



Massachusetts Tests for Educator Licensure[®]

TEST INFORMATION BOOKLET

10 General Science

MA-SG-FLD010-04

Massachusetts Department of Education

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General Science
(Field 10)

Test Overview Chart

Test Objectives

Sample Test Items

Answer Key and Sample Response

***Test Overview Chart:
General Science (10)***

Subareas	Approximate Number of Multiple-Choice Items	Number of Open-Response Items
I. History, Philosophy, and Methodology of Science	19–21	
II. Chemistry	19–21	
III. Physics	19–21	
IV. Biology	19–21	
V. Earth and Space Science	19–21	
VI. Integration of Knowledge and Understanding		2

The General Science test is designed to assess the candidate's knowledge of the subject matter required for the Massachusetts General Science license. This subject matter knowledge is delineated in the Massachusetts Department of Education's *Regulations for Educator Licensure and Preparation Program Approval* (7/2001), 603 CMR 7.06 "Subject Matter Knowledge Requirements for Teachers."

The General Science test assesses the candidate's proficiency and depth of understanding of the subject at the level required for a baccalaureate major, according to Massachusetts standards. Candidates are typically nearing completion of or have completed their undergraduate work when they take the test.

The multiple-choice items on the test cover the subareas as indicated in the chart above. The open-response items may relate to topics covered in any of the subareas and will typically require breadth of understanding of the general science field and the ability to relate concepts from different aspects of the field. Responses to the open-response items are expected to be appropriate and accurate in the application of subject matter knowledge, to provide high-quality and relevant supporting evidence, and to demonstrate a soundness of argument and understanding of the general science field.

Test Objectives:
General Science (10)

Massachusetts Tests for Educator Licensure™

**FIELD 10: GENERAL SCIENCE
TEST OBJECTIVES**

Subarea

Multiple-Choice	Range of Objectives	Approximate Test Weighting
I. History, Philosophy, and Methodology of Science	01–04	16%
II. Chemistry	05–08	16%
III. Physics	09–12	16%
IV. Biology	13–16	16%
V. Earth and Space Science	17–20	<u>16%</u>
		80%
Open-Response		
VI. Integration of Knowledge and Understanding	21	20%

SUBAREAS:

HISTORY, PHILOSOPHY, AND METHODOLOGY OF SCIENCE
CHEMISTRY
PHYSICS
BIOLOGY
EARTH AND SPACE SCIENCE
INTEGRATION OF KNOWLEDGE AND UNDERSTANDING

HISTORY, PHILOSOPHY, AND METHODOLOGY OF SCIENCE [16%]

0001 Understand the nature of scientific thought and inquiry and the historical development of major scientific ideas.

For example: the reliance of scientific investigation on empirical data; the use of verifiable evidence, reasoning, and logical arguments; the importance of avoiding bias; the evaluation of scientific claims and arguments; science and technology in the ancient world (e.g., China, Greece); the foundations for modern science in the seventeenth and eighteenth centuries; the development of modern science in the nineteenth and twentieth centuries; key figures, discoveries, and theories (e.g., the Copernican revolution, Darwin's theory of evolution); and social, religious, and economic conditions that supported or inhibited the development of science and technology.

0002 Understand principles and procedures of research and experimental design.

For example: the formulation of testable hypotheses; the use of carefully planned research to solve problems; procedures and considerations, including validity and reliability, in setting up and conducting scientific investigations; the use of sampling techniques; and hypothesis testing using control and experimental groups.

0003 Understand procedures for gathering, organizing, interpreting, evaluating, and communicating scientific information.

For example: the systematic observation of phenomena; strategies, tools, and technologies for gathering, measuring, recording, and processing data; advantages and disadvantages of various measurement methods and devices; solving problems involving measurement; the use of various formats (e.g., graphs, flowcharts, tables, step-by-step directions, maps, reports) for organizing, communicating, and interpreting information; the use of data for making predictions and drawing conclusions; and developing models and statistical methods for interpreting and reporting data.

0004 Understand the safe and proper use of tools, equipment, and materials (including chemicals and living organisms) related to classroom and other science investigations.

For example: practices and requirements related to the safe use and storage of tools and equipment; the use and proper disposal of materials; procedures for preventing accidents in the science laboratory; procedures for dealing with accidents and injuries in the science laboratory; and proper practices and requirements related to the use and care of living organisms.

CHEMISTRY [16%]

0005 Understand the structure and nature of matter.

For example: the atomic and molecular structure of matter; the structure of the atom; the use of models of atomic structure to explain chemical behavior; the relationship between atomic structure and the organization of the periodic table; the difference between mixtures and pure substances; and chemical symbols, formulas, and equations.

0006 Understand the nature of physical changes in matter.

For example: states of matter and their characteristics; properties of common materials; physical properties and changes; changes of state and related changes in energy; the concept of mass; the principle of conservation of matter; and types and properties of mixtures and solutions.

0007 Understand the nature of chemical changes in matter.

For example: the description of chemical changes in terms of properties and composition of reactants and products; the use of the principle of conservation of matter to analyze chemical reactions; types of chemical bonds, their characteristics, and their effects on the characteristics of matter; and factors that affect rates of reaction.

0008 Understand the kinetic molecular model of matter.

For example: use of the kinetic molecular theory to explain the states of matter; interrelationships among pressure, temperature, and volume in gaseous systems; and the relationship between temperature and kinetic energy.

PHYSICS [16%]

0009 Understand the concepts of force, motion, work, and power.

For example: Newton's laws of motion; the relationship between mass and inertia; the difference between mass and weight; the vector nature of force, displacement, velocity, and acceleration; characteristics of force, work, and power; the motion of an object in terms of speed, velocity, acceleration, inertia, and momentum; distance-versus-time graphs; and the types and characteristics of simple machines.

0010 Understand the concept of energy and the forms that energy can take.

For example: the concept of conservation of energy; forms of energy (e.g., mechanical, light, thermal, electrical, nuclear); the classification of energy as kinetic or potential; the relationship between kinetic and potential energy; processes of energy transfer and conversion; elastic and inelastic collisions; and the concepts of entropy and thermodynamics.

0011 Understand characteristics of waves and the behavior of sound and light waves.

For example: transverse and longitudinal waves; characteristics (e.g., amplitude, wavelength, frequency) of waves and oscillations; the relationship of wave characteristics to wave speed and wave energy; the relationship between wave characteristics and properties of sound (e.g., loudness, pitch) and light (e.g., color, intensity); wave interactions; the properties and behavior of sound and light waves in various media; phenomena related to light and the behavior of light in various situations (e.g., refraction, diffraction, dispersion); and characteristics and properties of the electromagnetic spectrum.

0012 Understand principles of electricity, magnetism, and electromagnetism.

For example: the properties and formation of static electricity; characteristics of electron flow and electric current; characteristics and components (e.g., batteries, resistors) of simple electric circuits; the interpretation of electric circuit diagrams; characteristics of magnets and magnetic fields; and the principles of electromagnetism.

BIOLOGY [16%]

0013 Understand the characteristics and life processes of living organisms.

For example: differences between living organisms and nonliving things; basic cell structures and their functions; comparisons between animal cells and plant cells; growth of multicellular organisms by cell growth and reproduction; processes of photosynthesis and cellular respiration; homeostatic and metabolic processes; levels of biological organization (i.e., molecules, cells, tissues, organs, and systems); and structures and functions of major systems in plants and animals and interactions between the systems.

0014 Understand principles related to the inheritance of characteristics.

For example: how characteristics are passed on from generation to generation, including mutations and the influence of environmental factors on the inheritance of characteristics; and the structures and functions of DNA, genes, and chromosomes.

0015 Understand principles and theories related to biological evolution.

For example: theories and processes associated with the origin and evolution of life and scientific evidence for these theories and processes; methods used to investigate evolution; the roles of genetic and phenotypic variation, environmental factors, and natural selection in speciation; and the connection between evolutionary relationships and taxonomy.

0016 Understand characteristics of populations, communities, ecosystems, and biomes.

For example: biotic and abiotic factors that affect populations, communities, ecosystems, and biomes; strategies used by organisms to obtain basic requirements for life (e.g., food, shelter, oxygen, water); interrelationships among organisms, including humans, in ecosystems; energy transfers in food webs and food chains; the process of ecological succession; responses of ecosystems to change; and factors regulating population sizes within ecosystems.

EARTH AND SPACE SCIENCE [16%]

0017 Understand geologic history and processes related to the changing earth.

For example: theories of the origin and history of the earth; methods of determining the relative and absolute ages of inorganic and organic materials; the structure and composition of the earth and its layers; types and characteristics of minerals, rocks, and soils; the processes of mineral formation; processes that are involved in the formation and destruction of igneous, sedimentary, and metamorphic rock; the theory of plate tectonics and supporting evidence; processes of structural change of the earth's crust; the effects of various agents (e.g., glaciers, water, wind) on the earth's surface; important topographical features of the earth and their characteristics; types and characteristics of maps and map projections commonly used in science; and the effects of catastrophic phenomena (e.g., earthquakes, collisions with asteroids) on the earth and its inhabitants.

0018 Understand characteristics and properties of the hydrosphere.

For example: properties of water; characteristics of oceans, surface water, and ground water; and use of the water cycle to explain the movement and renewal of ground water and of water in oceans, glaciers, rivers, lakes, and watersheds.

0019 Understand the earth's atmosphere, weather, and climate.

For example: the structure and characteristics of the atmosphere; factors that contribute to the uneven heating of the earth's surface; the effects on weather of the uneven heating of the earth's surface; mechanisms of energy transfer in the atmosphere; air pressure and the movement of air in the atmosphere; cloud formation and precipitation; equipment and techniques used to monitor the weather; the interpretation of meteorological information; and techniques used to predict the weather and climatic change.

0020 Understand components of the solar system and universe and their interactions.

For example: the planets and their characteristics; interactions and movements of the earth, moon, and sun (e.g., seasons, moon phases, tides, eclipses); characteristics of stars and other objects in the solar system and universe; and theories of the origin and evolution of the universe.

INTEGRATION OF KNOWLEDGE AND UNDERSTANDING [20%]

In addition to answering multiple-choice items, candidates will prepare written responses to questions addressing content from the preceding objectives, which are summarized in the objective and descriptive statement below.

- 0021 Prepare an organized, developed analysis on a topic related to one or more of the following: history, philosophy, and methodology of science; chemistry; physics; biology; and earth and space science.**

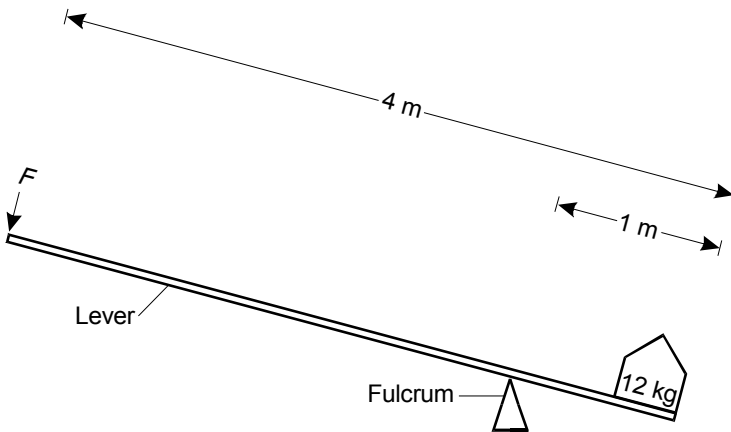
For example: the structure and nature of matter; chemical and physical changes in matter; the concepts of energy, force, and motion; characteristics and behavior of waves, sound, and light; characteristics and life processes of living organisms; principles and theories related to the inheritance of characteristics and biological evolution; the structure and composition of the earth and processes of structural change in the earth's crust; characteristics and properties of the hydrosphere and atmosphere; components of the solar system and universe and their interactions; and the nature of scientific thought and inquiry.

Sample Test Items:

General Science (10)

1. Students are planning to study the effects of a nitrogen fertilizer on the growth of young corn plants. Two weeks earlier, the students started approximately 100 plants from seed under identical conditions. From this group of 100 seedlings, the students will select 40 seedlings to use in their study. To provide experimental results that will be most representative of corn seedlings in general, the students should choose:
 - A. 20 large and 20 small seedlings.
 - B. 40 mid-sized seedlings.
 - C. 40 randomly selected seedlings.
 - D. the 40 smallest-looking seedlings.
2. In a classroom laboratory, a teacher is demonstrating a method of determining relative humidity using a procedure that involves swinging an apparatus on the end of a lightweight chain. The apparatus contains a mercury thermometer with its bulb covered by a piece of water-soaked cotton cloth. The teacher supplies each student with safety goggles. Which of the following changes to the demonstration is necessary in this situation?
 - A. Perform the demonstration outdoors.
 - B. Replace the mercury thermometer with an alcohol thermometer.
 - C. Wrap the thermometer in plastic in case it shatters.
 - D. Show students a video recording of the demonstration rather than a live demonstration.
3. A teacher adds a pure solid to a pure transparent liquid. The solid disappears as it enters the liquid, producing a transparent sample. Which of the following would provide the strongest evidence that the new sample is a suspension rather than a solution?
 - A. The solid can be recovered by passing the sample through a filter.
 - B. The solid can be recovered by evaporating the sample.
 - C. The sample conducts an electric current.
 - D. The sample transmits light of some wavelengths better than light of other wavelengths.
4. Containers 1 and 2 are identical. Container 1 contains one mole of gas X, and container 2 contains one mole of gas Y. Both containers are sealed and represent closed systems. The molecules of the gases in the two containers have the same average speeds, but gas Y has a much higher temperature than gas X. Which of the following pairs of gases is possible for gas X and gas Y?
 - A. Gas X is helium, and gas Y is hydrogen.
 - B. Gas X is argon, and gas Y is hydrogen.
 - C. Gas X is oxygen, and gas Y is helium.
 - D. Gas X is oxygen, and gas Y is argon.

5. Use the diagram below to answer the question that follows.



The lever shown in the diagram above is 4 m long, with the fulcrum 1 m from one end. A 12 kg load is placed on the end of the lever nearest the fulcrum. What load must be applied to the opposite end of the lever at F in order to balance the 12 kg load?

- A. 3 kg
- B. 4 kg
- C. 8 kg
- D. 9 kg

6. A circuit is created using a dry cell battery, two pieces of wire, and a small lightbulb. The current in the circuit is produced by:
- A. the movement of protons between the positive and negative terminals within the battery.
 - B. the transfer through the wire of voltage created by the separation of charge in the battery.
 - C. the difference in resistance between the pieces of wire and the lightbulb filament.
 - D. the chemical reactions within the battery that change chemical energy into electrical energy.
7. A genetic mutation that results in a nucleotide insertion usually has a much greater effect on the organism than a genetic mutation that results in a nucleotide substitution. This is true because a nucleotide insertion:
- A. causes a shift in the reading frame of the DNA code.
 - B. causes structural damage to the DNA molecule.
 - C. makes a gene unreadable at the ribosomal sites.
 - D. disrupts normal processes of mitosis and meiosis.

8. Use the information below to answer the question that follows.

In California, the *Ensatina* salamander lives in the area surrounding a valley but not in the valley itself. Populations of the salamander in different locations around the valley have different identifiable markings, so a given pattern can be used to identify the home of a given salamander. At each border where salamanders with one pattern leave off and salamanders with another pattern begin, individuals from the two populations are able to interbreed. There is one exception to this—at the southern end of the valley there are two populations of *Ensatina* salamanders that are not able to interbreed. The *Ensatina* salamander is an example of what is known as a "ring species." Each local group is able to interbreed with its neighbor, except for the two groups that seem to represent a beginning and an end to the ring and apparently are too distantly related to interbreed with one another.

This concept of a ring species implies that evolutionary mechanisms have which of the following characteristics?

- A. Evolutionary changes can accumulate over time.
- B. Evolutionary change in a species can be affected by abiotic environmental factors.
- C. Evolutionary changes are reversible in some situations.
- D. Two species will diverge more quickly if they are geographically close.

Use the information below to answer the two questions that follow.

As Pangaea pulled apart, the modern Atlantic Ocean was formed. At the same time, another rift developed just to the west, along the present-day Connecticut River Valley. This rift, rather than forming an ocean or sea, resulted in volcanic activity and lava flows in the area that is known today as the Holyoke Range. Much of the old rift has since been filled in by sediment that later lithified.

9. Based on the information in this passage, the rock making up the Holyoke Range can best be classified as:
- A. aggregate.
 - B. sedimentary rock.
 - C. metamorphic rock.
 - D. igneous rock.
10. The events described in this passage most likely occurred about how long ago?
- A. 20 thousand years ago
 - B. 65 million years ago
 - C. 200 million years ago
 - D. 2.5 billion years ago

11. **Use the information below to complete the exercise that follows.**

In the lungs of mammals, including humans, the circulatory and respiratory systems are closely associated anatomically and physiologically.

Using your knowledge of the circulatory and respiratory systems, write an essay in which you:

- describe what important physiological process occurs in the lungs;
- explain how the structures of the lungs and the circulatory system facilitate this process; and
- briefly describe how pulmonary circulation differs from systemic circulation.

Answer Key and Sample Response: General Science (10)

Question Number	Correct Response	Test Objective
1.	C	Understand principles and procedures of research and experimental design.
2.	B	Understand the safe and proper use of tools, equipment, and materials (including chemicals and living organisms) related to classroom and other science investigations.
3.	A	Understand the nature of physical changes in matter.
4.	D	Understand the kinetic molecular model of matter.
5.	B	Understand the concepts of force, motion, work, and power.
6.	D	Understand principles of electricity, magnetism, and electromagnetism.
7.	A	Understand principles related to the inheritance of characteristics.
8.	A	Understand principles and theories related to biological evolution.
9.	D	Understand geologic history and processes related to the changing earth.
10.	C	Understand geologic history and processes related to the changing earth.

The sample response below reflects a strong knowledge and understanding of the subject matter.

The lungs carry out the first stages of the physiological process of respiration, which carries oxygen to the cells of the body and removes carbon dioxide.

Inhaled air travels through the trachea, bronchi, bronchioles, and into the alveoli. The alveoli are air-filled sacs with walls that are only one cell thick and are surrounded by tiny capillaries filled with blood. Carbon dioxide dissolved in the blood diffuses across the walls of the alveoli into the air of the lungs and is exhaled. Oxygen diffuses from the air in the lungs across the alveolar walls and into the blood. This oxygen-rich blood travels to the heart as part of the pulmonary circulation and is then pumped to all the cells of the body as part of the systemic circulation.

The pulmonary circulation and the systemic circulation differ primarily in the relative amounts of oxygen and carbon dioxide in the arteries and veins. Blood that is low in oxygen and high in carbon dioxide is pumped through the pulmonary arteries to the capillaries surrounding the alveoli of the lungs. In the lungs, the blood loses carbon dioxide, picks up oxygen, and returns to the heart through the pulmonary veins. This blood, which is oxygen-rich and carbon dioxide-poor, is then pumped by the heart through the systemic arteries to the capillary beds of the body where it loses oxygen to the cells and picks up carbon-dioxide. The blood, which is now oxygen-poor and carbon dioxide-rich, then returns to the heart through the systemic veins and is pumped by the heart back to the lungs.