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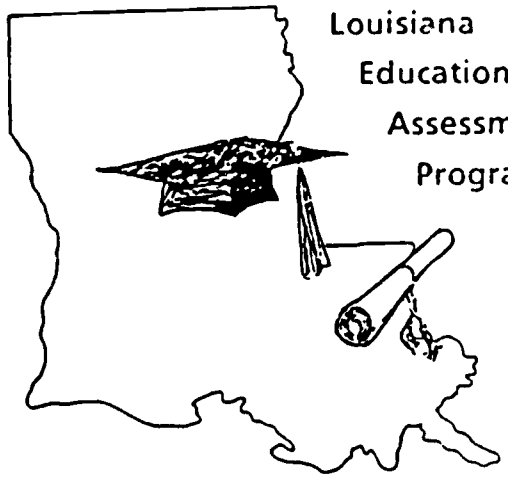
ABSTRACT

The Louisiana Educational Assessment Program (LEAP) Grade 11 Test is designed to measure proficiency in four subject areas including English, mathematics, social studies, and science. This guide for science is intended to provide a description of the way in which specific skill areas are assessed on the LEAP test and instructional considerations in promoting proficiency of these target skill areas. Skill areas included are: (1) "Biology/General Science"; (2) "Chemistry/Physical Science"; (3) "Physics/Physical Science"; (4) "Earth and Space Sciences/General Science"; and (5) "Scientific Method." Specific skills in each area are described at the beginning of each section. In each skill area, sample items, descriptions of test questions, descriptions of answer choices, and instructional analyses are provided. (CW)



LEAP

INSTRUCTIONAL STRATEGIES GUIDE

Grade 11

SCIENCE

Louisiana Department of Education

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Introduction

Recent efforts by the Louisiana Department of Education (LDE) to upgrade the state's competency-based educational plan include the establishment of a criterion-referenced high school exit level testing program. The Louisiana Educational Assessment Program (LEAP) Grade 11 Test is designed to measure proficiency in four subject areas: English/language arts, mathematics, social studies, and science.

In accordance with R.S. 17:24.4 (Act 146 of the 1986 Regular Session of the Louisiana Legislature) the Grade 11 criterion-referenced test items will be piloted on an approximate 5 percent sample of public school eleventh-grade students during the week of April 11-15 and April 18-22, 1988. The legislation requires statewide implementation of the test in 1988-89.

State Board of Elementary and Secondary Education (SBESE) policy, Standard 2.099.00, Bulletin 741, Louisiana Handbook for School Administrators, states that the test will be used as a graduation requirement. The 1990-91 school year was established by the SBESE as the effective date to require satisfactory performance on the test in order to receive a high school diploma. Students who fail to pass the Grade 11 test must be offered retake opportunities. R.S. 17:24.4 states that those students who fail to meet required proficiency levels on the state-administered criterion-referenced tests of the LEAP shall receive remedial education programs that comply with regulations adopted by SBESE.

Developmental activities for the LEAP Grade 11 Test have been substantial. Specific target skills and skill areas were selected by subject area advisory committees after a thorough review of appropriate textbooks and LDE curriculum standards. These skills represent the most salient, testable skills emphasized in the curriculum.

Test item specifications, test blueprints, and test items were developed by IOX Assessment Associates of Culver City, California, under the direction of both the LDE and subject area advisory committees composed of local education agency curriculum specialists.

The science section of the LEAP examination will consist of approximately 50 multiple-choice items* and require about one hour of administration time. The items were developed under the readability restriction that no words used exceed an eleventh-grade vocabulary level. There are five science skill areas

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*The exact number of science items to appear on the LEAP Grade 11 Test has yet to be determined.

covered on the LEAP Grade 11 Test. These skill areas and the approximate percent of items in the LEAP Grade 11 Science item pool representing these areas are listed below:*

Scientific Method	10%
Biology/Life Science	38%
Chemistry/Physical Science	19%
Physics/Physical Science	18%
Earth and Space Sciences/ General Science	15%

The specific content eligible for testing in the skill areas is limited to (1) science for grades 1 through 8, (2) high school biology, and (3) the areas of overlap between high school general science, physical science, and earth and space sciences. The following curriculum guides served as the basis for the science test specifications and test items:

Science K-6 Curriculum Guide, Bulletin No. 1613
Life Science Curriculum Guide, Bulletin No. 1614
Earth Science Curriculum Guide, Bulletin No. 1643
Physical Science Curriculum Guide, Bulletin No. 1644
General Science Curriculum Guide, Bulletin No. 1645
Biology Curriculum Guide, Bulletin No. 1646 (Revised)

Because of the high stakes associated with the LEAP Grade 11 Test, the LDE is making available to Louisiana educators instructional strategies guides that focus on the examination. These guides are intended to provide: (1) a clear description of the way in which specific skill areas are assessed on the LEAP test and (2) instructional considerations that might be used by Louisiana educators in promoting proficiency of these target skill areas.

Components of the Instructional Strategies Guide

The specific components of the guide for each skill area are briefly described below.

Sample item. An illustrative item (or items) is presented that is representative of the LEAP test items that will be used to assess students' proficiency in a given skill or skill area.

Description of test questions. The essential elements in the questions used in test items, such as format and content, are listed.

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*The percentages refer to the item pool as it existed prior to field-testing.

Description of answer choices. Basic characteristics of an item's answer choices are presented. In addition to noting the general nature of the correct answer choice, descriptive information is provided for the categories of incorrect answer choices.

Sample item answer choice descriptions. The correct and incorrect answer choices for the sample item(s) are identified. The particular incorrect-answer category represented by each incorrect answer choice is specified.

Instructional analysis. Instructional considerations relevant to preparing students for the various skill areas tested on the LEAP examination are described. In addition, a content outline which summarizes the content eligible for testing is provided. These instructional analyses are neither comprehensive nor prescriptive. Rather, they are intended to provide suggestions to Louisiana educators for instructional strategies that might be used to further student competence in the LEAP target skill areas.

Use of the Instructional Strategies Guide

This guide has been developed by experienced educators and revised by Louisiana teachers and curriculum specialists. Its purpose is to provide Louisiana educators with information regarding assessment strategies used on the LEAP Grade 11 Test as well as suggested instructional approaches to enhancing student proficiency in the skill areas covered on the examination. Use of this guide should assist Louisiana educators in providing students with effective, on-target instruction in these critical skill areas.

The materials in this guide will be useful in a variety of settings, including regular classes and LEAP-focused review/ remedial classes. The guide is organized in a manner that permits flexible use. Therefore, its sections dealing with individual skill areas are self-contained to facilitate use by educators who choose to focus on a specific skill area.

SKILL AREA: BIOLOGY/GENERAL SCIENCE

The skill area testing biology/general science includes seven content areas: Cellular Biology, Reproduction, Natural Selection and Evolution, Characteristics of Living Organisms, Anatomy and Physiology, and Ecology.

SAMPLE ITEMS*:

Cellular Biology

What is the primary difference between photosynthesis and cellular respiration?

A. Photosynthesis occurs only in plants; cellular respiration occurs only in animals.

B. Photosynthesis occurs only during the day; cellular respiration occurs only during the night.

C. Carbon dioxide is given off in photosynthesis; oxygen is given off in cellular respiration.

D. Glucose is formed during photosynthesis; glucose is broken down during cellular respiration.

Reproduction

A pure tall pea plant is crossed with a pure short pea plant. The dominant trait is tall. Two of these first-generation plants are then crossed. What is the probability that a short pea plant will be produced?

A. 0 out of 4

B. 1 out of 4

C. 2 out of 4

D. 3 out of 4

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*Correct answers and descriptions of other answer choices to sample items are presented on pages 8 and 9.

Natural Selection and Evolution

Given below is a description of a species of insect and its habitat.

> The insect has a light brown, segmented body and two large antennae. It eats the leaves and stems of the few plants that grow in the dry area in which it lives. It is hunted by birds that search for it among the plants.
>
> Eventually, the climate in the area changes. Rainfall increases and many plants began to grow. The area becomes green and moist.

Which of the following mutations would be the most favorable trait for this species of insect in its new habitat?

A. a non-segmented body

B. a dark brown body

C. a green body

D. small antennae

Diversity of Living Organisms

During an expedition, a biologist discovers a new organism. He observes that it is multicellular and has specialized tissues. Its cells have cell walls and contain chlorophyll. In which kingdom should this organism be placed?

A. plant

B. animal

C. protist

D. The organism's kingdom cannot be determined from the information provided.

Anatomy and Physiology

In vertebrates, the circulatory system includes the heart and blood vessels. What is the purpose of the circulatory system?

A. to provide structural support for body organs

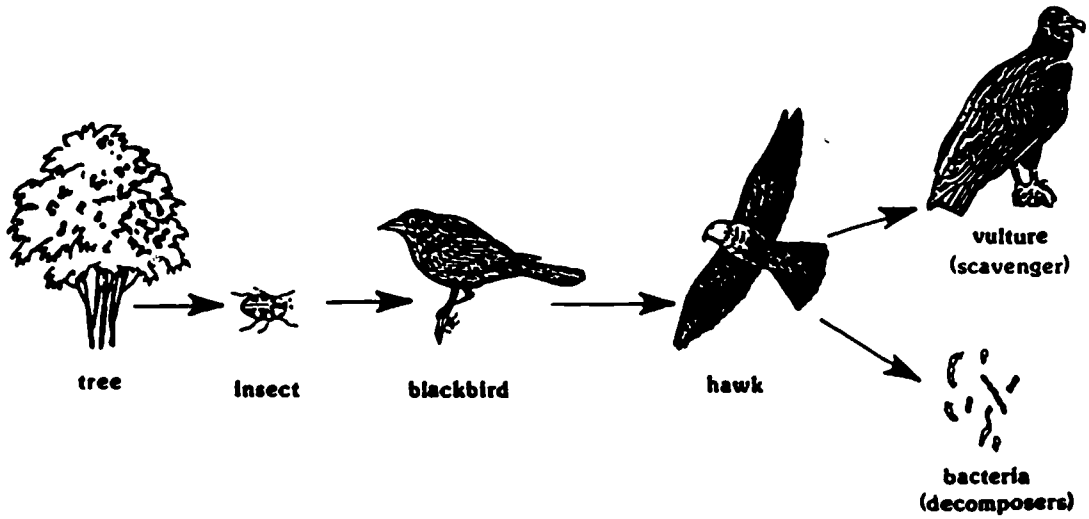
B. to deliver nutrients to body tissues

C. to store body wastes

D. to prepare food so that it may be used by body tissues

Ecology

Which of the organisms is a predator of the blackbird in the food web presented below?



A. the bacteria

B. the vulture

C. the insect

D. the hawk

DESCRIPTION OF TEST QUESTIONS:

1. The student will be presented with a question about a basic concept in biology.

2. The question will be based on information in the content areas of cellular biology, reproduction, heredity, natural selection and evolution, characteristics of living organisms, anatomy and physiology, and ecology.

3. The question may be preceded by a diagram, table, graph, or verbal description of information relevant to the test item.

4. To the extent possible, the question will require the application or analysis of the information to be tested, rather than straight recall.

DESCRIPTION OF ANSWER CHOICES:

1. The correct answer choice will be the response that represents the proper application or analysis of the concept tested in the item.

2. An incorrect answer choice will be one of the following types:

   a. contradicted: an application or analysis of the concept that is opposite to the correct application or analysis;

   b. incomplete: an application or analysis of the concept that does not take into account all of the relevant information presented in the test item;

   c. incorrect concept: an application or analysis of a concept listed in the content outline* other than the concept relevant to the question; or

   d. irrelevant: an application or analysis of a concept that is essentially unrelated to the question.

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*See pages 13-15 for content outline of biology items.

SAMPLE ITEM ANSWER CHOICE DESCRIPTIONS:

Cellular Biology

A. incorrect concept

B. contradicted

C. contradicted

D. correct

Reproduction

A. incomplete

B. correct

C. irrelevant

D. irrelevant

Natural Selection and Evolution

A. irrelevant

B. contradicted

C. correct

D. irrelevant

Diversity of Living Organisms

A. correct

B. contradicted

C. contradicted

D. incomplete

Anatomy and Physiology

A. incorrect concept

B. correct

C. contradicted

D. incorrect concept

Ecology

A. contradicted

B. contradicted

C. incorrect concept

D. correct

INSTRUCTIONAL ANALYSIS:

Biology is the science of living things. A solid understanding of biology prepares students for advanced study in botany, anatomy, physiology, and other branches of the life sciences. Biology is emphasized on the LEAP Grade 11 Science Test because all students in Louisiana are required to take biology in high school. Students will be required to apply their knowledge of biology in the content areas described below.

Cellular Biology

The cell is the basic structural and functional unit of all living things. An animal cell contains a nucleus, a cell membrane, and cytoplasm. A plant cell contains these structures encased by a cell wall. Your students should know the functions of these cell structures. One way to reinforce this knowledge is to have students observe cells under the microscope and relate the different cellular structures to their functions.

Students also need to understand the cellular processes of photosynthesis and respiration. Photosynthesis is a series of chemical reactions during which glucose is formed. Because it can only occur in the presence of chlorophyll, photosynthesis takes place only in plants. Respiration, on the other hand, occurs in all living cells. During cellular respiration, glucose and oxygen are broken down to form water, carbon dioxide and most importantly, energy. The sample item, which requires students to identify the primary difference between photosynthesis and cellular respiration, provides a good example of the level of knowledge typically needed to answer cellular biology test items. In order to answer any of the test items correctly, students must demonstrate an understanding of the fundamentals of the structures and processes described briefly herein.

Reproduction

Knowledge of several important biological processes is eligible for testing in this content area: mitosis, meiosis, asexual reproduction, sexual reproduction, and protein synthesis.

Reproduction items call for a basic understanding of these processes. In your lessons you may find it helpful to use illustrations in conjunction with your descriptions of these processes or conduct laboratory demonstrations that illustrate these concepts.

To understand the cellular basis of reproduction, students need to be familiar with the cell division processes (that is, mitosis and meiosis) and their respective roles in reproduction. Mitosis is the process in which the nucleus of a cell replicates, resulting in the formation of two new cells that are identical to the original cell. Mitosis is the basis of asexual reproduction, or the production of one or more offsprings from a single parent. Meiosis is basic to sexual reproduction, or the production of one or more offspring from two parents. During meiosis a cell divides into new cells each of which has half as many chromosomes as the original cell. One of these new sex cells then unites with another sex cell to form a unique organism with a complete set of chromosomes.

During reproduction, the chemical information necessary to produce essential proteins is passed to the next generation of cells. The process of protein synthesis is vital because the living condition is contingent upon having the right kind of proteins in the cells. Students should be familiar with the major steps of protein synthesis from DNA replication to the formation of new protein chains on the ribosomes.

With respect to basic genetic concepts, students should also know Mendel's laws and be able to apply these laws to the inheritance of general traits and sex-linked traits. For example, students will be expected to know how to determine the expected outcomes of given gene pairings. The sample reproduction item illustrates this type of application. Students should also know how to solve gene-pairing problems by using Punnett squares. You will, therefore, want to give students sufficient practice solving this type of problem.

Natural Selection and Evolution

Evolution is a process of change over successive generations of living things. According to Darwinian theory, the organisms best adapted to an environment are the ones to survive and reproduce. This process is referred to as "natural selection." Students need to know the basic premises of Darwin's theory of natural selection and be able to apply the theory to different situations. For example, the sample natural selection and evolution item calls for an understanding of the following concepts:

(1) The environment determines which organisms will survive.

(2) Members of a species that have traits best suited to the environment are more likely to survive.

(3) Surviving members will mate and pass the helpful trait on to their offspring.

(4) Eventually, all members of the species are likely to possess the helpful trait.

According to the situation described in the sample item, the climate changes and the surroundings become green. Thus, answer choice C is correct because a green body would help the insect blend into its surroundings. Members of this species of insect who have the trait for a green body would tend to survive in the green environment. They would mate and pass the trait on. Eventually, most or all members of the species would have a green body. In contrast, none of the characteristics identified in the other answer choices would be particularly helpful to the survival of the insect in this described environment. Therefore, there is no reason to expect insects that possess one of those traits to be more likely to survive, mate, and pass the trait on to future generations.

During your lessons on natural selection, you may wish to also introduce the concepts of migration, isolation, and convergent evolution. You may find it helpful to provide students with several examples to illustrate the various principles of evolution.

Diversity of Living Organisms

This content area requires an understanding of the classification system used in the biological sciences. Students need to know what features distinguish the organisms in the different kingdoms and major phyla. The LEAP Grade 11 Science Test focuses on those features that are considered most important. Focus your lessons on such characteristics. Ask your students to consider why certain organisms are placed in the same kingdom or phylum. What features do these organisms have in common? What important processes do these organisms undergo?

The sample item for this content area, for example, asks for identification of the kingdom of an organism, based on a description of the organism. To answer this item correctly, the student would need to know the crucial characteristics that distinguish organisms in the different kingdoms. The organism in question could not be a protist because it is described as having specialized tissues. Moreover, it could not be an animal because it contains chlorophyll. Finally, because cell walls are a characteristic of plants only, the organism in question must be a plant. Thus, there are several critical details presented in the

sample item that would lead the student who has a basic knowledge of modern taxonomy to the correct answer.

Anatomy and Physiology*

Students need to know the basic structures, functions, and primary components of the major body systems. The sample item, for example, asks about the function of the circulatory system. The correct answer is, of course, to deliver nutrients to body tissues. The other answer choices presented are functions of other body systems.

Students also need to be familiar with the key body nutrients. Specifically, students need to know the functions of the nutrients in the human body and the sources of the nutrients in the diet. Bear in mind that students are tested only on the basic principles of nutrition. They are not required to know, for example, the functions of specific vitamins.

Ecology

This content area focuses on the relationships of organisms to each other and their surroundings. The interaction between populations of organisms living in the same area and their environment is called an ecological system or ecosystem. Within any ecosystem there are feeding relationships among organisms. Each time an organism feeds on another organism there is a transfer of material and some energy. A series of transfers from one organism to another is called a food chain. There can be numerous food chains in any ecosystem. Interrelated food chains make up a food web. For the LEAP examination, students are expected to know how a food chain/web works, including the transfer of energy within a food chain. Having students interpret and make predictions based on given food chains, such as the one illustrated in the ecology sample item, will help them to better understand the concept of an ecosystem.

Understanding the causes and consequences of the major types of pollution is another major objective in the study of ecology. Students should be familiar with the sources of and contributing factors to pollution, the consequences of pollution, and the efforts to conserve the natural resources. Students should find the study of pollution and conservation to be very compelling, considering the gravity and timeliness of the topic.

Finally, students should be familiar with population trends and the factors that limit population growth in different communities. The limits to population size include

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*The specific body systems and nutrients eligible for testing are listed in the content outline on pages 14 and 15.

density-dependent factors such as space, food, and disease, and density-independent factors such as weather and energy patterns. You may want to show how these factors can affect different populations of organisms, including humans.

CONTENT OUTLINE

From the above discussion, it is clear that the content eligible for testing in biology is fairly extensive. To better delineate the eligible biology test content, an outline is presented. This outline, which was developed from the currently used curriculum guides, served as the template for the development of the biology items on the LEAP Grade 11 Science Test.

A. Cellular Biology

(1) Describe the functions of the cell wall, cell membrane, nucleus, and cytoplasm.

(2) Distinguish between the processes of cellular respiration and photosynthesis.

B. Reproduction

(1) Mitosis and meiosis

a. Apply the concept of mitosis.

b. Apply the concept of meiosis.

(2) Heredity

a. Illustrate the role of DNA and RNA in genetics.

b. Apply Mendel's Laws of Inheritance.

c. Apply principles of the inheritance of sex-linked traits.

(3) Distinguish between sexual and asexual reproduction.

C. Natural Selection and Evolution

(1) Apply the concepts of natural selection and evolution.

D. Diversity of Living Organisms

(1) Distinguish between the various kingdoms on the basis of physical characteristics.

(2) Protists

a. Distinguish between major types of protists.

b. Identify the critical processes in major types of protists.

(3) Multicellular plants

a. Distinguish between vascular and nonvascular plants.

b. Describe the functions of critical parts of multicellular plants.

(4) Vertebrates and invertebrates

a. Distinguish between vertebrates and invertebrates.

b. Identify the distinguishing characteristics of major types of lower and higher invertebrates.

c. Identify the distinguishing characteristics of major types of vertebrates.

E. Anatomy and Physiology

(1) Describe the functions of the components of the body systems.

a. Digestive

b. Circulatory

c. Excretory

d. Integumentary

e. Nervous

f. Respiratory

g. Skeletal

h. Muscular

i. Reproductive

j. Endocrine

(2) Analyze the need for key body nutrients.

a. Carbohydrates

b. Fats

c. Proteins

d. Minerals

e. Vitamins

f. Water

F. Ecology*

(1) Analyze the interrelationships in a community involving food chains and food webs.

(2) Analyze the causes and consequences of major types of pollution.

(3) Analyze the major types of conservation strategies.

(4) Analyze population trends in light of the concept of carrying capacity.

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*This content is covercd in LDE's revised Biology 1 Curriculum Guide.

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*This content is covered in LDE's revised Biology 1 Curriculum Guide.

SKILL AREA: CHEMISTRY/PHYSICAL SCIENCE

The skill area testing chemistry/physical science includes four content areas: Properties of Matter; Atomic Structure; Elements, Compounds, and Mixtures; and Acids and Bases.

SAMPLE ITEMS*:

Properties of Matter

Which of the following is an illustration of a physical change in matter?

A. the melting of ice

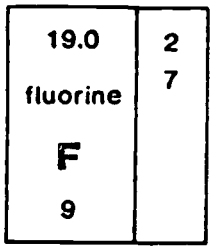
B. the burning of a tree

C. the rusting of a nail

D. the digestion of an apple

Atomic Structure

Use the information below taken from the periodic table to answer the following question.



How many neutrons are in the fluorine atom?

A. 9

B. 10

C. 19

D. 28

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*Correct answers and descriptions of other answer choices to sample items are presented on pages 18 and 19.

Elements, Compounds, and Mixtures

Air is a mixture of nitrogen, oxygen, and several other gases. Which of the following is true of air?

A. Air is formed when nitrogen, oxygen, and other gases combine chemically.

B. Air has the chemical formula NOH.

C. The ratio of nitrogen to oxygen in the air is always the same.

D. The exact amounts of nitrogen and oxygen in the air can vary from place to place.

Acids and Bases

Substance A has a pH of 6.0. Substance B has a pH of 8.0. Which of the following statements best describes these substances?

A. Both substances are acids.

B. Both substances are bases.

C. Substance A is an acid; substance B is a base.

D. Substance A is a base; substance B is an acid.

DESCRIPTION OF TEST QUESTIONS:

1. The student will be presented with a question about a basic concept in chemistry.

2. The question will be based on information in the content areas involving the following: properties of matter; atomic structure; elements, compounds, and mixtures; and acids and bases.

3. The question may be preceded by a diagram, table, graph, or verbal description of information relevant to the test item.

4. To the extent possible, the question will require the application or analysis of the information to be tested, rather than straight recall.

DESCRIPTION OF ANSWER CHOICES:

1. The correct answer choice will be the response that represents the proper application or analysis of the concept tested in the item.

2. An incorrect answer choice will be one of the following types:

   a. contradicted: an application or analysis of the concept that is opposite to the correct application or analysis;

   b. incomplete: an application or analysis of the concept that does not take into account all of the relevant information presented in the test item;

   c. incorrect concept: an application or analysis of a concept listed in the content outline* other than the concept relevant to the question; or

   d. irrelevant: an application or analysis of a concept that is essentially unrelated to the question.

SAMPLE ITEM ANSWER CHOICE DESCRIPTIONS:

Properties of Matter

A. correct

B. incorrect concept

C. incorrect concept

D. incorrect concept

Atomic Structure

A. incorrect concept

B. correct

C. incomplete

D. irrelevant

---

*See pages 22 and 23 for content outline of chemistry items.

Elements, Compounds, and Mixtures

A. incorrect concept

B. incorrect concept

C. contradicted

D. correct

Acids and Bases

A. incorrect concept

B. incorrect concept

C. correct

D. contradicted

INSTRUCTIONAL ANALYSIS:

Chemistry is the science of substances--their composition, properties, structure, and the changes they undergo. It is an experimental and theoretical science. Basic knowledge of chemistry will provide students with a better understanding of our environment. Knowledge and application of the following content areas in chemistry will be required for the LEAP Grade 11 Science Test.

Properties of Matter

The concept of matter is fundamental to the study of chemistry. Matter can be defined as anything that takes up space and has mass. There are three states of matter: gas, liquid, and solid.

The Law of Conservation of Matter states that matter and energy are interchangeable, and that the amount of matter and energy in the universe will always remain constant. Emphasize to students that an important implication of this law is that in ordinary chemical reactions the sum of the mass of the individual reacting materials is equal to the mass of the product(s).

Students should also know the basics of the Kinetic Theory of Matter. Kinetic theory explains the properties of gases, liquids, and solids as a function of the forces between particles of matter and the energy possessed by the particles. There are three fundamental assumptions of kinetic theory with respect to a closed system: (1) matter is composed of minuscule particles; (2) the particles of matter are always in motion; and (3) the

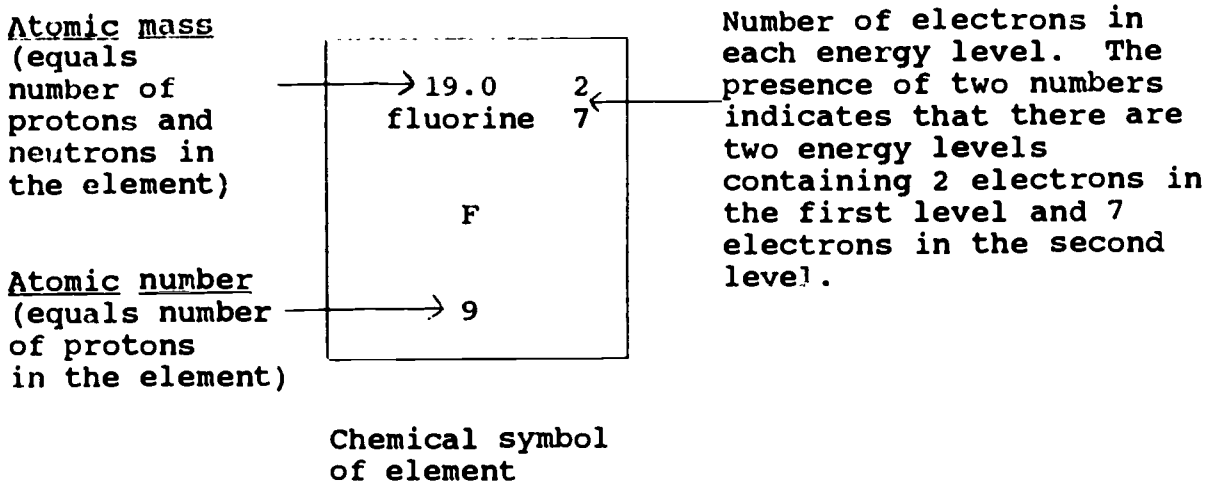
total kinetic energy (energy of motion) of colliding particles remains constant. Decreasing the volume of a gas or increasing the temperature of a gas, liquid, or solid will increase the pressure (the speed of the molecules), leading to an increase in kinetic energy. It is important for your students to be able to determine the kinetic result when the temperature or compression of an element or compound is changed.

In your lessons, emphasize the differences between physical and chemical changes in matter. Students should understand that physical changes involve changes in one or more physical properties of a substance but not in the identifying chemical properties or molecular composition of the substance. A slight energy loss or gain may accompany a physical change. For example, water can be physically changed from a solid to a liquid to a gas and still retain the same composition (H_2O). In contrast, a chemical change results in the formation of a different substance with new properties. An energy change always accompanies a chemical change. For example, silver reacts with air to form a silver compound, tarnish, which possesses a different composition from that of either silver or air. Your students should be able to determine whether a physical or chemical change has occurred given the original substance(s), the procedure, and the product(s) of an experiment. For example, the sample item asks students to identify which of four phenomena represents a physical change in matter. Students need to recognize that only answer choice A represents a compositional change in the original substance, that is, the melting of ice. Therefore, answer choice A is the correct answer.

Atomic Structure

There are two main parts of an atom: the positively charged central part, or nucleus, which is made up of protons and neutrons; and the outer electron cloud, which is made up of negatively charged electrons. You may wish to review the characteristics of neutrons, protons, and electrons with your students.

The ability to comprehend and utilize the Periodic Table is essential to the study of chemistry. However, on the LEAP examination only the first three rows of the Periodic Table are eligible for testing. Students should understand the significance of each number displayed in an element's block on these rows.



Because the atomic structure items focus on the first three rows of the Periodic Table, students should be aware of the number of electrons it takes to fill the first three energy levels. The number of energy levels in an element and the number of electrons in the element's outer shell are important in the creation of chemical bonds. An ionic bond is created when there is an electron transfer in the outer shell of two elements. A covalent bond occurs when two elements share electrons in the outer shell. Students should be able to determine from the Periodic Table the number of electrons in the outer shell of an element and identify from this information which elements can easily bond.

Review the organization of the elements in the Periodic Table with students; it is organized according to periods (horizontal rows) and groups (vertical rows). The atomic weight of elements in a period increases by one from the left to the right of the chart. The number of electrons within each element increases as its atomic number increases. The groups (or families) contain elements that have similar properties and have a similar arrangement of electrons in their highest energy level. Point out to your students the patterns in the Periodic Table within and across the periods and groups. Students should be able to identify the attributes of a significant period or group based on information in the Periodic Table.

Students will also be tested on their basic knowledge of chemical equations. Specifically, students should be able to determine the number of atoms and elements in a compound or an equation and to perceive whether an equation is balanced.

Elements, Compounds, and Mixtures

There are three general classes of matter: elements, compounds, and mixtures. An element is a homogeneous material that cannot be decomposed further by ordinary chemical means. A compound consists of two or more elements that have been chemically joined and can be decomposed by ordinary chemical means into its original elements. Both elements and compounds are substances, that is, homogeneous material consisting of one particular kind of matter. Mixtures are solutions that are composed of homogeneous or heterogeneous matter. Unlike a compound, there is no chemical bonding in a mixture. Each kind of matter in a mixture retains its own distinctive properties. Students should know the distinguishing features of an element, compound, or mixture. In addition, they should be able to apply this knowledge in predicting how each of these types of matter might react in an ordinary chemical experiment.

Acids and Bases

The pH of a solution indicates the hydronium ion concentration. Because pH is defined on a logarithmic scale, a small pH value (less than 7) indicates a high hydronium ion concentration, and a large pH value (greater than 7) indicates a low hydronium ion concentration. Thus, acidic solutions have pH values less than 7, and basic solutions have pH values greater than 7. Water, which is a neutral substance (neither acid nor basic), has a pH of 7. Typically, pH values range from 0 to 14. The higher the pH value, the more basic the solution; the lower the pH value, the more acidic the solution.

Review with students the distinguishing characteristics of acids and bases such as their (1) effect on litmus paper, (2) reactions with other substances, and (3) taste. Also, students should be familiar with common examples of acidic and basic solutions. An experiment with litmus paper and some common solutions such as pine water, sea water, lemon, vinegar, and milk should prove interesting and informative to students.

CONTENT OUTLINE

The following content outline represents a summary of the chemistry content eligible for testing on the LEAP Grade 11 Test as described above.

A. Properties of Matter

(1) Apply the Law of Conservation of Matter.

(2) Apply the Kinetic Theory of Matter.

(3) Distinguish between physical and chemical changes in substances.

B. Atomic Structure

(1) Distinguish among the basic structural components of atoms and molecules.

(2) Periodic Table of the Elements (first three rows only)

a. Apply information from the Periodic Table of the Elements to determine the characteristics of specified elements.

b. Apply information from the Periodic Table of the Elements to determine which elements can bond.

c. Interpret patterns in the Periodic Table of the Elements.

(3) Chemical equations

a. Determine the number of elements and atoms that make up a compound.

b. Select a balanced simple chemical equation.

C. Elements, Compounds, and Mixtures

(1) Classify substances as elements, compounds, or mixtures/solucions.

D. Acids and Bases

(1) Distinguish between acids and bases using the pH scale.

SKILL AREA: PHYSICS/PHYSICAL SCIENCE

The skill area testing physics/physical science includes six content areas: Mechanics, Electricity and Magnetism, Heat Energy, Light Energy, Sound Energy, and Nuclear Energy.

SAMPLE ITEMS*:

Mechanics

The same force is applied for the same amount of time to each of two objects under equivalent conditions. Object X accelerates to a speed of 5 km/hour. Object Y accelerates to a speed of 8 km/hour. What can be determined about the relative masses of the two objects?

A. Object X has a greater mass than object Y.

B. Object Y has a greater mass than object X.

C. Objects X and Y have equal mass.

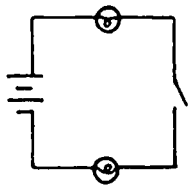
D. The relative masses of objects X and Y can not be determined from this information.

*Correct answers and descriptions of other answer choices to sample items are presented on pages 29 and 30.

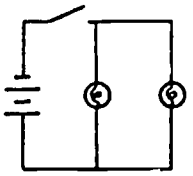
Electricity and Magnetism

You want to set up an electric circuit so that when one light bulb burns out the other one stays lit. Which of the diagrams below is an example of such a circuit?

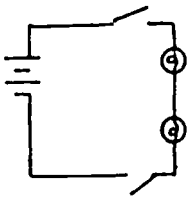
A.



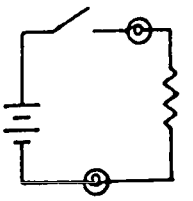
C.

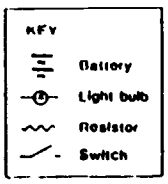


B.



D.





Heat Energy

A small pot and a large pot are each filled with water. You are told that the heat energy of the water is the same in each pot. Which of the following is true of the relative temperature of the water in these pots?

A. The water in the large pot must be warmer than the water in the small pot.

B. The water in the large pot must be cooler than the water in the small pot.

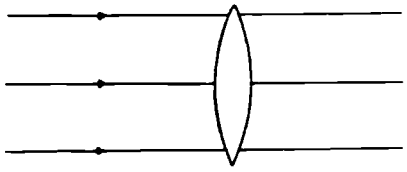
C. The temperature of the water in both pots must be the same.

D. The relative temperatures of the water in the pots cannot be determined from the information provided.

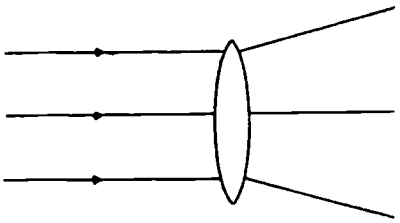
Light Energy

Light waves are passed through a convex lens. Which of the following diagrams shows the path of the light rays through the lens?

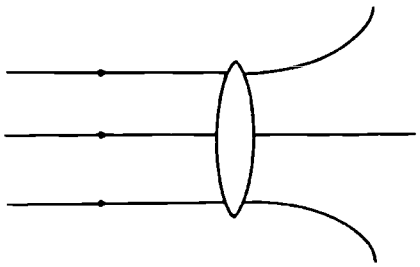
A.



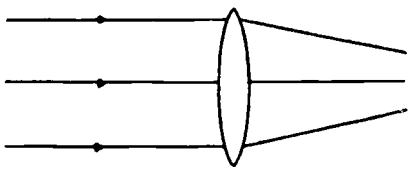
B.



C.

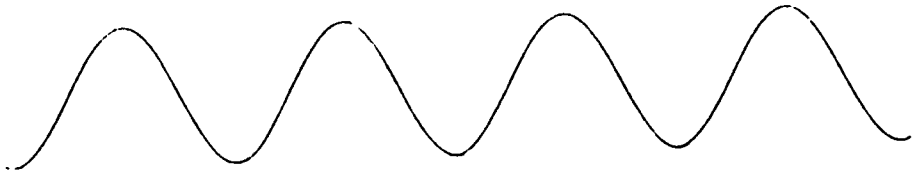


D.



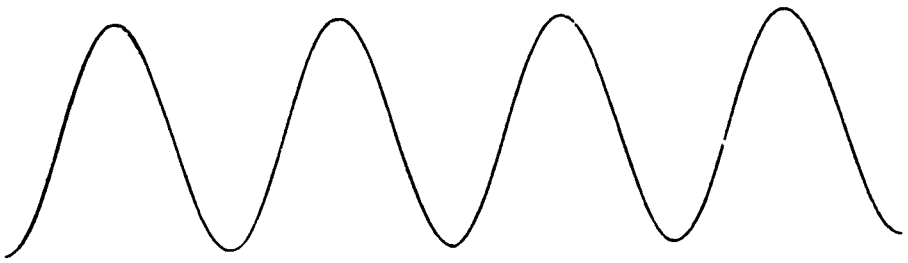
Sound Energy

A piano is struck gently and produces the following sound wave.



Which of the following best represents the sound wave if the same key is hit harder?

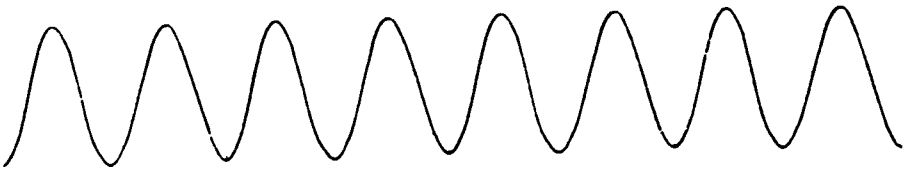
A.



B.

C.

D.



Nuclear Energy

A radioactive substance gives off equal amounts of alpha particles, beta particles, and gamma rays. A piece of cardboard is placed in front of the substance. Which types of radiation will pass through the cardboard?

A. Only the gamma rays will pass through the cardboard.

B. Both the alpha particles and the beta particles will pass through the cardboard.

C. Both the gamma rays and the beta particles will pass through the cardboard.

D. All of the rays will pass through the cardboard.

DESCRIPTION OF TEST QUESTIONS:

1. The student will be presented with a question about a basic concept in physics.

2. The question will be based on information in the content areas of mechanics, electricity and magnetism, light energy, sound energy, and nuclear energy.

3. The question may be preceded by a diagram, table, graph, or verbal description of information relevant to the test item.

4. To the extent possible, the question will require the application or analysis of the information to be tested, rather than straight recall.

DESCRIPTION OF ANSWER CHOICES:

1. The correct answer choice will be the response that represents the proper application or analysis of the concept tested in the item.

2. An incorrect answer choice will be one of the following types:

   a. contradicted: an application or analysis of the concept that is opposite to the correct application or analysis;

   b. incomplete: an application or analysis of the concept that does not take into account all of the relevant information presented in the test item;

c. incorrect concept: an application or analysis of a concept other than the concept listed in the content outline* relevant to the question; or

d. irrelevant: a plausible but incorrect application or analysis of the concept relevant to the question.

SAMPLE ITEM ANSWER CHOICE DESCRIPTIONS:

Mechanics

A. correct

B. contradicted

C. contradicted

D. incomplete

Electricity and Magnetism

A. incomplete

B. incomplete

C. correct

D. irrelevant

Heat Energy

A. contradicted

B. correct

C. incorrect concept

D. incomplete

Light Energy

A. incorrect concept

B. contradicted

C. incorrect concept

D. correct

*See pages 34-36 for content outline of physics items.

Sound Energy

A. correct

B. incomplete

C. incorrect concept

D. incorrect concept

Nuclear Energy

A. incomplete

B. contradicted

C. correct

D. contradicted

INSTRUCTIONAL ANALYSIS:

This skill area focuses on concepts from physics that are fundamental to the study of the physical sciences. The six content areas covered by this skill area are described below. Although the study of physics involves mathematics, computation is not required by the items in this skill area. Instead, problem solving through the application of basic concepts in physics will be emphasized.

Mechanics

Mechanics deals with forces and motion, including their effects on objects. The force and motion of an object depends on the mass and weight of the object. The distinction between mass and weight is important: mass measures the amount of matter in an object, whereas weight measures the gravitational force acting on an object. The mass of an object is constant and is established by comparison with other known masses. The weight of an object can be influenced by its mass as well as by its distance from the face of the earth. To reinforce the distinction between mass and weight, you may wish to have students calculate what the weight of their own bodies would be on various planets in the solar system. At the same time, emphasize that their mass (bodies) on the various planets would remain constant.

Newton's three laws of motion explain how motion and force are related. According to the first law, an object at rest tends to remain at rest, and an object in motion tends to remain in motion at the same speed and in the same direction. Inertia

refers to this tendency to resist changes in motion. Using common examples such as a moving car, illustrate to students how this law works. The faster a car is moving, the greater the resistance to change in motion; therefore, the greater the distance required for stopping.

Newton's second law states that the acceleration of an object is (1) directly proportional to the force applied to the object and (2) inversely proportional to the mass of the object. As an example of the first part of this law, explain to students what happens when you increase the pressure on the gas pedal of a car. This increased pressure leads to more gas being sent to the engine, thereby creating more force, which results in the acceleration of speed. The second part of this law can be demonstrated by the fact that it takes more force to stop a freight truck than a car, due to the truck's greater mass.

When one object exerts a force on another, according to Newton's third law of motion, the second object will exert an equal force in the opposite direction. Demonstrate Newton's third law by having students place their hands in front of them palm to palm. Then ask students to keep their hands in the same position but press forward with their right hand. Students should notice that the left hand also presses forward, exerting the exact same amount of pressure as the right hand in order to maintain the same position.

The scientific definition of work is very specific: work is the product of the force expended to move an object multiplied by the distance the object moves (work = force x distance). Force is measured in units called newtons, and distance is measured in meters. Work is measured by joules, where one joule equals the output of one newton acting over a distance of one meter. Given two factors of a problem, students must be able to determine the amount of force, distance, or joules needed to complete the problem.

Energy can be considered the ability to do work. There are two types of energy: energy of motion (kinetic energy) and energy of position (potential energy). Students should be able to apply the concepts of potential and kinetic energy to explain common phenomena. Fuel, for instance, provides a good example of both types of energy. In its unused state, fuel is potential heat energy because it is capable of doing work. When it is burned, the fuel becomes kinetic energy. When all the fuel has burned, all of the potential energy has been changed to kinetic energy. Explain to students how one form of energy can be converted to another form.

Electricity and Magnetism

Most people have played with magnets and have discovered that one end of a bar magnet will attract some magnets and repel others. This is because a magnet has two poles: magnetic north (N) pole and magnetic south (S) pole. Like poles repel each other, whereas unlike poles attract each other. Students should understand that due to the magnetic field of force that is around each magnet, every magnet exerts a force on other magnets. The closer the poles of two given magnets, the greater the force between the two magnets.

A knowledge of magnets and magnetic fields is necessary to understand how electricity works. Electricity is a collection of electrons (static electricity) or movement of electrons (current electricity). Objects become electrically charged when they gain or lose electrons. This can happen when two objects are rubbed together. For example, after rubbing against each other in a dryer, pieces of clothing often become electrically charged and stick together. This built-up charge is an example of static electricity. The primary difference between static electricity and current electricity is that the electrical charge of current electricity moves through a conductor. Most metals are good conductors of current electricity; that is, they easily allow an electrical charge to flow through. Materials that will not easily transfer an electrical charge are called insulators. Glass, hard rubber, silk, dry air, and many plastics are good insulators.

Electricity usually flows through a conductor from a source of energy to a device that uses the electric energy. The path followed by the conductor(s) for the electrons is referred to as a circuit. Students should be able to diagram and understand a simple electrical circuit (such as that shown in the electricity sample item) and to differentiate between the two types of circuits, series circuits and parallel circuits.

Knowledge of how electrical currents flow is important to understanding electrical energy use. Ohm's law explains the relationship between voltage (V), current (I), and resistance (R). The law states that current is equal to the potential difference (voltage) divided by the resistance. This law can be expressed by the following formula: $I \text{ (current)} = \frac{V \text{ (voltage)}}{R \text{ (resistance)}}$.

Students should be able to solve problems related to Ohm's law.

Heat Energy

Heat can be defined as the total kinetic energy possessed by a substance due to the motion of its molecules. When a substance is heated, its molecules vibrate more quickly and move farther

apart. Thus, heat causes matter to expand. In contrast, when matter is cooled, the molecules slow down and move closer together; as a result, the volume of the substance decreases. It is also important for students to understand that heat and temperature are not the same. Temperature is a measure of average kinetic energy; whereas, heat is a measure of total kinetic energy. Heat energy is dependent on both mass and temperature. Thus, if two different quantities of the same substance have the same total energy, as in the heat energy sample item, it must be true that the temperature of the larger quantity is lower.

With respect to temperature, students should also be aware that there are two scales used to measure it: Celsius (C) and Fahrenheit (F). Water freezes at $0^{o}C$, or $32^{o}F$, and water boils at $100^{o}C$, or $212^{o}F$.

Light Energy

Light seen by the eye is part of the electromagnetic spectrum, which consists of electromagnetic waves (that is, waves that can be produced by electricity or magnetism) arranged in order of their wavelength and frequency. It is important to note that although wavelengths differ in length and frequency, they travel through space at the same velocity. Familiarize students with a diagram of the electromagnetic spectrum. Point out that it is the frequency of the wavelength that determines the colors we see.

White light is formed when all colors are mixed together. When white light is passed through a prism, the colors separate into a color spectrum. The colors are created through reflection and refraction of the light as it hits the prism. According to the law of reflection, the angle at which light is reflected from a surface is the same as the angle at which it strikes the surface; this creates a reflection such as that produced with a mirror. Refraction refers to the bending of light particles as they pass at an angle from one medium to another (for example, air to water). It is the change in the speed of light as it passes from one substance to another that bends the light waves and creates a visual distortion such as that of an object that has been dropped into a glass container of clear liquid.

A lens will refract light differently depending on whether it is convex or concave. A convex lens bends light waves to bring them together to a central focus point in front of the lens, as shown in the light energy sample item. A magnifying glass is a good example of a convex lens. A concave lens bends the light waves away from the central point of the lens, forming a fan shape of light waves in front of the lens. Review with students the type of image that is formed by each type of lens.

Students should have the opoportunity to examine and experiment with each type of lens.

Sound Energy

Sound is a form of energy produced by vibrating matter. For example, when we speak our vocal cords vibrate, creating sound. Like light, sound is transmitted in waves. Students should be able to relate the properties of sound waves to the characteristics of sounds. For example, as the sound energy sample item demonstrates, the volume (loudness) of a sound is determined by the amplitude (height) of the sound wave. The greater the wave amplitude, the louder the sound. In contrast, pitch (how high a sound would be on a musical scale) depends on the frequency (how many occur within a given time period) of sound waves. The shorter the wavelength, the higher the frequency and the higher the pitch.

For a sound to be heard, it must have a substance through which to travel. Some substances transmit sound better than others. Students should know whether sounds travel faster through solids, liquids, or gases.

Nuclear Energy

A nuclear reaction occurs when there is a change in the nucleus of an atom. Nuclear fission refers to the splitting of the nucleus. When the nucleus splits, neutrons are released along with a tremendous amount of energy. Nuclear fusion occurs when nuclei join together to form a larger nucleus. Nuclear fusion can only happen under extremely high temperatures. For example, two hydrogen nuclei may fuse together under extremely high temperatures to form helium. Students should be able to distinguish between nuclear fission and fusion as well as knowing what conditions are needed for either reaction.

Radioactive elements give off alpha and beta particles as well as gamma rays. Of the three types of radiation, gamma rays have the most power to penetrate matter, whereas alpha particles contain the least amount of penetrating power. Point out to your students the characteristics of alpha particles, beta particles, and gamma rays, and provide instruction on how each nuclear product differs from the others.

CONTENT OUTLINE

The outline presented below summarizes the content eligible for testing in this content area.

A. Mechanics

(1) Force and motion

a. Distinguish between weight and mass.

b. Apply Newton's three laws of motion.

c. Apply the concept that work is proportional to force and distance.

(2) Apply the concepts of potential and kinetic energy.

B. Electricity and Magnetism

(1) Apply the basic rule of magnetic force (i.e., likes repel, opposites attract).

(2) Distinguish between static electricity and current electricity.

(3) Distinguish between conductors and nonconductors (insulators).

(4) Diagram simple electrical circuits.

(5) Apply Ohm's Law (when it is presented).

C. Heat Energy

(1) Determine the impact of changes in heat energy on matter.

(2) Distinguish between temperature and heat energy.

(3) Identify the boiling and freezing points of water in degrees Fahrenheit and Celsius.

D. Light Energy

(1) Apply the concepts of the electromagnetic spectrum.

(2) Apply the concepts of reflection and refraction.

(3) Distinguish between concave and convex lenses.

E. Sound Energy

(1) Relate the properties of sound waves to the characteristics of sounds.

F. Nuclear Energy

(1) Distinguish between nuclear fission and nuclear fusion.

(2) Distinguish among alpha particles, beta particles, and gamma rays and their effects on matter.

SKILL AREA: EARTH AND SPACE SCIENCES/GENERAL SCIENCE

The skill area testing earth and space sciences includes four content areas: Geology, Oceanography, Meteorology, and Astronomy.

SAMPLE ITEMS*:

Geology

Which of the following processes describes the way in which igneous rocks such as granite are formed?

A. Extreme pressure compresses rocks under the Earth's crust.

B. Minerals in the water of a lake harden after all the water in the lake evaporates.

C. The wind and rain slowly break down a mountain into smaller pieces.

D. Hot, melted material under the Earth's crust cools and hardens.

Oceanography

During a 24-hour period, the water level of the ocean rises and falls regularly. This motion is called a tide. Which of the following is primarily responsible for this motion?

A. the density of the water

B. the changing wind patterns

C. the moon's gravitational pull

D. the temperature of the water

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*Correct answers and descriptions of other answer choices to sample items are presented on pages 39 and 40.

Meteorology

Air fronts influence global weather conditions. Which of the following describes the formation of a warm front?

A. A large mass of air develops and remains stationary over an ocean.

B. A large body of warm air advances over the edge of a cold air mass.

C. A cold air mass meets a warm air mass and lifts the warmer air.

D. A warm air mass meets with a large body of cold air and the air mixes.

Astronomy

How would conditions on Earth change if the Earth's revolution were longer than it is now?

A. The length of a day would be shorter.

B. The length of a day would be longer.

C. The length of a year would be shorter.

D. The length of a year would be longer.

DESCRIPTION OF TEST QUESTIONS:

1. The student will be presented with a question about a basic concept in earth and space sciences.

2. The question will be based on information in the content areas of geology, oceanography, meteorology, and astronomy.

3. The question may be preceded by a diagram, table, graph, or verbal description of information relevant to the test item.

4. To the extent possible, the question will require the application or analysis of the information to be tested, rather than straight recall.

DESCRIPTION OF ANSWER CHOICES:

1. The correct answer choice will be the response that represents the proper application or analysis of the concept tested in the item.

2. An incorrect answer choice will be one of the following types:

   a. contradicted: an application or analysis of the concept that is opposite to the correct application or analysis;

   b. incomplete: an application or analysis of the concept that does not take into account all of the relevant information presented in the test item;

   c. incorrect concept: an application or analysis of a concept listed in the content outline* other than the concept relevant to the question; or

   d. irrelevant: an application or analysis of a concept that is essentially unrelated to the question.

SAMPLE ITEM ANSWER CHOICE DESCRIPTIONS:

Geology

A. incorrect concept

B. irrelevant

C. incorrect concept

D. correct

Oceanography

A. irrelevant

B. incorrect concept

C. correct

D. irrelevant

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*See pages 43 and 44 for content outline of earth and space science items.

Meteorology

A. contradicted

B. correct

C. incorrect concept

D. contradicted

Astronomy

A. irrelevant

B. incorrect concept

C. contradicted

D. correct

INSTRUCTIONAL ANALYSIS:

The earth and space sciences items were developed from overlapping objectives from earth science, general science, and the elementary science curriculum guides. The items covering earth and space science are divided among the four content areas of geology, oceanography, meteorology, and astronomy, which are described below.

Geology

Geology is the study of the surface of the Earth: its structures and the changes it undergoes. For the LEAP Grade 11 Science Test, students must possess basic knowledge pertaining to rock types, plate tectonics, and erosion.

There are three types of rocks: igneous, sedimentary, and metamorphic. Students need to know the sources and characteristics of each. For example, to correctly answer the geology sample item, students must know that igneous rocks are formed when hot, melted material under the Earth's crust cools and hardens.

Geologists use the theory of plate tectonics to explain some of the changes that the Earth's surface undergoes. According to the theory, the Earth's crust is made up of giant plates that move slowly in relation to one another. The movement along the boundaries of the plates is associated with several important geological activities, including the formation of mountains and volcanoes and the occurrence of earthquakes. Students should be

familiar with the causes and consequences of these geological activities.

Erosion, or the wearing away of land, is also responsible for changes on the Earth's surface. Both wind and water are agents of erosion; they pick up, carry, and eventually deposit particles which scour the land. In your lessons, discuss with students the different types of erosion, such as coastal erosion and erosion by rivers. Explain how erosion is affecting the Mississippi and Atchafalaya Rivers as well as the environment in which you live. Be sure to point out the ways in which harmful effects of erosion can be minimized.

Oceanography

Water on the Earth's surface moves in a continuous cycle. It evaporates from the ocean to form water vapor, which condenses and falls to Earth as precipitation. Eventually, most of the water returns to the ocean, and the cycle starts over again. The water cycle is an important determinant of the salinity, or salt content, of the oceans. For the LEAP test, students are expected to apply the concept of the water cycle to ocean salinity. They need to understand those factors that influence variations in salinity from one location to another, as well as those factors that ensure the relative constancy of the ocean's salinity. You may want to set up an experiment that demonstrates the evaporation and condensation of salt water in the water cycle.

Students are also expected to know the factors that determine movement in the oceans. The ocean is in a state of constant motion, as evidenced by waves, currents, and tides. Winds, which are responsible for much of the ocean's movement, are created in the atmosphere by the sun's energy. They blow across the oceans, forming small waves. If the winds continue to blow, the waves become larger. If the winds shift direction, the waves shift. Winds also affect the ocean's currents by blowing in established patterns over the entire globe and pushing the oceans' waters along with them. Currents are determined by the global patterns of winds, the presence of continents, and the Earth's rotation. In contrast, tides are formed by the combined gravity of the moon and the sun, with the moon exerting the most influence.

The oceanography sample item demonstrates how knowledge of ocean movements may be tested. It asks students to identify the primary cause of tides. The incorrect answer choices present factors that do not influence tidal movement. For example, changing wind patterns are important to the formation of waves, not tides. The correct answer is the moon's gravitational pull, answer choice C.

Meteorology

Meteorology is the science of the atmosphere. Students are required to know the effects of specific weather conditions, such as temperature change, humidity, air masses and fronts, barometric pressure, and cloud patterns.

One notable effect of temperature change involves humidity, the moisture in the atmosphere. The amount of water vapor in a given volume of air is referred to as absolute humidity. Relative humidity is a measure that compares the absolute humidity of the air to the total amount of moisture that the air can actually hold. Students should know how temperature increases and decreases affect both absolute and relative humidity. They should also understand how temperature change and humidity are related to condensation, or the changing of water vapor to a liquid or solid state.

Weather patterns are greatly influenced by the development and movement of air masses. An air mass is a large body of air with a nearly uniform temperature and humidity throughout. An air front is the boundary that forms when these air masses meet. There are two types of air fronts, warm and cold. As demonstrated by the meteorology sample item, students should understand how air masses and the two types of air fronts are formed. You may want to have students work with actual weather maps to explore the development and effects of air masses and air fronts.

Changes in air pressure are also related to changes in weather. Air pressure is the force that air exerts on the Earth's surface. It is measured by an instrument called a barometer. Students should be aware of how increases and decreases in barometric pressure are used to predict weather changes.

Cloud patterns are indicative of various weather patterns. Clouds are formed when a body of air is cooled and the water vapor in the air condenses. There are three basic and distinct forms of cloud patterns: cirrus clouds (which are wispy), cumulus clouds (which have a flat base and rounded outlines and are solid in appearance), and stratus clouds (which, when close to the ground, are known as fog). Students should understand the cloud formation process and the various types of cloud patterns.

Astronomy

Astronomy is the science of celestial bodies, which include the Earth. Students need to understand the Earth's two types of motion: rotation and revolution. The Earth rotates on its axis once every 24 hours and revolves around the sun once every 365 days. Eligible test items will focus on the consequences of the

Earth's rotation and revolution. The Astronomy sample item, for example, requires students to apply their knowledge regarding the Earth's revolution to a hypothetical situation. To answer the question correctly, students need to know that one revolution of the Earth around the sun represents one year and that a longer revolution would mean a longer year.

Students also need to be familiar with our solar system and galaxy. They should have a basic understanding of the planets in our solar system and be familiar with other objects such as stars and moons. In your lessons, discuss the other planets in relation to Earth; compare and contrast their major features to those of our own planet.

Solar and lunar eclipses are also eligible concepts for testing on the LEAP examination. A solar eclipse occurs when the moon passes between the sun and Earth, casting its shadow on the Earth. A lunar eclipse occur when the Earth passes between the sun and the moon, casting its shadow on the moon. Demonstrations with three-dimensional models of the Earth, moon, and sun should help students understand these phenomena.

CONTENT OUTLINE

To assist you in preparing your students for the items in this content area, a summary outline of the eligible content is presented below.

A. Geology

(1) Distinguish among groups of rocks (i.e., igneous, sedimentary, and metamorphic).

(2) Analyze the causes and consequences of changes in the Earth's surface.

a. Plate tectonics

(i) Mountains

(ii) Volcanoes

(iii) Earthquakes

b. Erosion

(i) Wind and water

(ii) Coastal erosion and salt water intrusion

B. Oceanography

(1) Apply the concept of the water cycle to explain ocean salinity.
(2) Analyze factors that cause water movement in oceans.

C. Meteorology

(1) Determine the effects of specified weather conditions.

a. Temperature change

b. Air fronts

c. Barometric pressure

d. Humidity

e. Cloud patterns

D. Astronomy

(1) Analyze the impact of rotation and revolution on day/night and seasonal variation.

(2) Distinguish among the major objects that form the solar system (i.e, moons, planets, stars, constellations, and galaxies).

(3) Analyze the causes and consequences of solar and lunar eclipses.

SKILL AREA: SCIENTIFIC METHOD

This skill area requires that students apply the principles of the scientific method in the domains of biology, chemistry, physics, earth and space science, and environmental sciences.

SAMPLE ITEMS*:

> **A scientist wants to determine the factors that affect the rate at which plants grow. The scientist prepares four different combinations of soil nutrients that include nitrogen, phosphorus, and sulphur. Each of the four combinations is added to a separate sample of the same type of soil. Identical seedlings are grown in each of the four soil samples for a period of 30 days. Each seedling receives equal amounts of water and light throughout the experiment.**

Generate Hypotheses

1. Which of the following hypotheses could have been tested in this experiment?

   A. The amount of water given to the seedlings affects the rate at which the seedlings grow.

   B. The amount of light given to the seedlings affects the rate at which the seedlings grow.

   C. The mixture of nutrients added to the soil in which the seedlings are grown affects plant growth.

   D. The type of soil in which the seedlings are grown affects the plant growth.

*Correct answers and descriptions of other answer choices to sample items are presented on pages 50 and 51.

Experimental Design

2. What variable should be measured to determine which of the combinations of nutrients is most effective?

   A. The type of seedlings used in the experiment.

   B. The amount of each nutrient in the soil.

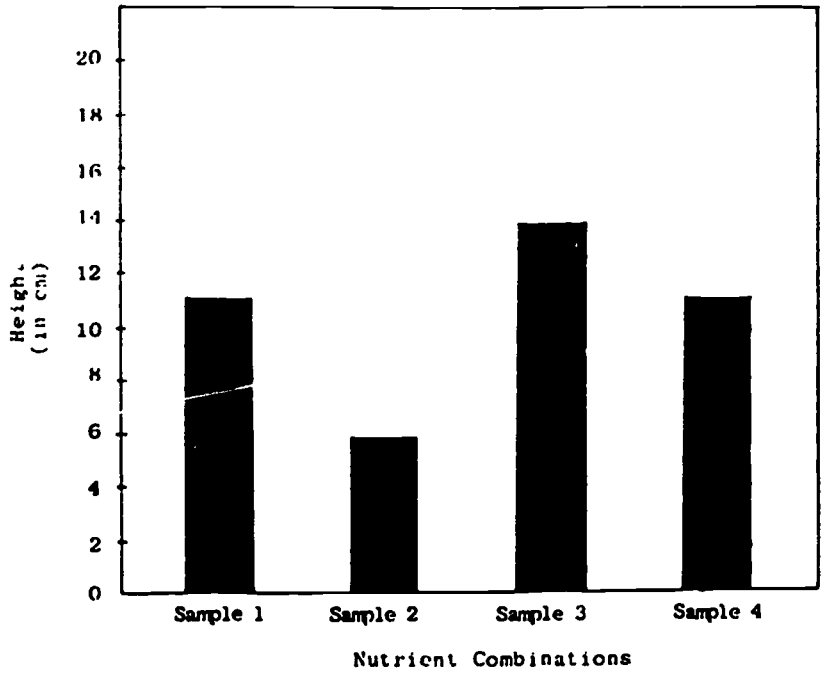
   C. The amount of time for which the seedlings are grown.

   D. The amount of growth of each seedling.

Interpret Data and Form Conclusions

3. At the end of the experiment described above, the scientist organized the data into the following graph.

Height In Centimeters of Seedlings Grown
Using Various Combinations of Nutrients



Which of the following interpretations can be made based on the experiment and the data presented in the graph?

A. The same combination of nutrients was used in sample 1 and sample 4.

B. The combination of nutrients used in sample 3 had the greatest effect on plant growth.

C. The seedlings used in sample 3 were grown for more time than were the seedlings used in the other samples.

D. The combination of nutrients used in sample 2 did not help the plant grow.

Formulate Problems in Testable Terms

Science students were examining factors that affect the amount of time it takes particles to diffuse in water. The students used three identical beakers, each two-thirds full of water. The first beaker contained hot water, the second beaker contained warm water, and the third beaker contained cold water. All three beakers were allowed to stand untouched until the water became still.

Two drops of food coloring were added to each beaker. Students observed the beakers and recorded their observations.

4. Which of the following is the best statement of the problem that the students were investigating?

A. How long must the water stand before the food coloring is added?

B. Is there a relationship between the amount of water in a beaker and the time it takes particles to diffuse?

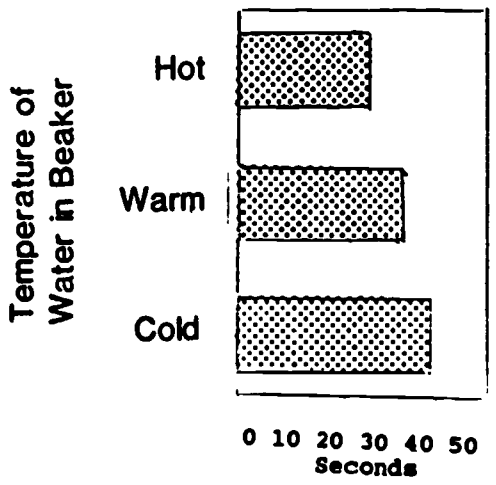
C. Is there a relationship between the temperature of water and the time it takes particles to diffuse?

D. Does the amount of food coloring added to water affect the time it takes particles to diffuse?

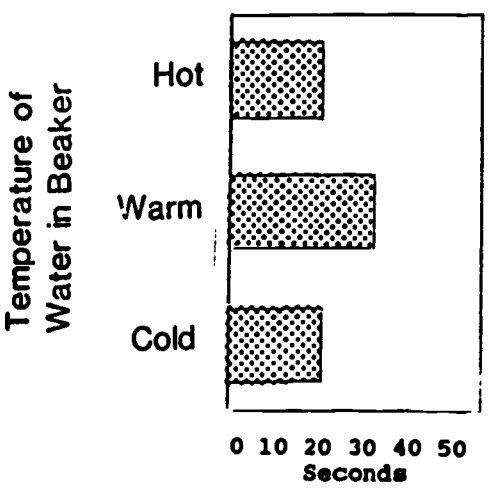
The students observed that it took less time for the food coloring to spread in hot water than in warm water. The coloring in the cold water took the longest amount of time to spread.

5. Which of the following graphs best illustrates these results?

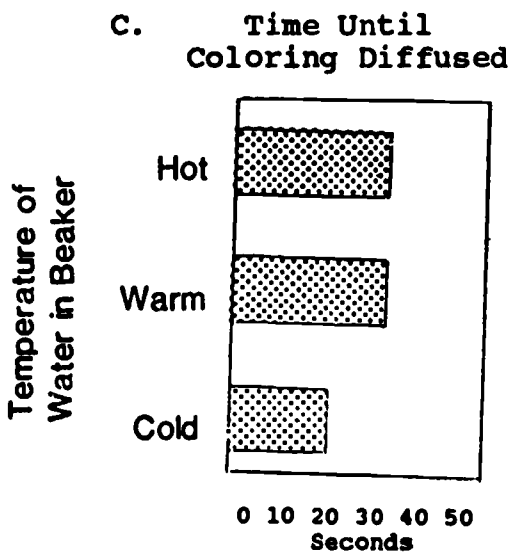
A.



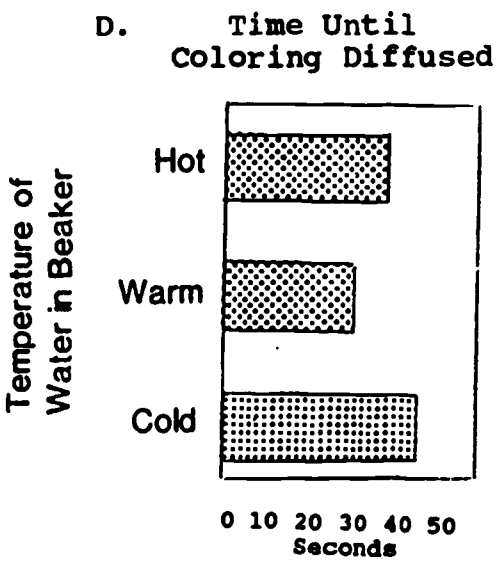
B.



C.



D.



DESCRIPTION OF TEST QUESTIONS:

1. The student will be presented with either:

   A. a description of an information need (a research question or hypothesis) followed by a question about designing an appropriate experiment; or

   B. a description of the design and results of an experiment followed by a question about interpreting the procedures or results of the experiment.

2. The question will require the student to apply the steps of the scientific method.

3. Multiple test questions will follow each description. A test item may include a diagram, table, or graph.

4. A test item will be in one of the domains of biology, chemistry, physics, earth and space sciences, or environmental science. However, the test question will not require students to apply specific content knowledge. It will require students to apply the scientific method independent of a specific knowledge base.

DESCRIPTION OF ANSWER CHOICES:

1. The correct answer choice will be the response that represents the proper application of the scientific method in the situation described.

2. An incorrect response alternative will be one of the following types:

   a. <u>contradicted</u>: an application of the scientific method that is opposite to the correct application;

   b. <u>incomplete</u>: an application of the scientific method that does not take into account the full information needed or all the relevant design information or data presented in the test item;

   c. <u>incorrect concept</u>: an application of a component listed in the scientific method content outline* other than the component relevant to the question;

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*See page 52 for content outline of scientific method items.

d. irrelevant: a plausible but incorrect application of the scientific method;

SAMPLE ITEM ANSWER CHOICE DESCRIPTIONS:

Generate Hypotheses

A. incomplete

B. incomplete

C. correct

D. incomplete

Experimental Design

A. irrelevant

B. incorrect concept

C. irrelevant

D. correct

Interpret Data and Form Conclusions

A. incorrect concept

B. correct

C. contradicted

D. contradicted

Formulate Problems in Testable Terms

A. irrelevant

B. irrelevant

C. correct

D. irrelevant

Organize Data Into Tables, Graphs, etc.

A. correct

B. contradicted

C. contradicted

D. contradicted

INSTRUCTIONAL ANALYSIS:

Scientific investigation is a process of discovery. A scientist is a problem solver who uses the scientific method when looking for answers in the biological and physical sciences. This skill area requires that students have a solid understanding of the rationale underlying the scientific method as well as of the basic steps involved.

In reviewing the scientific method, you may wish to present students with frequent descriptions of typical experimental situations such as the ones presented in the sample items. Show students how to identify the problem, hypothesis, procedures, and inferences that are appropriate to each situation. Then, have students work out such problems on their own. In reviewing each step of the scientific method, emphasize the importance of precision at every step to allow experiment validation by other scientists.

The first step of the scientific method is to clarify the nature of the problem, or question of interest, and state it in testable terms. This enables the scientist to set up an experiment that is appropriately tailored to test the question. Then, the scientist makes a prediction, or hypothesis, about the outcome of the experiment.

The next step in the scientific method is to test the hypothesis. The experiment should be set up carefully to enable the scientist to observe any changes that may occur during the procedure(s). Explain the distinction between a control and experimental group and the importance of including both types of groups in an experiment. Students should also be able to identify the dependent and independent variable in any given experiment and to recognize potential confounding variables.

When a scientist has completed an experiment, the results need to be documented in a manner that can be easily interpreted. Graphs, tables, and charts provide a clear visual representation of experimental results. Review with students how to interpret and use information found in any of these displays.

After the results have been organized and interpreted, the scientist forms a conclusion based on the data. Stress to students that the conclusion formed must follow from the data.

CONTENT OUTLINE

In summary, the steps of the scientific method that students will be required to apply in order to perform successfully in this skill area are as follows:

1. Formulate problems in testable terms.

2. Generate hypotheses.

3. Experimental design

   a. Distinguish between control and experimental groups.

   b. Distinguish between independent (manipulated) and dependent (responding) variables.

4. Organize data into tables, graphs, etc.

5. Interpret data and form conclusions.