells; analyzing how temperature, concentrations, and catalysts affect reaction rates; demonstrating knowledge of the basic principles of chemical thermodynamics; and analyzing energy-reaction coordinate diagrams.

010 Apply the principles and methods of stoichiometry and the rules of chemical nomenclature and notation for inorganic and organic substances.

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

011 Understand analytical techniques.

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 methods and equipment used for determining the types of substances present in a sample using spectroscopy (i.e., mass, IR, visible, and UV); and identifying common techniques of qualitative analysis.

III. CONCEPTS AND PRINCIPLES OF PHYSICS

012 Analyze forces and motion in one and two dimensions.

Includes analyzing information related to displacement, speed, velocity, and acceleration presented in one or more representations (e.g., graphs, tables, equations); solving problems involving constant acceleration (e.g., free fall); applying principles of trigonometry and properties of vectors to analyze two-dimensional situations (e.g., equilibrium, uniform circular motion, projectile motion, rotational dynamics); applying Newton's laws of motion to solve a variety of problems involving different types of forces (e.g., normal, tension, friction, buoyant); analyzing the vector nature of force; identifying action-reaction forces; identifying methods for measuring force; differentiating between mass and weight; and applying the law of universal gravitation in a variety of situations (e.g., satellite and planetary motion).

013 Understand conservation laws and thermodynamics.

Includes applying the concepts of work, forms of energy, and power in a variety of situations (e.g., inclined planes, pulleys); analyzing the kinetic and potential energy of various systems (e.g., a simple harmonic oscillator, a spring that obeys Hooke's law, a satellite in orbit); applying the principles of conservation of energy and conservation of linear and angular momentum to a variety of situations; differentiating between temperature, internal energy, and heat; calculating heat loss or gain using specific heat; identifying processes of thermal energy transfer (i.e., convection, conduction, radiation); applying the principles of enthalpy, internal energy, and thermodynamic work; and analyzing the relationship between entropy and the availability of energy to perform work.

014 Understand the characteristics of waves and wave motion, including the principles of sound and acoustics.

Includes describing the transfer of momentum and energy by wave motion; comparing longitudinal and transverse waves; analyzing characteristics of waves (e.g., amplitude, wavelength, frequency, speed); demonstrating knowledge of reflection, refraction, diffraction, and the Doppler effect; analyzing the production and propagation of mechanical waves; applying the principle of superposition to investigate the properties of constructive and destructive interference; and analyzing resonance and the production of musical sounds in vibrating strings and air columns.

015 Understand basic principles of electromagnetism.

Includes demonstrating knowledge of principles of electrostatics; identifying the properties of conductors, insulators, semiconductors, and superconductors; applying Ohm's law to the analysis of series and parallel circuits; analyzing energy transfer and conservation in electrical circuits; applying Coulomb's law to determine forces and fields due to various charge distributions (e.g., electric dipole); applying the concepts of electric potential; identifying the sources and properties of magnetic fields (e.g., strength, direction); determining the effect of a magnetic field on moving charges; analyzing the role of magnetic force in the operation of technological devices (e.g., solenoids, galvanometers, motors, loudspeakers); and using the principle of electromagnetic induction to explain the operation of technological devices (e.g., generators, transformers, dynamic microphones).

016 Understand the electromagnetic spectrum and the properties of electromagnetic waves.

Includes analyzing the generation and propagation of electromagnetic waves; demonstrating knowledge of the properties of the electromagnetic spectrum (e.g., wavelength, frequency, energy per photon); using the wave theory of light to analyze reflection, refraction, dispersion, interference, diffraction, and polarization; using ray diagrams and formulas for lenses and mirrors; demonstrating knowledge of the operation of optical instruments and materials (e.g., microscope, telescope, fiber optic cable); and recognizing technological applications of electromagnetic waves (e.g., cell phones, remote controls, medical x-rays).

017 Understand the basic concepts and applications of modern physics.

Includes demonstrating knowledge of the Bohr model of the atom and its limitations; using quantum numbers to describe atoms; identifying the wave-particle duality of radiation and matter; demonstrating knowledge of black body radiation and the photoelectric effect; relating nuclear structure and forces to radioactivity; solving problems involving half-life; differentiating among fission, fusion, and chemical reactions and their applications; and demonstrating a basic understanding of the theory of special relativity as it relates to time dilation, length contraction, and mass-energy equivalents.