

science items

TIMSS 1999 SCIENCE ITEMS



BOSTON
COLLEGE

Released Set for Eighth Grade



TIMSS 1999

IEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade

TIMSS 1999 Science Items: *Released Set for Eighth Grade*

Overview of TIMSS

TIMSS 1999 represents the continuation of a long series of studies conducted by the International Association for the Evaluation of Educational Achievement (IEA). Since its inception in 1959, the IEA has conducted more than 15 studies of cross-national achievement in the curricular areas of mathematics, science, language, civics, and reading. The Third International Mathematics and Science Study (TIMSS), conducted in 1995-1996, was the largest and most complex IEA study to date, and included both mathematics and science at third and fourth grades, seventh and eighth grades, and the final year of secondary school.

In 1999, TIMSS again assessed eighth-grade students in both mathematics and science to measure trends in student achievement since 1995. This study was also known as TIMSS-Repeat, or TIMSS-R. The results of TIMSS 1999 were published in two companion volumes, *TIMSS 1999 International Mathematics Report* (Mullis, Martin, Gonzalez, Gregory, Garden, O'Connor, Chrostowski, and Smith, 2000) and *TIMSS 1999 International Science Report* (Martin, Mullis, Gonzalez, Gregory, Smith, Chrostowski, Garden, and O'Connor, 2000).

TIMSS 1999 also included a voluntary Benchmarking Study including 13 United States of America states and 14 districts and consortia. The results were published in *Mathematics Benchmarking Report TIMSS 1999 - Eighth Grade: Achievement for U. S. States and Districts in an International Context* (Mullis, Martin, Gonzalez, O'Connor, Chrostowski, Gregory, Garden and Smith, 2001) and *Science Benchmarking Report TIMSS 1999 - Eighth Grade: Achievement for U. S. States and Districts in an International Context* (Martin, Mullis, Gonzalez, O'Connor, Chrostowski, Gregory, Smith and Garden, 2001).

Participants in TIMSS 1999

Of the 42 countries that participated in TIMSS¹ at the eighth grade in 1995, 26 availed themselves of the opportunity to measure changes in the achievement of their students by also taking part in 1999 (see Exhibit 1). Twelve additional countries participated in 1999, for a total of 38 countries. Of those taking part in 1999, 19 had also participated in 1995 at the fourth grade. Since fourth-grade students in 1995 were in eighth grade in 1999, these countries can compare their eighth-grade performance with their performance at the fourth grade, as well as with the eighth-grade performance of students in other countries.

1. Results for 41 countries are reported in the 1995 international reports; Italy also completed the 1995 testing, but too late to be included.

Exhibit 1: Countries Participating in TIMSS 1999 and TIMSS 1995

Country	TIMSS 1999	TIMSS 1995 (Grade 8)	TIMSS 1995 (Grade 4)
Australia	●	●	●
Austria		●	●
Belgium (Flemish)	●	●	
Belgium (French)		●	
Bulgaria	●	●	
Canada	●	●	●
Chile	●		
Chinese Taipei	●		
Colombia		●	
Cyprus	●	●	●
Czech Republic	●	●	●
Denmark		●	
England	●	●	●
Finland	●		
France		●	
Germany		●	
Greece		●	●
Hong Kong, SAR	●	●	●
Hungary	●	●	●
Iceland		●	●
Indonesia	●		
Iran, Islamic Republic	●	●	●
Ireland		●	●
Israel	●	●	●
Italy	●	●	●
Japan	●	●	●
Jordan	●		
Korea, Republic of	●	●	●
Kuwait		●	●
Latvia	●	●	●
Lithuania	●	●	
Macedonia, Republic of	●		
Malaysia	●		
Moldova	●		
Morocco	●		
Netherlands	●	●	●
New Zealand	●	●	●
Norway		●	●
Philippines	●		
Portugal		●	●
Romania	●	●	
Russian Federation	●	●	
Scotland		●	●
Singapore	●	●	●
Slovak Republic	●	●	
Slovenia	●	●	●

Country	TIMSS 1999	TIMSS 1995 (Grade 8)	TIMSS 1995 (Grade 4)
South Africa	●	●	
Spain		●	
Sweden		●	
Switzerland		●	
Thailand	●	●	●
Tunisia	●		
Turkey	●		
United States	●	●	●

The TIMSS 1999 Science Test

The TIMSS curriculum framework underlying the TIMSS 1995 science test was developed by groups of science educators with input from the TIMSS National Research Coordinators (NRCs).² The content aspect of the framework represents the subject matter content of school science. The performance expectations aspect of the framework describes, in a non-hierarchical way, the many kinds of performances or behaviors that might be expected of students in school science. Working within the science curriculum framework, science test specifications were developed for TIMSS 1995 that included items representing a wide range of science topics and eliciting a range of skills from the students.

To provide as much information as possible about the nature and scope of the 1995 TIMSS achievement tests, almost two thirds of the items on the tests were released to the public. The remaining one-third were kept secure as a basis for accurately measuring trends in student achievement from 1995 to 1999. Releasing most of the 1995 items enabled more meaningful reports, both national and international, to be published and also provided information for secondary research. But it also meant that students in the TIMSS 1999 samples may have been exposed to these items, which necessitated the development of new science items for TIMSS 1999.

The major goal of TIMSS 1999 test development was to produce a test that would parallel that of TIMSS 1995 in overall structure and content. The strategy used involved treating the 1995 items as a representative sample from the “pool” of all possible items within the defined test domain and selecting new items from this “pool” with the same subdomains as the released items from TIMSS 1995. In practice, each released item was evaluated to define its

2. The complete TIMSS curriculum frameworks can be found in Robitaille, D.F. et al. (1993). TIMSS Monograph No. 1: Curriculum Frameworks for Mathematics and Science. Vancouver, B.C.: Pacific Educational Press.

subdomain (mathematics or science content, performance expectation, item format, and difficulty level), and a set of potential replacement items from the same subdomain was then created. This method ensured that the final test, comprising the nonreleased and replacement items, covered the same test domain as in TIMSS 1995.

The tests were developed through an international consensus involving input from experts in science and measurement specialists.³ The TIMSS Subject Matter Item Committee, which included distinguished scholars from 10 countries, ensured that the test reflected current thinking and priorities within the field of science. The items underwent an iterative development and review process with one pilot testing effort involving 31 countries. Every effort was made to help ensure that the tests represented the curricula of the participating countries and that the items did not exhibit any bias towards or against particular countries. The final forms of the test were endorsed by the NRCs of all the participating countries. The resulting test for the TIMSS 1999 students (eighth grade in many countries) contained 146 science items representing a range of science topics and skills.

Approximately one-fourth of the TIMSS items were in the free-response format, which required students to generate and write their own answers. Designed to represent approximately one-third of students' response time, some free-response questions asked for short answers, while others called for extended responses and required students to show their work. The remaining questions used a multiple-choice format. The distribution of items across content areas (as reported in the international reports) and performance expectations, as well as by item format, is presented in Exhibits 2 and 3, respectively. To ensure broad subject matter coverage without overburdening individual students, TIMSS used a rotated design that included both the mathematics and science items. In accordance with the design, the mathematics and science items were assembled in 26 different clusters — labeled A through Z. The clusters were assigned to eight different booklets in accordance with the rotated design so that representative samples of students responded to each cluster.⁴ Each student completed one 90-minute test booklet containing both mathematics and science items.

Exhibit 2: Distribution of Science Items by Content Reporting Category

Reporting Category	Item Type			Number of Items	Score Points
	Multiple-Choice	Short-Answer	Extended Response		
Earth Science	17	4	1	22	23
Life Science	28	7	5	40	42
Physics	28	11	-	39	39
Chemistry	15	2	3	20	22
Environmental and Resource Issues	7	2	4	13	14
Scientific Inquiry and the Nature of Science	9	2	1	12	13
Total	104	28	14	146	153

Exhibit 3: Distribution of Science Items by Performance Category

Performance Category	Percentage of Items	Total Number of Items	Number of Multiple-Choice Items	Number of Free-Response Items	Number of Score points
Understanding Simple Information	39	57	56	1	57
Understanding Complex Information	31	45	30	15	47
Theorizing, Analyzing and Solving Problems	19	28	5	23	32
Using Tools, Routine Procedures and Science Processes	7	10	9	1	10
Investigating the Natural World	4	6	4	2	7
Total	100	146	104	42	153

3. Garden, R. A. and Smith, T. A. (2000) "TIMSS Test Development" in M.O. Martin, K. D. Gregory, and S. E. Stemler, eds, TIMSS 1999 Technical Report, Chestnut Hill, MA: Boston College.

4. The TIMSS test design is documented in Garden, R. A. and Smith, T. A. (2000) "TIMSS Test Development" in M.O. Martin, K. D. Gregory, and S. E. Stemler, eds, TIMSS 1999 Technical Report, Chestnut Hill, MA: Boston College.

Item Release Policy

In accordance with IEA policy, TIMSS kept about one-half of the TIMSS 1999 items secure for future use in measuring international trends in mathematics and science achievement. The secure items are in every second cluster, starting with cluster A. All the remaining items, those in every second cluster starting with cluster B, are available for general use. This means that half of the secure items from 1995 are now being released. To facilitate their use, the released TIMSS items for TIMSS 1999 have been replicated in their entirety in this science volume and in the companion mathematics volume. As shown in Exhibit 4, this volume contains 68 science items. To provide a unique identifier for each item, the TIMSS cluster and item number is shown in the box on the right hand side of each page.

Some of the free-response items have multiple parts, indicated as A, B, or C. In addition, for some items, students were asked to provide an answer with supporting work, or to provide two reasons, examples, consequences, etc. For these items, derived variables based on the combined scores of the separate parts (A and B, or B and C) were also computed. These derived variables are indicated as D.

While the purpose of this volume is to encourage the use of TIMSS and TIMSS items, please note the IEA copyright; appropriate references to the IEA and TIMSS should be provided in your use of these items.

Item Documentation and Item Results

The TIMSS tests were prepared in English and translated into 33 additional languages. Each item is reproduced for this volume as it was presented to each of the TIMSS countries. In translating the tests or making adaptations for cultural purposes, every effort was made to ensure that the meaning and difficulty of items did not change. This process required an enormous effort by the national centers, with many checks made along the way.⁵

All of the items in this volume are science items. The mathematics items are provided in a companion volume, *TIMSS 1999 Mathematics Items: Released Set for Grade 8*

Across the top of each item, there is documentation about the item including the item label, item identification, the classification of the item by content category and performance expectation as well as information about scoring, trend status and international performance. If the item is a two-part item, the documentation for Part A is shown on the first page and the documentation for Part B is shown on the following page.

KEY. For multiple-choice items, the key for the correct answer is provided. For free-response questions, the scoring rubrics identifying categories of responses and their codes are shown next to the item. In scoring the TIMSS free-response questions, TIMSS utilized two-digit codes with rubrics specific to each item. The first digit designates the correctness level of the response. The first digit is usually a “1” designating a correct response, a “7” indicating an incorrect response, or a “9” for non-response. Sometimes, however, fully correct responses are differentiated from partially correct responses. In these instances, the fully correct responses are designated by a “2” and the partially correct responses by a “1.” The second digit, combined with the first digit, represents a diagnostic code used to identify specific types of approaches, strategies, or common errors and misconceptions.

CONTENT CATEGORY. The science items were reported according to six content areas.

- Earth Science
- Life Science
- Physics
- Chemistry
- Environmental and Resource Issues
- Scientific Inquiry and the Nature of Science

Exhibit 4 indicates which items have been classified into each of the six content areas.

5. More details about the translation verification procedures can be found in O'Connor, K. M. and Malak, B. (2000) "Translation and Cultural Adaptation of the TIMSS Instruments", in M.O. Martin, K. D. Gregory, and S. E. Stemler, eds, TIMSS 1999 Technical Report, Chestnut Hill, MA: Boston College.

PERFORMANCE EXPECTATION. Items were classified into the following performance expectations.

- Understanding Simple Information
- Understanding Complex Information
- Theorizing, Analyzing, and Solving Problems
- Using Tools, Routine Procedures, and Science Processes
- Investigating the Natural World

INTERNATIONAL AVERAGE PERCENTAGE OF EIGHTH GRADE STUDENTS

RESPONDING CORRECTLY. The percent of students responding correctly to the item reflects the international average across the countries participating in TIMSS 1999. That is, first the percentage of students responding correctly to the item was calculated for each country. Next, an average was calculated across the 38 countries. For items using a partial credit scoring scheme, the percentages given are for students responding with fully correct answers.

For More Information About TIMSS

For more details about the TIMSS 1999 results and procedures, please see the following reports:

Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., Gregory, K.D., Smith, T.A., Chrostowski, S.J., Garden, R.A., & O'Connor, K.M. (2000). *TIMSS 1999 International Science Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade*. Chestnut Hill, MA: Boston College.

Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., Gregory, K.D., Garden, R.A., O'Connor, K.M., Chrostowski, S.J., & Smith, T.A. (2000). *TIMSS 1999 International Mathematics Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade*. Chestnut Hill, MA: Boston College.

Martin, M.O., Gregory, K.D., and Stemler, S.E., eds., (2000), *TIMSS 1999 Technical Report*, Chestnut Hill, MA: Boston College.

Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., O'Connor, K.M., Chrostowski, S.J., Gregory, K. D., Garden, R. A. & Smith, T.A. (2001). *Science Benchmarking Report TIMSS 1999 - Eighth Grade: Achievement for U. S. States and Districts in an International Context*. Chestnut Hill, MA: Boston College.

Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., O'Connor, K.M., Chrostowski, S.J., Gregory, K. D., Smith, T.A. & Garden, R. A. (2001). *Mathematics Benchmarking Report TIMSS 1999 - Eighth Grade: Achievement for U. S. States and Districts in an International Context*. Chestnut Hill, MA: Boston College.

Exhibit 4: Item Listing by Science Content Area

Earth Science	
B05	Elevation diagram of wind/temperature
D03	Contour map showing river
F05	Oxygen equipment on mountain tops
H03	Why moon shines
H04	Diagram of soil layers
J01	Earth's plates over millions of years
J06	Factor explaining seasons on Earth
J09	Life on other planets
R04	Atmospheric conditions in jets
Z02	Diagram of rain from sea

Life Science	
D05	Sensory messages to the brain
D06	Seed development from plant part
F01	Characteristic of mammal
F03	Interpretation of senses
H01	NOT a function of blood
H02	Role of vitamins
J02	Feature shared by all insects
J07	Reason for protein in diet
L02	Large leaves on seedlings
L03	Physical characteristic of prey
L05	Wolves marking territory
L08	Complete food web
N02	Food web - effect of crop failure
N03	Bacteria to convert milk to yogurt
N05	Bone meal for plant growth
N06	Definition of tissue
N08	Mammal/lizards living in cold regions
P03	Tree growth
P04	Hibernating animals
P06	Digestion in stomach
R03A	Two outcomes of introducing new species
R03B	Two outcomes of introducing new species
R03D	Two outcomes of introducing new species
X02A	Importance of trees/sun in rain forest
X02B	Importance of trees/sun in rain forest

Physics	
B02	Energy released from car engine
B03	Greatest density from mass/volume table
B06	Color reflecting most light
D01	Light rays through magnifying glass
D02	Magnetic substances
D04	Sequence of energy changes
F02	Why light-colored clothes are cooler
H05	Energy stored in food
J04	Evaporation rate by surface area
J05	Gravity acting on rocket
J08	Sunscreen to protect against radiation
L01	Rotating forces on wheel
L04	Efficiency of machines
N01	Complete circuits
N09	Balancing 10 and 5 liter buckets
N10	Flashlights with white/black reflectors
P01	Determination of speed from graph
P02	Amount of light on wall and ceiling
R02	Appearance of red dress in green light
X01	Conversion of electrical/light energy
Z03	Heat expansion of balloons

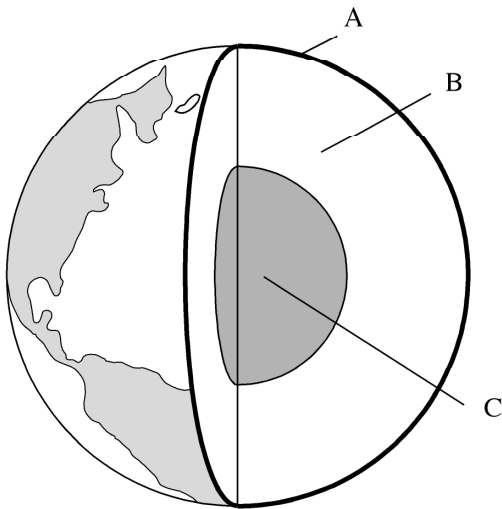
Chemistry	
F06	Best reason for painting iron surfaces
H06	Burning wood absorbs/releases energy
J03	Compounds, molecules and atoms
L06	Filtration of mixtures
N07	Example of chemical reaction
R05	Small pieces of wood burn faster
Z01A	Galvanization of steel
Z01B	Galvanization of steel
Z01C	Galvanization of steel
Z01D	Galvanization of steel

Environmental and Resource Issues	
F04	Area where soil is washed away
L07	Effectiveness of insecticides
P05A	Two reasons for famine
P05B	Two reasons for famine
P05D	Two reasons for famine
R06	Result of global warming

Scientific Inquiry and the Nature of Science	
N04	Evaporation of vinegar and oil
P07	Replication of measurements
R01	Bacteria/mold experiment
X03	Heart rate experiment design

Layers of Earth					B01
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Understanding Simple Information	C	1	82	Y

The picture shows the three main layers of the Earth.



Where is it the hottest?

- A. Layer A
- B. Layer B
- C. Layer C
- D. All three layers are the same temperature.

Energy released from car engine					B02
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Simple Information	B	1	58	Y

Most of the chemical energy released when gasoline burns in a car engine is not used to move the car, but is changed into

- A. electricity
- B. heat
- C. magnetism
- D. sound

Greatest density from mass/volume table**B03**

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Theorizing, Analyzing and Solving Problems	C	1	28	Y

Which object listed in the table has the greatest density?

Object	Mass of Object	Volume of Object
W	11.0 grams	24 cubic centimeters
X	11.0 grams	12 cubic centimeters
Y	5.5 grams	4 cubic centimeters
Z	5.5 grams	11 cubic centimeters

- A. W
- B. X
- C. Y
- D. Z

Pulse/breathing rate after exercise					B04
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Complex Information	C	1	87	Y

Immediately before and after running a 50 meter race, your pulse and breathing rates are taken. What changes would you expect to find?

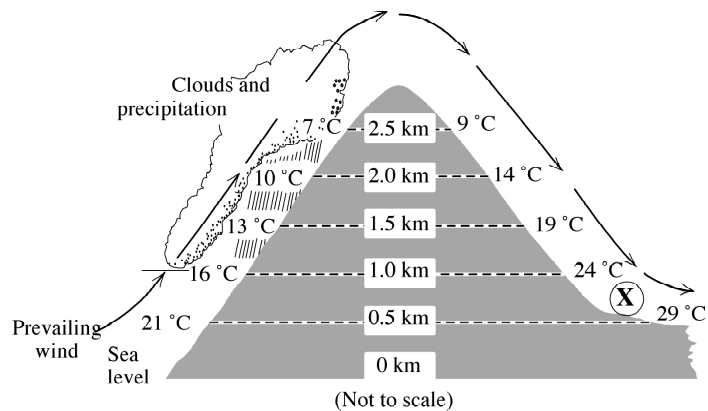
- A. no change in pulse but a decrease in breathing rate
- B. an increase in pulse but no change in breathing rate
- C. an increase in pulse and breathing rate
- D. a decrease in pulse and breathing rate
- E. no change in either

Elevation diagram of wind/temperature

B05

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Using Tools, Routine Procedures and Science Processes	A	1	47	Y

The diagram below shows a mountain. The prevailing wind direction and average air temperatures at different elevations on both sides of the mountain are indicated.



Which feature is probably located at the base of the mountain at location (X)?

- A. a dry region
- B. a jungle
- C. a glacier
- D. a large lake
- E. a rain forest

S012011

Color reflecting most light					B06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Simple Information	A	1	82	Y

The walls of a building are to be painted to reflect as much light as possible. What color should they be painted?

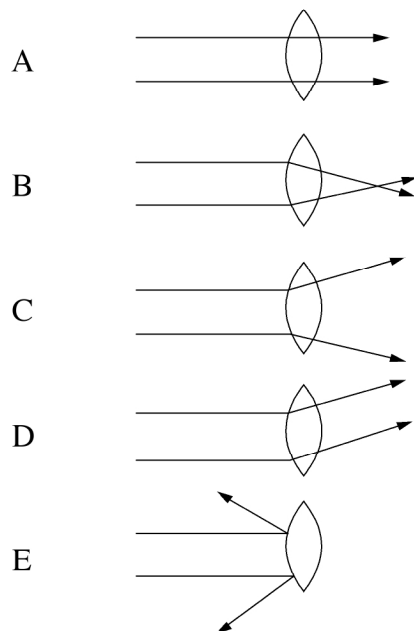
- A. White
- B. Red
- C. Black
- D. Pink

Light rays through magnifying glass

D01

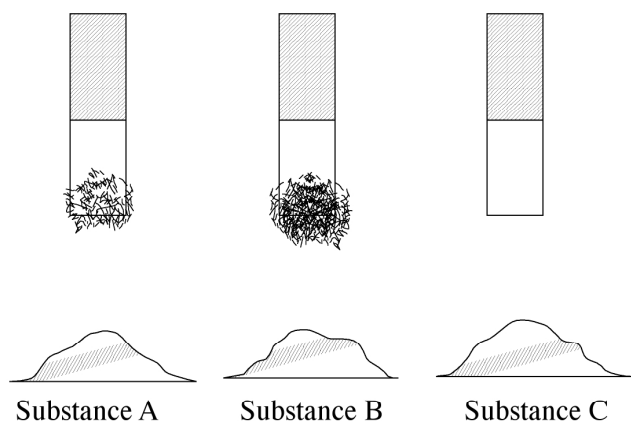
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Complex Information	B	1	42	Y

Which diagram best shows what happens when light passes through a magnifying glass?



Magnetic substances					D02
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Complex Information	C	1	72	Y

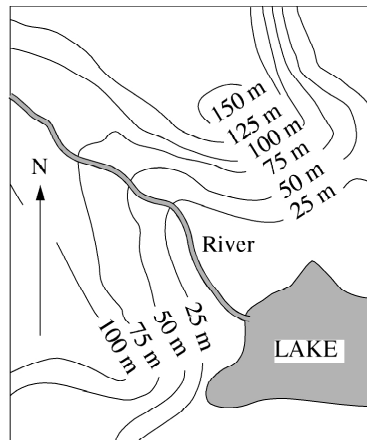
Each of the three magnets shown has been dipped into the substance below it. Which of the substances could be coffee?



- A. A only
- B. B only
- C. C only
- D. A and B only

Contour map showing river					D03
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Using Tools, Routine Procedures and Science Processes	B	1	37	Y

On the diagram, hills and valleys are shown by means of contour lines. Each contour line indicates that all points on the line have the same elevation above sea level.



In which direction does the river flow?

- A. Northeast
- B. Southeast
- C. Northwest
- D. Southwest
- E. It is not possible to tell from the map.

Sequence of energy changes					D04
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Complex Information	C	1	59	Y

Chemical Energy → Heat Energy → Mechanical Energy
(with wasted heat)

The sequence of energy changes shown in the diagram explains which event?

- A. A flashlight is on.
- B. A candle burns.
- C. Gasoline burns to power a car.
- D. Electric current runs a refrigerator.

Sensory messages to the brain					D05
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	C	1	69	Y

Sensory messages are taken to the brain by

- A. arteries and veins
- B. arteries and hormones
- C. nerves and hormones
- D. muscles and veins

Seed development from plant part					D06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	A	1	71	Y

Seeds develop from which part of a plant?

- A. Flower
- B. Leaf
- C. Root
- D. Stem

Characteristic of mammal					F01
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	B	1	70	Y

A small animal called the duckbilled platypus lives in Australia. Which characteristic of this animal shows that it is a mammal?

- A. It eats other animals.
- B. It feeds its young milk.
- C. It makes a nest and lays eggs.
- D. It has webbed feet.

Why light-colored clothes are cooler					F02
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Complex Information	A	1	65	Y

- .
- On a warm sunny day, you will feel cooler wearing light-colored clothes because they
- A. reflect more radiation
 - B. prevent sweating
 - C. are not as heavy as dark clothes
 - D. let more air in

Interpretation of senses					F03
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	A	1	65	Y

Humans interpret seeing, hearing, tasting and smelling in the

- A. brain
- B. spinal cord
- C. receptors
- D. skin

Area where soil is washed away					F04
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Environmental and Resource Issues	Understanding Complex Information	D	1	68	Y

Rain and running water can wash away soil. From which area is soil most likely to be washed away?

- A. A sloping area with bushes
- B. A flat area with grasses
- C. A flat area that is barren
- D. A sloping area that is barren

Oxygen equipment on mountain tops					F05
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Understanding Complex Information	A	1	79	Y

Why do mountain climbers use oxygen equipment at the top of the world's highest mountains?

- A. There is less oxygen in the air at great heights.
- B. There is little nitrogen in the air at great heights.
- C. There is a hole in the ozone layer.
- D. There is no air at the top of very high mountains.

Best reason for painting iron surfaces					F06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Chemistry	Understanding Simple Information	E	1	67	Y

Paint applied to an iron surface prevents the iron from rusting. Which ONE of the following provides the best reason?

- A. It prevents nitrogen from coming in contact with the iron.
- B. It reacts chemically with the iron.
- C. It prevents carbon dioxide from coming in contact with the iron.
- D. It makes the surface of the iron smoother.
- E. It prevents oxygen and moisture from coming in contact with the iron.

NOT a function of blood					H01
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	A	1	70	Y

Which of these is NOT a function of the blood?

- A. Digesting food
- B. Protecting against disease
- C. Carrying waste materials away from the cells
- D. Carrying oxygen to different parts of the body

Role of vitamins					H02
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	D	1	78	Y

What are vitamins?

- A. Substances that break down food
- B. Bacteria that people get when they eat some foods
- C. Substances that people make from protein
- D. Substances that people need in small amounts in order for their bodies to function normally

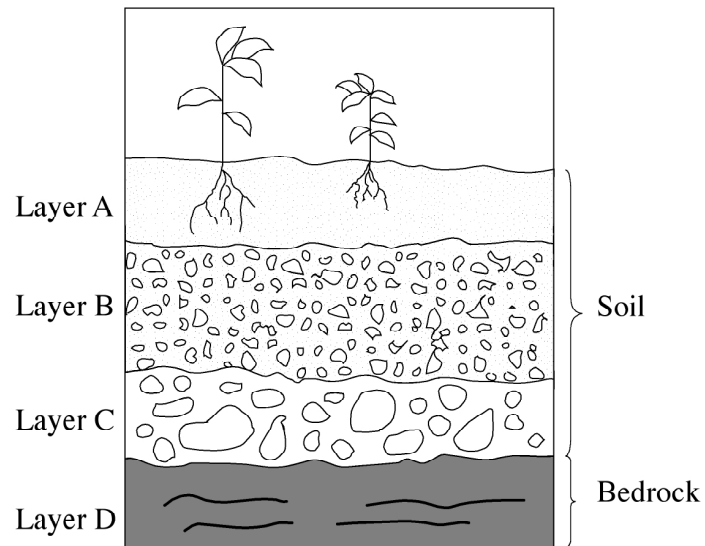
Why moon shines					H03
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Understanding Simple Information	A	1	81	Y

The Moon produces no light, and yet it shines at night. Why is this?

- A. The Moon reflects the light from the Sun.
- B. The Moon rotates at a very high speed.
- C. The Moon is covered with a thin layer of ice.
- D. The Moon has many craters.

Diagram of soil layers					H04
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Understanding Complex Information	A	1	48	Y

Which layer in the diagram contains the most organic material?



- A. Layer A
- B. Layer B
- C. Layer C
- D. Layer D

Energy stored in food					H05
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Simple Information	B	1	24	Y

People get energy from the food they eat. Where does the energy stored in food come from?

- A. Fertilizers
- B. The Sun
- C. Vitamins
- D. The soil

Burning wood absorbs/releases energy					H06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Chemistry	Understanding Simple Information	A	1	55	Y

If you are burning wood, the reaction will

- A. release energy
- B. absorb energy
- C. neither absorb nor release energy
- D. sometimes release and sometimes absorb energy, depending on the kind of wood

Earth's plates over millions of years					J01
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Understanding Simple Information	C	1	75	N

Which BEST describes the movement of the plates that make up Earth's surface over millions of years?

- A. They moved for millions of years but have now stopped.
- B. They stayed the same for millions of years but are now moving.
- C. They have been continually moving.
- D. They have never moved.

Feature shared by all insects					J02
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	A	1	49	N

What feature is shared by ALL insects?

- A. External skeleton
- B. Two pairs of wings
- C. Jumping legs
- D. Stinging mechanism

Compounds, molecules and atoms

J03

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Chemistry	Understanding Complex Information	Rubric	1	46	N

The words *organs*, *tissues*, and *cells* can be used in the following sentence:
Lungs are *organs* composed of *tissues* which are made up of *cells*.

Use the words *molecules*, *atoms*, and *compounds* to complete the following sentence:

Sugars are _____ composed of _____ which are made up of _____ .

Code	Response	Item: S022174
	Correct Response	
10	Compounds - Molecules - Atoms	
	Incorrect Response	
70	Compounds - Atoms - Molecules	
71	Molecules - Atoms - Compounds	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

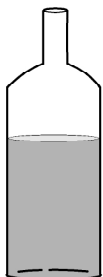
Evaporation rate by surface area

J04

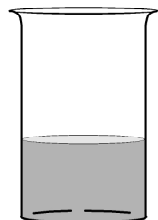
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Complex Information	C	1	84	N

A student put 100 mL of water in each of the open containers and let them stand in the sun for one day. Which container would probably lose the most water due to evaporation?

A.



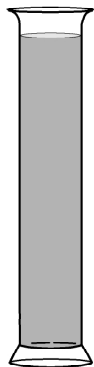
B.



C.



D.

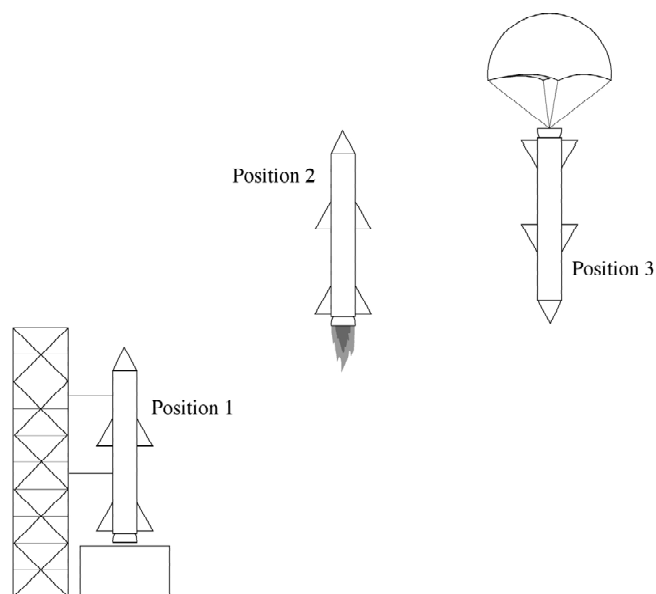


Gravity acting on rocket

J05

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Simple Information	D	1	36	N

The drawings show a rocket being launched from Earth and then returning.



In which of the three positions does gravity act on the rocket?

- A. 3 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2 and 3

Factor explaining seasons on Earth					J06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Understanding Complex Information	C	1	26	N

Which of the following is an important factor in explaining why seasons occur on Earth?

- A. Earth rotates on its axis.
- B. The Sun rotates on its axis.
- C. Earth's axis is tilted.
- D. The Sun's axis is tilted.

Reason for protein in diet					J07
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	C	1	33	N

The BEST reason for including protein in a healthy diet is because it is the main source of

- A. energy for the body
- B. fiber for digestion
- C. raw materials for cell growth and repair
- D. vitamins for fighting disease

Sunscreen to protect against radiation					J08
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Simple Information	D	1	62	N

Sunscreen is used to protect the skin from exposure to which type of solar radiation?

- A. Visible
- B. X-rays
- C. Infrared
- D. Ultraviolet
- E. Microwaves

Life on other planets

J09

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Theorizing, Analyzing and Solving Problems	Rubric	1	66	N

Diana and Mario were discussing what it might be like on other planets. Their science teacher gave them data about Earth and an imaginary planet Proto. The table shows these data.

	Earth	Proto
Distance from a star like the Sun	148 640 000 km	902 546 000 km
Atmospheric pressure at surface of planet	101 325 Pa	100 Pa
Atmospheric conditions		
• gas components	21% oxygen 0.03% carbon dioxide 78% nitrogen	5% oxygen 5% carbon dioxide 90% nitrogen
• ozone layer	yes	no
• cloud cover	yes	no

Write down one important reason why it would be difficult for humans to live on Proto if it existed. Explain your answer.

Note: A correct response must clearly indicate the reason why a condition listed in the table makes it hard for humans to live on Proto. Responses referencing insufficient (too little, less, not enough, etc.) oxygen with or without explicitly mentioning breathing will be given credit (Code 10) due to the assumption of common knowledge. If more than one reason is given, assign the code corresponding to the first correct reason.

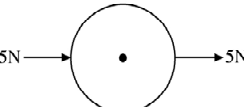
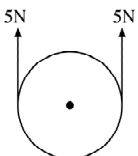
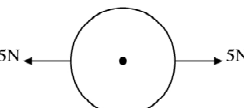
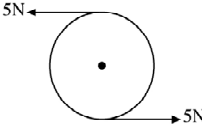
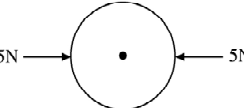
Code	Response	Item: S022081
	Correct Response	
10	States there would be insufficient (too little, less, not enough, etc.) oxygen (to breath). <i>Examples: People could not survive on Proto because there is not enough oxygen to breath. There is only 5% oxygen and that is not enough to survive.</i>	
11	States that the atmospheric pressure would be too low with an explanation based on low air/oxygen levels or effects of lower boiling point, etc. <i>Example: The atmosphere is too thin, so we cannot breath.</i>	
12	States that there is no ozone layer to protect people (against star's UV radiation). <i>Examples: There is not enough ozone on Proto to give humans adequate protection from UV rays. No protection (from Sun) by an ozone layer.</i>	
13	States that no cloud cover means no (low) water. <i>Example: Proto may not have any water on it since it lacks clouds.</i>	
14	States that it is too cold (due to distance from the star). <i>Examples: Proto is too far from the star, and therefore it would be very cold. People would freeze to death on Proto.</i>	
19	Other correct.	
	Incorrect Response	
70	Merely repeats information in table and/or stem with no explanation. <i>Examples: Proto has no ozone layer. The pressure is too low to survive. The oxygen is 5% and the nitrogen is 90%.</i>	
71	States that it is too hot due to no ozone layer. <i>Example: Without an ozone layer the planet would heat up too much.</i>	
72	States that there is little (no) gravity (confuses atmospheric pressure with gravity). <i>Examples: People would float on Proto because the pressure is too low. There is not enough pressure to keep people on the ground.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Rotating forces on wheel

L01

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Complex Information	D	1	62	N

A uniform wheel is free to rotate on its axle at its center. It is acted on by two forces in the same plane. Each force has the same size, equal to 5N (Newtons). In which case will the wheel rotate?

- A. 
- B. 
- C. 
- D. 
- E. 

Large leaves on seedlings					L02
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Complex Information	D	1	72	N

What is the primary function of the large leaves found on seedlings growing in a forest?

- A. To provide shade for the root systems
- B. To get rid of excess water that is entering through the roots
- C. To allow for leaf damage by insects
- D. To gather as much light as possible for photosynthesis

Physical characteristic of prey					L03
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Complex Information	A	1	37	N

Which one of the following characteristics is most likely to be found in mammals that are preyed on by other mammals for food?

- A. Eyes on the sides of the head
- B. Teeth that are long and pointed
- C. Claws on the feet
- D. Ears that cannot move

Efficiency of machines

L04

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Theorizing, Analyzing and Solving Problems	Rubric	1	31	N

Machine A and Machine B are each used to pump water from a river. The table shows what volume of water each machine removed in one hour and how much gasoline each of them used.

	Volume of Water Removed in 1 Hour (liters)	Gasoline Used in 1 Hour (liters)
Machine A	1000	1.25
Machine B	500	0.5

a) Which machine is more efficient in converting the energy in gasoline to work?

Answer: _____

b) Explain your answer.

Note: A correct response must identify **B** and include an explanation based on the concept of energy efficiency (ratio of energy output to energy input) that compares the volume of water pumped for an equivalent volume of gasoline used for the two machines. Responses based ONLY on comparing the amount of gasoline used OR the amount of water pumped by the machines without considering the ratio of water/gasoline are scored as incorrect (Codes 70 and 72). No credit is lost for missing/incorrect units or for minor computational errors, provided the correct conclusion and explanation are given.

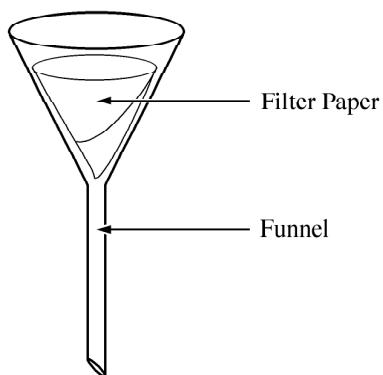
Code	Response	Item: S022017
	Correct Response	
10	B. With correct explanation based on the concept of energy efficiency (B uses less gasoline than A for an equivalent volume of water pumped). <i>Examples:</i> B. Because it uses 1L of gas per 1000L of water and A used 1.25L for 1000L of water. B. Because it uses less gasoline per liter of water. B. Because it can pump the same amount of liters using less gas.	
	Incorrect Response	
70	B. It uses less gasoline (no comparison of efficiency based on volume of water pumped). <i>Examples:</i> B. It used .5L of gas in an hour, and A used 1.25L in an hour. B. Its uses less gas in an hour. B. The engine used .75L less gas.	
71	B. Other incorrect/inadequate or no explanation.	
72	A. It removes more water in 1 hour (no comparison of efficiency based on gas used). <i>Examples:</i> A. It pumps more water. A. It pumps 1.25 liters and B only pumps 0.5 liters. A. It pumped 500L more than B.	
73	A. Other incorrect/inadequate or no explanation.	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Wolves marking territory					L05
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	C	1	60	N

When male wolves place their scent on trees, they most likely are doing this in order to

- A. attract female wolves
- B. attract prey
- C. mark their territory against other wolves
- D. mark the location of food supplies

Filtration of mixtures					L06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Chemistry	Using Tools, Routine Procedures and Science Processes	B	1	39	N



Filtration using the equipment shown above can be used to separate which materials?

- A. A mixture of salt and pepper
- B. A mixture of pepper and water
- C. A mixture of oxygen and water
- D. A solution of silver nitrate in water
- E. A solution of sugar in water

Effectiveness of insecticides					L07
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Environmental and Resource Issues	Understanding Complex Information	B	1	48	N

Insecticides are used to control insect populations so that they do not destroy crops. Over time, some insecticides become less effective at killing insects, and new insecticides must be developed. What is the most likely reason insecticides become less effective over time?

- A. Surviving insects have learned to include insecticides as a food source.
- B. Surviving insects pass their resistance to insecticides to their offspring.
- C. Insecticides build up in the soil.
- D. Insecticides are concentrated at the bottom of the food chain.

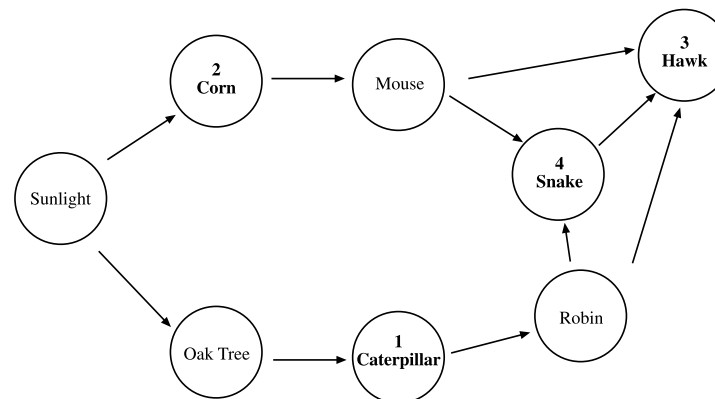
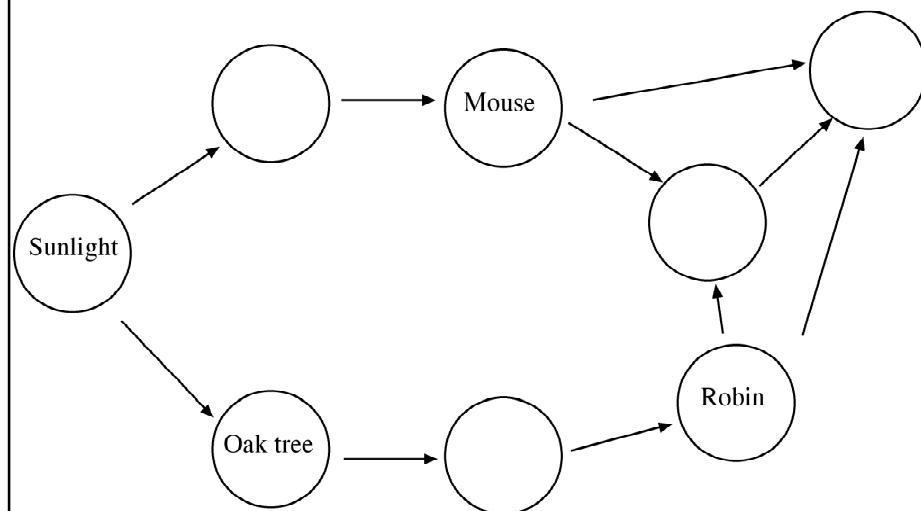
Complete food web

L08

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Complex Information	Rubric	1	55	N

An incomplete food web has been drawn for you. Complete it by filling in each of the empty circles with the number of the correct animal or plant from the list. Remember that the arrows represent energy flow and go from the provider to the user.

- 1) Caterpillar
- 2) Corn
- 3) Hawk
- 4) Snake



Note: There are two possible food webs that are accepted as correct. The most likely corresponds to Code 10. An alternative, but less preferred, food web with the hawk (3) and snake (4) reversed is also scored as correct (Code 11).

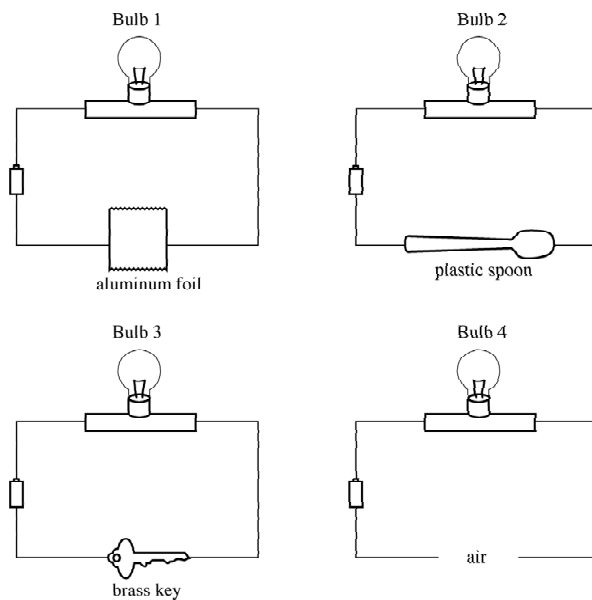
Code	Response	Item: S022140
	Correct Response	
10	Four placed correctly: 2,1,4,3 or names of animals/plants (corn, caterpillar, snake, hawk) as shown in the diagram above.	
11	Same as with Code 10 but with hawk and snake reversed.	
	Incorrect Response	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Complete circuits

N01

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Complex Information	C	1	64	N

The following diagrams show a battery and a bulb connected by wires to various materials.



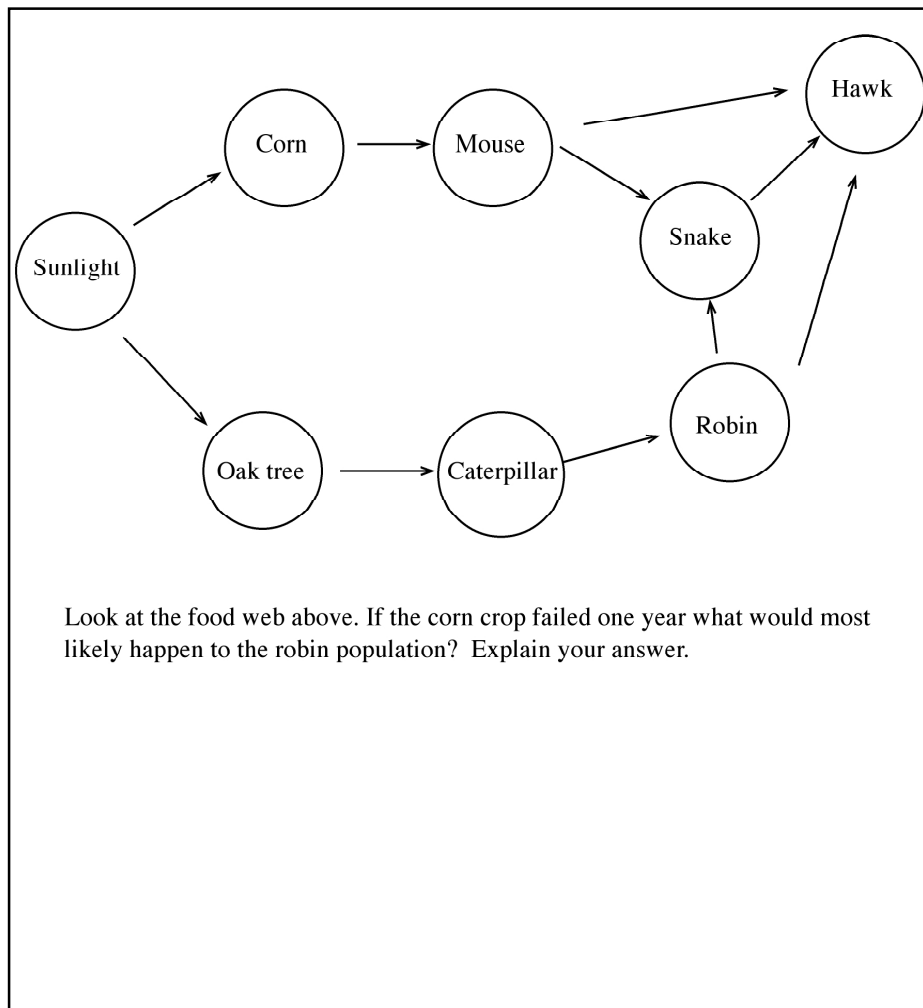
Which of the bulbs will light?

- A. 1 only
- B. 2 and 3 only
- C. 1 and 3 only
- D. 1, 3 and 4 only
- E. 1, 2 and 3 only

Food web - effect of crop failure

N02

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Theorizing, Analyzing and Solving Problems	Rubric	1	26	N



Note: A correct response must include a feasible explanation directly relating the predicted change in robin population to the effect of corn crop failure on prey/predator relationships indicated in the food web. Responses do not have to use the specific terms **decrease**, **increase**, and **same**, as long as the explanation is clear with respect to the effect on the robin population. If more than one effect is given, assign the code corresponding to the first correct explanation.

Code	Response	Item: S022141
Correct Response		
10	Robin population may decrease . Explanation based on predators (snakes/hawks) eating more robins if mice die. <i>Examples: Goes down. The mice would starve and the snake would eat the robins. There would be less robins because the mouse population would decrease and the snakes (and/or hawks) would eat more of the robins.</i>	
11	Robin population may increase . Explanation based on predators (snakes/hawks) dying due to lack of food (mice). <i>Examples: It would go up because the snakes die if the mouse starves. There could be more robins because there are fewer snakes (and/or hawks) to eat them.</i>	
12	Robin population would stay the same with a feasible explanation. <i>Example: It would not change because the mouse would find other grain to eat so the snake would be unaffected.</i>	
19	Other acceptable explanation.	
Incorrect Response		
70	Robin population would decrease . Incorrect explanation based on robins starving if snakes die (confuses prey/predator relationship). <i>Examples: Decreases because there are less snakes to eat. When corn dies, mice die, then snakes, then robins starve.</i>	
71	Robin population would decrease . Incorrect explanation based on the robin needing corn to survive. <i>Example: Decrease because they need the corn.</i>	
72	Robin population would stay the same . Incorrect explanation based on the robins not needing corn to survive or not being connected to corn in the food web. (Does not consider the effect of predators.) <i>Examples: Nothing because the robin only eats insects. Nothing would happen. The corn is on a different chain in the food web.</i>	
73	Mentions only that the whole food web will be upset and/or all the animals will die. <i>Example: The whole food web would erupt and everything would die.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
Nonresponse		
99	BLANK	

Bacteria to convert milk to yogurt					N03
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	A	1	54	N

Which of the following organisms are used to convert milk to yogurt?

- A. Bacteria
- B. Protozoa
- C. Viruses
- D. Algae

Evaporation of vinegar and oil					N04
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Scientific Inquiry and the Nature of Science	Investigating the Natural World	C	1	48	N

Two open bottles, one filled with vinegar and the other with olive oil, were left on a window sill in the Sun. Several days later it was observed that the bottles were no longer full. What can be concluded from this observation?

- A. Vinegar evaporates faster than olive oil.
- B. Olive oil evaporates faster than vinegar.
- C. Both vinegar and olive oil evaporate.
- D. Only liquids containing water evaporate.
- E. Direct sunlight is needed for evaporation.

Bone meal for plant growth					N05
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	B	1	56	N

Some plants grow better if bone meal (ground-up bones) is spread around their roots. What does bone meal supply to plants that makes them grow better?

- A. Energy
- B. Minerals
- C. Vitamins
- D. Carbon dioxide
- E. Water

Definition of tissue					N06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Simple Information	A	1	41	N

Tissues are found in living things. What is the definition of a tissue?

- A. A group of cells with similar structure and function
- B. A group of cells with different structure and function
- C. A group of organelles contained inside a cell
- D. A group of substances that make up the walls of a cell

Example of chemical reaction					N07
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Chemistry	Understanding Simple Information	C	1	49	N

Which is an example of a chemical reaction?

- A. Water boiling
- B. Sugar dissolving
- C. Nails rusting
- D. Wax melting

Mammal/lizards living in cold regions					N08
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Complex Information	D	1	40	N

Which statement best explains why mammals are found in very cold regions of the world but lizards are not?

- A. Both mammals and lizards are cold-blooded, but mammals have fur to keep them warm.
- B. Both mammals and lizards are warm-blooded, but lizards get too cold when they shed their skin.
- C. Since mammals, but not lizards, are warm-blooded, their body temperature will adjust to match the external temperature.
- D. Since mammals, but not lizards, are warm-blooded, they will maintain their body temperature using heat from metabolic processes.

Balancing 10 and 5 liter buckets					N09
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Theorizing, Analyzing and Solving Problems	D	1	71	N

Which picture shows the best way for the man to balance a ten-liter bucket of water and a five-liter bucket of water?

A.

B.

C.

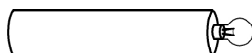
D.

Flashlights with white/black reflectors

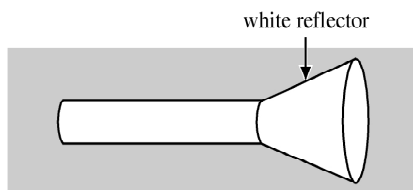
N10

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Theorizing, Analyzing and Solving Problems	Rubric	1	39	N

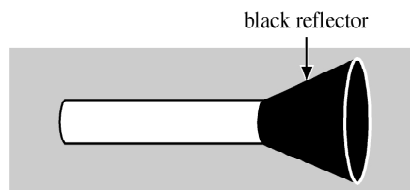
Roddy and Stephanie each make a flashlight using identical batteries and bulbs.



They then add cardboard reflectors to their flashlights as shown below. Roddy's reflector is made of white cardboard and Stephanie's reflector is made of black cardboard.



Roddy's Flashlight



Stephanie's Flashlight

The flashlights are then switched on.

- a) Which flashlight shines more light on a wall two meters away?
(check one)

☐ Roddy's (white reflector)

☐ Stephanie's (black reflector)

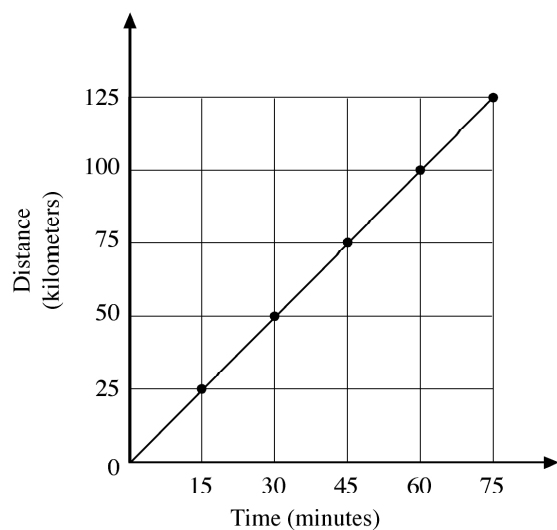
- b) Explain your answer.

Note: A correct response must identify **Roddy's** and include an explanation based on the relative reflectivity of the white and black cardboard. Credit is given both for responses explicitly mentioning the higher reflectance of the white cardboard and/or the higher absorptance of the black cardboard as well as responses communicating this concept using less scientific terminology.

Code	Response	Item: S022049
	Correct Response	
10	Roddy's. With correct explanation based on the higher reflectivity of the white cardboard (or lower reflectivity/higher absorption of the black cardboard). [Explicitly refers to absorption and/or reflectivity.] <i>Examples:</i> Roddy's. Because light reflects better off lighter colors. Roddy's. Roddy's does not absorb as much as Stephanie's. Roddy's. Because white reflects light and black absorbs it. Roddy's. Dark colors absorb the light so more light would be absorbed by Stephanie's flashlight. Roddy's. Stephanie's reflector would absorb the light and not reflect it onto the wall.	
11	Roddy's. Explanation based on the concept of higher reflectivity but using other terminology. [Does not explicitly refer to absorption/reflection properties.] <i>Examples:</i> Roddy's. The light will bounce off something brighter like the white reflector. Roddy's. White reflector throws off light better than black. Roddy's. Because black draws the light and white repels it. Roddy's. The light gets defined more by the white one. Roddy's. More light shines off a white surface.	
19	Other correct.	
	Incorrect Response	
70	Roddy's with an inadequate/incorrect or no explanation. <i>Examples:</i> Roddy's. You can see the light with the white cardboard. Roddy's. White cardboard intensifies the light. Roddy's. Far away. Roddy's. Its white.	
71	Stephanie's. With or without explanation. <i>Examples:</i> Stephanie's. The black reflector is better. Stephanie's. Black absorbs light and heat, white deflects it. Stephanie's. The light will shine through the white reflector.	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Determination of speed from graph					P01
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Theorizing, Analyzing and Solving Problems	D	1	54	N

The graph shows the progress made by a car traveling along a straight road.



What is the speed of the car?

- A. 25 kilometers per hour
- B. 50 kilometers per hour
- C. 75 kilometers per hour
- D. 100 kilometers per hour

Amount of light on wall and ceiling

P02

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Theorizing, Analyzing and Solving Problems	Rubric	1	24	N

James turns on a flashlight in his bedroom and shines it on his wall one meter away to produce a small circle of light. He then shines the flashlight on his ceiling two meters away to produce a larger circle of light.

a) Does more light reach the ceiling than the wall?
(Check one)

☐ Yes

☐ No

b) Explain your answer.

Note: A correct response is based on the same amount of light reaching both the ceiling and the wall but being more spread out (less bright) on the ceiling. Correct responses must identify **NO** and include an explanation that states that the light is the **same** (Code 10) or that indicates that the light is just more spread out (less bright) on the ceiling **without** explicitly stating **same** (Code 11). If the explanation merely repeats information that is in the stem, it is scored as incorrect (Code 71) even if **NO** is checked. If a response indicates that there is **less** light on the ceiling, the explanation must include a correct reason based on more air absorption/scattering at a greater distance to receive the correct Code 12. Responses that indicate **less** light at a greater distance **without** further explanation should receive Code 70.

Code	Response	Item: S022043
Correct Response		
10	No. Explains that the same amount of light reaches the wall and ceiling. (May also refer to light being more spread out on the ceiling or less concentrated/focused/bright). <i>Examples: No. It is going to be the same amount of light because James is using the same flashlight. No. The light might be bigger but will not be as bright. They are equal. No. The same amount of light hits the ceiling but is more spread out.</i>	
11	No. Explains (or shows in a diagram) that light is (only) more spread out (less bright) at a greater distance. (Does not explicitly state that the light is the same.) <i>Example: No. It only looks bigger because it spreads out more as it gets farther away.</i>	
12	No. Explains that less light reaches the ceiling because of more air absorption/scattering at a greater distance. <i>Example: No. The ceiling is further away, and a little bit more of the light is soaked up by the air.</i>	
19	No. Other correct explanation.	
Incorrect Response		
70	No. States that less light reaches the ceiling with inadequate explanation related to distance from source. (Does not include explanation of less light due to air absorption or scattering as in Code 12). <i>Examples: No. Because the flashlight is closer to the wall, the wall will receive more light. No. The ceiling is further than the wall is so there is less light.</i>	
71	No. Other incorrect/inadequate or no explanation. (Includes explanations that merely paraphrase the stem). <i>Example: No. When it is close its a smaller circle.</i>	
72	Yes. Explanation based on light being bigger or more spread out. <i>Examples: Yes. Because the light makes a bigger circle. Yes. Because if you move back it makes a large circle on the wall and if you move close it makes a small circle. Yes. The further it goes, the bigger it gets.</i>	
73	Yes. Other incorrect/inadequate or no explanation.	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
Nonresponse		
99	BLANK	

Tree growth					P03
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Theorizing, Analyzing and Solving Problems	Rubric	1	41	N

Ethan hammered a nail into the trunk of a young tree. Explain why the nail was still at the same height from the ground twenty years later even though the tree had grown to a height of 22 meters.

Note: A correct response is based on trees increasing in height as a result of growth at the tips of stems/branches (apical meristem) and trunk growth only resulting in increased diameter. Responses should be scored as correct if either of these two factors are included.

Code	Response	Item: S022258
	Correct Response	
10	Mentions that trees grow in height at the tips of stems/branches. (May also mention trunk growth increasing in diameter.) <i>Examples: Trees grow at the bottom, but the bottom only gets wider. The branches grow wider and taller. Because the tree grows from the top of the branches The increased height was because the top of the tree grew, not the bottom.</i>	
11	Mentions ONLY that the trunk grows in width or diameter but not height (without mentioning growth of the stem or branches). <i>Examples: The trunk size will either expand (get fatter) or grow in width, but will not grow upward. Trunks are the only parts that do not grow upwards. Because the trunk gets thicker not higher.</i>	
19	Other correct.	
	Incorrect Response	
70	Mentions only that the trunk does not grow (is dead). <i>Examples: The trunk had stopped growing. The tree trunk was probably not growing the branches there. He hammered the nail into the trunk of the tree which does not grow.</i>	
71	Mentions that the nail stops or prevents growth. <i>Examples: Because the nail stopped it from growing at that certain part. The tree will not grow on that side.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Hibernating animals					P04
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Complex Information	D	1	48	N

Animals hibernate to survive cold weather and poor food supplies. Which of the following occurs in animals when they hibernate?

- A. Their blood stops circulating.
- B. Their body temperature increases.
- C. Their body fat remains constant.
- D. Their rate of metabolism decreases.

Two reasons for famine					P05D
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Environmental and Resource Issues	Understanding Complex Information	Rubric	2	42	N

What are two reasons why famine (a great shortage of food) occurs?

1.

2.

A, B: Codes for each reason

Note: Each of the two reasons must be coded separately. The same code can be used twice. However, if the reasons described are essentially the same, or an extension of the same idea, a Code 79 should be given to the second one. If only one reason is given, a Code 99 should be given for the second reason.

Code	Response	Item: S022277
	Correct Response	
10	Mentions agriculturally-related factors (soil depletion, overgrazing, erosion, poor farming techniques). <i>Examples: When the soil cannot grow any food. The farmers may have tried to raise too many animals on the land.</i>	
11	Mentions natural disasters or weather-related factors (floods, earthquakes, rain distribution, drought, temperature, sun, etc.). <i>Examples: Not enough rain. Too much heat (sun).</i>	
12	Mentions crop disease, insect infestation or other pests. <i>Examples: Famine occurs because of disease of the crop. Plagues.</i>	
13	Mentions overpopulation or consumption. <i>Examples: There are too many people and too little food. There may be too many people living in that area.</i>	
14	Mentions specific social/economic/political factors. <i>Examples: War. Lack of money to keep crops growing. Poor economic system.</i>	
15	Mentions pollution or other contamination. <i>Examples: Unsanitized food could not be eaten. The soil was polluted.</i>	
19	Other correct.	
	Incorrect Response	
70	Mentions ONLY a lack or need of food (or other responses related to a general definition of famine). <i>Example: Famine occurs when you are hungry.</i>	
71	Response too vague. <i>Example: The government.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Digestion in stomach					P06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Complex Information	Rubric	1	41	N

What digestive substance is found in the stomach? What does it do?

Note: To receive code 10 or 11, a response must name a specific digestive substance found in the stomach (enzyme, hydrochloric acid, or gastric juices) with or without a full description of its function. A general response related to “acid” will be accepted as correct (code 12), but an incorrect acid will be scored as incorrect (code 70).

Code	Response	Item: S022158
	Correct Response	
10	Names enzyme, hydrochloric acid or gastric juices with an explanation based on breaking down food (particles) or protein. <i>Example: The enzymes in the stomach dissolve the food so it can be absorbed. There is hydrochloric acid in the stomach that breaks down the food. The gastric juices break the food into smaller pieces.</i>	
11	Names enzyme, hydrochloric acid or gastric juices without a complete explanation.	
12	Names acid with or without a complete explanation (does not explicitly name hydrochloric acid).	
19	Other correct.	
	Incorrect Response	
70	Names an incorrect acid not involved in digestion in stomach (lactic acid, amino acid, sulfuric acid, etc.).	
71	Names a substance (or body part) not found in the stomach but involved in digestion (saliva, bile salts, bacteria, intestines, etc.).	
72	Mentions digesting (breaking down) food but no specific substance or body part is named.	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Replication of measurements					P07
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Scientific Inquiry and the Nature of Science	Understanding Simple Information	C	1	40	N

The primary reason scientists repeat the measurements they take during experiments is so that they can

- A. check that the equipment is working
- B. list all the results in a table
- C. estimate experimental error
- D. change the experimental conditions

Bacteria/mold experiment					R01
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Scientific Inquiry and the Nature of Science	Investigating the Natural World	B	1	35	N

Alexander Fleming noticed that bacteria growing on a plate of agar did not grow next to a mold that was growing on the same plate. He wrote in his laboratory report: "The mold may be producing a substance that kills bacteria." This statement is best described as

- A. an observation
- B. a hypothesis
- C. a generalization
- D. a conclusion

Appearance of red dress in green light					R02
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Understanding Complex Information	C	1	37	N

As a play begins, white stage lights shine on an actress wearing a red dress. Suddenly, the lights go off and a green light is shone on the actress. The dress looks black. Why does the dress look black?

- A. The dress reflects the green part of light.
- B. The dress absorbs the red part of light.
- C. The dress absorbs the green part of light.
- D. The dress reflects the black part of light.

Two outcomes of introducing new species					R03D
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Understanding Complex Information	Rubric	2	40	N

A new species of fish was released into a lake. State two unwanted outcomes that could arise from the introduction of this new species.

1.

2.

Note: Each of the two outcomes are coded separately. The same code may be used twice, since they are based on general outcome categories. However, if the two outcomes are essentially the same, the second outcome should be coded as 79. If only one outcome is given, the second should be coded as 99.

Code	Response	Item: S022165
	Correct Response	
10	Mentions competition with native species (e.g. overpopulation, eating the limited food supply). <i>Examples: They could eat all the plants the other fish need to survive. The new fishes will overbreed.</i>	
11	Mentions new species introducing diseases (bacteria, parasites, etc.). <i>Examples: This new species could carry viruses which kill off the other fish. They release disease and bacteria.</i>	
12	Mentions effects of predation (new species killing off existing species or vice-versa). <i>Examples: The fish can destroy other species in the water. The new species gets eaten by the fish already in the lake.</i>	
13	Mentions that the new species cannot survive in the lake (extinction due to inhospitable habitat). <i>Examples: They could have trouble adapting and die out. The fish may die out immediately because it is not the right type of water. The new fish might catch a disease in the lake and die.</i>	
14	Mentions upsetting food web or ecological balance. <i>Examples: The species could damage the food web. It could alter the environment. The food chain is disturbed.</i>	
15	Mentions mating with existing species. <i>Examples: Could give rise to new species of fish. The new species might mate with other fish.</i>	
19	Other correct.	
	Incorrect Response	
70	Response too general. <i>Examples: The other fish might not like them. It makes the world change. Upsets everything. They could pollute the lake.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Atmospheric conditions in jets

R04

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Understanding Complex Information	Rubric	1	33	N

Jet aircraft typically fly at altitudes of approximately 10 000 meters. Atmospheric conditions at this altitude are different from those at ground level. Write down one difference that exists and explain why it must be controlled for in order for people to survive inside jet aircraft.

Note: A correct response must include an explanation identifying an atmospheric condition that is different at high altitudes and why it must be controlled for. Responses referencing low oxygen level (too little, less, not enough) with or without explicitly mentioning breathing will be given credit (code 10) due to the assumption of prior knowledge.

Code	Response	Item: S022284
	Correct Response	
10	Refers to controlling for low oxygen level and/or little air ("thin atmosphere") in order to breath. <i>Examples: The higher up you go, the thinner the air gets and the lower the pressure. People are not used to these conditions and cannot breath. At 10 000m there is hardly any air, this needs to be controlled so people can breathe. The difference is less oxygen, making it hard to breath. So they have to supply oxygen. You get less oxygen as you go higher up.</i>	
11	Refers to controlling for low atmospheric pressure with explanation relating to the effect on humans. <i>Example: Air pressure is a lot less at 30,000 feet. If it is not controlled inside the aircraft, the people inside could blow apart because of the pressure difference.</i>	
12	Refers to controlling for low atmospheric temperature. <i>Example: Because you are further from the Earth, the temperature is different, so it must be kept warm in the jet aircraft.</i>	
19	Other correct.	
	Incorrect Response	
70	Mentions pressure, temperature or oxygen with incorrect or no further explanation. <i>Examples: There will be too much pressure on the jet. I think it is the temperature. Air pressure has to be controlled. It's oxygen.</i>	
71	Mentions gravity. <i>Example: The gravity is not so strong that far up. The plane has to be sort of heavy.</i>	
72	Refers only to effects of wind, air currents, or turbulence, etc. <i>Examples: Air currents and turbulence caused by high altitude. Wind. Can make the plane change course.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Small pieces of wood burn faster

R05

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Chemistry	Theorizing, Analyzing and Solving Problems	Rubric	1	24	N

A large log of wood will burn more slowly than the same log chopped into smaller pieces. Explain why.

Note: A correct response is based on the concept of increased surface area in the smaller pieces resulting in faster burning (reaction with oxygen). Credit is given both for higher-level responses indicating increased availability of oxygen/air (Code 10) or surface area (Code 11) in the chopped wood pieces as well as less sophisticated responses describing only that more wood is exposed to the flame and can, therefore, burn simultaneously (Code 12).

Code	Response	Item: S022213
	Correct Response	
10	Mentions that there is more wood (surface area) in contact with oxygen or air in the smaller pieces. [Explicitly mentions availability to oxygen/air.] <i>Examples: The small pieces have more of the wood in contact with oxygen. The oxygen can only attack the log at the surface. The larger log has less surface area. The air can reach the inner surface of wood in the smaller pieces faster.</i>	
11	Mentions effect of increased surface area in the chopped wood pieces. [Explicitly mentions surface area, surface, or area. No mention of oxygen/air.] <i>Examples: The smaller bits have more area exposed. It is because of less surface in the large log.</i>	
12	Mentions that when chopped, more parts of the wood are exposed to flame (ignite, catch fire) and all the small pieces can burn simultaneously. [No explicit mention of oxygen/air or surface area.]	
19	Other correct.	
	Incorrect Response	
70	Refers only to relative rates of burning (burning through). [Does not refer explicitly to surface area, oxygen/air, or simultaneous burning.] <i>Examples: The fire will burn through from the outside faster in the small pieces. The large log is thicker and has more area to burn.</i>	
71	Refers only to the relative rate of ignition (catching on fire, heating up). [Does not refer explicitly to surface area, oxygen/air, or simultaneous burning.] <i>Example: The smaller pieces are easier to light.</i>	
72	Mentions only the need for oxygen/air. [Incorrect/inadequate or no connection to increased availability in chopped wood.] <i>Example: The bigger logs need more oxygen.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Result of global warming					R06
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Environmental and Resource Issues	Understanding Simple Information	A	1	33	N

What is predicted to be a result of global warming?

- A. Rising ocean level
- B. More severe earthquakes
- C. Larger volcanic eruptions
- D. Thinning ozone layer

Conversion of electrical/light energy

X01

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Theorizing, Analyzing and Solving Problems	Rubric	1	8	N

Electrical energy is used to power a lamp. How does the amount of electrical energy used compare to amount of light energy produced?

a) The amount of electrical energy used is:
(Check one)

- ☐ more than the amount of light energy produced.
- ☐ less than the amount of light energy produced.
- ☐ the same as the amount of light energy produced.

b) Give a reason to support your answer.

Note: A correct response must identify **more** and include a correct explanation based on electrical energy being converted to heat (Code 10) or a more general description of energy losses or low efficiency (Code 11). Responses that include explanations based on heat, energy losses or low efficiency but with an incorrect application to the problem by checking **less** are scored as incorrect (Code 72).

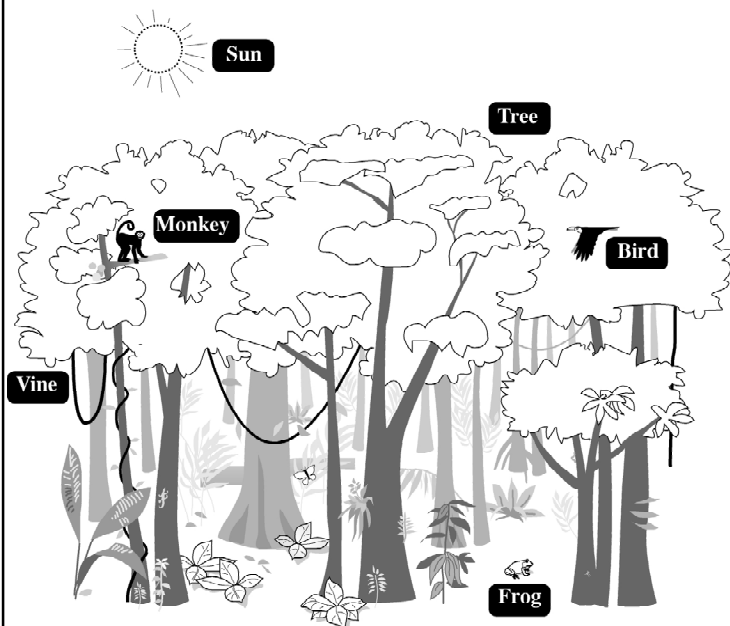
Code	Response	Item: S022282
	Correct Response	
10	MORE. With an explanation based on (much) energy being converted to heat. <i>Examples: More. When a lamp is on it heats up. So some of the electricity goes into heat instead of light.</i> <i>More. Some of the electrical energy is changed into heat energy to make the lamp work and only a small amount of the energy is actually changed into light.</i>	
11	MORE. With other correct explanation of energy (power) loss or low efficiency. [Must clearly indicate that "some" energy goes elsewhere]. <i>Examples: More. Because some of the energy is lost in conversions.</i> <i>More. The lamp is not very efficient, so not all of the electrical energy is changed into light.</i>	
19	MORE. Other correct explanation.	
	Incorrect Response	
70	MORE. Incorrect/inadequate or no explanation. <i>Examples: More. The light gives out lots of energy.</i> <i>More. The people have got to make the electricity first.</i> <i>More. Because of all the electricity from the wall socket.</i>	
71	SAME. Explanation is based on the concept of conservation of energy without considering energy losses. <i>Examples: Same. Energy is always preserved.</i> <i>Same. You cannot create or destroy energy, so it has to be the same.</i>	
72	LESS. Explanation based on heat, energy losses or low efficiency but with an incorrect application. <i>Examples: Less. Some of the electrical energy is changed into heat.</i> <i>Less. The lamp is not very efficient.</i>	
73	LESS. Any other incorrect or no explanation. <i>Examples: Less. Today's lamps do not use up much voltage.</i> <i>Less. It does not take much electricity to power a lamp.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Importance of trees/sun in rain forest

X02A

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Theorizing, Analyzing and Solving Problems	Rubric	1	72	N

In the picture of a rainforest, six objects have been labeled.



Explain why each of the following is important in maintaining the ecosystem in the rainforest.

A. The Tree

B. The Sun

A: Codes for Trees

Note: If student response refers to oxygen/carbon dioxide cycle, use Code 10 even if other reasons are given. If more than one reason is given, assign the code corresponding to the first correct reason, giving priority to Code 10.

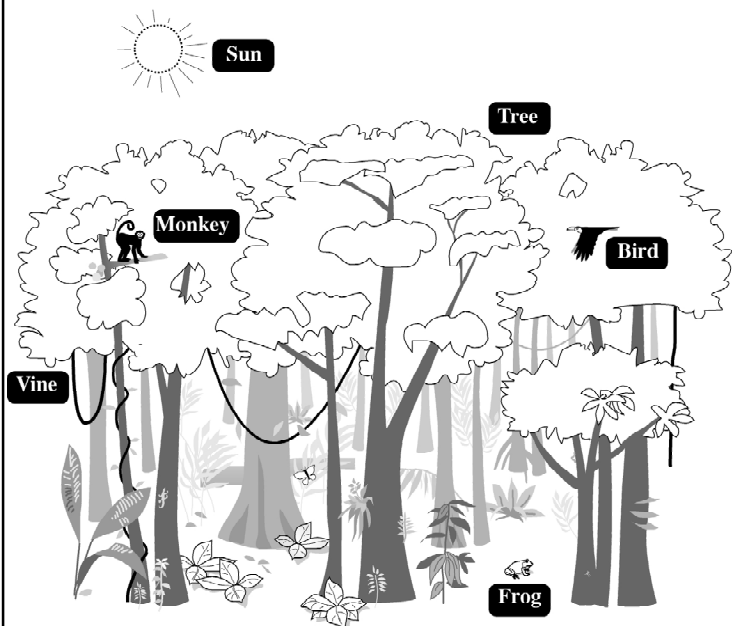
Code	Response	Item: S022172a
	Correct Response	
10	Trees produce oxygen and/or use carbon dioxide. <i>Examples: Trees provide oxygen. Trees are important because the ecosystem needs the oxygen they give off. The trees take in carbon dioxide and give off oxygen which animals need. The trees help the rainforest by turning the carbon dioxide into oxygen. The trees recycle carbon dioxide which animals give out.</i>	
11	Trees provide food or energy. <i>Examples: Food energy for Earth. Trees provide fruit for the animals. Animals eat leaves on trees. Trees provide energy for the ecosystem.</i>	
12	Trees provide a place to hide/shelter. <i>Examples: Trees are important because they give a home for the animals. The trees provide a habitat (for animals). Trees are where the monkeys and birds live.</i>	
13	Trees provide shade or protection from the Sun. <i>Examples: Trees block sunlight to protect animals. It would get too hot in the forest without shade from trees.</i>	
19	Other correct.	
	Incorrect Response	
70	Response too vague. <i>Examples: You need trees for the animals. They are part of the whole ecosystem.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Importance of trees/sun in rain forest

X02B

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Life Science	Theorizing, Analyzing and Solving Problems	Rubric	1	68	N

In the picture of a rainforest, six objects have been labeled.



Explain why each of the following is important in maintaining the ecosystem in the rainforest.

A. The Tree

B. The Sun

B: Codes for Sun

Note: If response refers explicitly to **photosynthesis**, use Code 10 even if other reasons are given. If more than one reason is given, assign the code corresponding to the first correct reason, giving priority to Code 10 and then Code 11.

Code	Response	Item: S022172b
	Correct Response	
10	Sun is needed for photosynthesis (by plants). <i>Examples: The Sun provides light energy for plants so they can grow using photosynthesis. The Sun gives energy to chlorophyll in plants to make photosynthesis.</i>	
11	Sun is needed in order for chlorophyll in plants to produce food. (Does not explicitly mention photosynthesis). <i>Examples: The trees use chlorophyll and make their food from the Sun. Sun gives food to the trees through chlorophyll.</i>	
12	Sun provides energy and/or is needed for plant growth. (No mention of photosynthesis or chlorophyll). <i>Examples: The Sun helps trees stay healthy and strong. The Sun helps things grow and it gives nutrients to the trees. The Sun keeps the trees and all plants living which give us oxygen. The Sun gives energy.</i>	
13	Sun provides heat (warmth) or maintains the temperature. (No mention of photosynthesis or chlorophyll). <i>Examples: The Sun heats the Earth so the plants and animals will not freeze to death. The Sun creates heat that helps animals to grow and the trees to make their food.</i>	
14	Sun provides light and/or enables animals to see. <i>Examples: The Sun is the source of light for plants and animals. The animals need the light from the Sun in order to see.</i>	
19	Other correct.	
	Incorrect Response	
70	Response too vague. <i>Examples: Sun is needed by plants and animals. Everything needs the sun to survive. The Sun is probably the most important part of the ecosystem. It nourishes everything.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Heart rate experiment design

X03

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Scientific Inquiry and the Nature of Science	Investigating the Natural World	Rubric	2	12	N

Suppose you want to investigate how long it takes for the heart rate to return to normal after exercising. What materials would you use and what procedures would you follow?

Note: A fully correct procedure may or may not include a separate materials list in order to receive full credit. If a materials list is not included, then time measurements must be explicitly referenced within the procedure (e.g. 'time how long it takes'). Partial credit is given for responses where one of the criteria for Code 20 is not completely satisfied.

Code	Response	Item: S022288
	Correct Response	
20	Describes a procedure in which: i) Somebody (or self) measures "normal" pulse or heart rate at rest (using a timer or watch). ii) Subject does an exercise (physical activity). iii) The time interval is measured from completion of exercise until pulse rate returns to "normal"	
29	Other fully correct.	
	Partial Response	
10	As in Code 20, but no mention of beginning ('normal') pulse measurement. <i>Example: Materials: watch, clock, person. Make the person ride an exercise bike for 5 minutes and then stop. Time how long it takes for the pulse to return to normal.</i>	
11	As in Code 20, but no mention of measuring the time interval after exercise until pulse returns to normal. <i>Examples: Materials: Watch with stop watch. Take your resting pulse. Exercise vigorously. Then take your pulse until its normal again. Record your pulse. Then exercise for awhile. Stop exercising and record the point when it gets back to the resting rate</i>	
19	Other partially correct with one criteria not completely satisfied.	
	Incorrect Response	
70	No procedure given; only mentions materials. <i>Example: Use a stopwatch, people, exercise equipment.</i>	
71	Describes a minimal procedure not satisfying two or more of the criteria stated in Code 20. <i>Example: Have a person exercise and then take her pulse.</i>	
72	Refers only to how to measure the heart (pulse) rate. <i>Example: You put your finger on your wrist and count for 10 seconds.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Galvanization of steel

Z01A

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Chemistry	Theorizing, Analyzing and Solving Problems	Rubric	1	37	N

A steel manufacturer uses a chemical process called ‘galvanization’ to protect the surface of steel beams that are used to construct high-rise buildings. It takes a crew of steel workers 8 hours to ‘galvanize’ a large batch of steel.

a) Why **MUST** the surface of the steel be protected?

b) A new ‘galvanization’ process is developed that shortens the procedure to 4 hours. Describe two consequences of the steel manufacturer switching to the shorter ‘galvanization’ process.

1.

2.

A: Codes for why steel is galvanized

Note: A correct response must explicitly reference rusting, corrosion, oxidation, or comparable term.

Code	Response	Item: S022217a
	Correct Response	
10	Explicitly refers to rusting, corrosion, or oxidation. <i>Examples: So it does not rust and become weak. So there is no corrosion.</i>	
	Incorrect Response	
70	Mentions only the general structural properties of steel (hardness, strength, durability, etc.). [No mention of rusting, corrosion, oxidation, or equivalent]. <i>Examples: So the building is strong and sturdy. The steel will last longer. When the steel is galvanized it won't get scratched or dented.</i>	
71	Mentions protection from weather, water, air, etc. [No mention of rusting, oxidation, corrosion, or equivalent.] <i>Examples: To keep it from weathering so it does not erode. So that it does not come in contact with rain.</i>	
72	Mentions only protecting the surface (repeats information in stem). <i>Examples: It needs protection, so they galvanize it. It is not good for the surface to not be protected.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Galvanization of steel					Z01D
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Chemistry	Theorizing, Analyzing and Solving Problems	Rubric	2	20	N

A steel manufacturer uses a chemical process called ‘galvanization’ to protect the surface of steel beams that are used to construct high-rise buildings. It takes a crew of steel workers 8 hours to ‘galvanize’ a large batch of steel.

a) Why MUST the surface of the steel be protected?

b) A new ‘galvanization’ process is developed that shortens the procedure to 4 hours. Describe two consequences of the steel manufacturer switching to the shorter ‘galvanization’ process.

1.

2.

Code	Response	Item: S022217
	Correct Response	
10	Mentions that there is more profit (or lower cost) for the manufacturing company. <i>Examples: The faster process cost less money for the company. The company makes more money if it takes less time to galvanize.</i>	
11	Mentions greater efficiency/productivity or that more steel/buildings can be produced (faster). <i>Examples: The faster the steel is galvanized, the more steel can be made. Steel can be produced in half the time. The work can be completed faster. There are more buildings being built.</i>	
12	Mentions unemployment or lower pay for workers. <i>Examples: People will get fired. The steel workers will not make as much money as before.</i>	
13	Mentions any other worker-related consequence. <i>Examples: The steel workers do not have to work as long every day. They are freed up for other jobs. More chances of human error. Everyone will need to be taught the new procedure.</i>	
14	Mentions that the new method might be inferior to the old (shorter process saves time at the expense of quality; unproven method compared to old reliable one). <i>Examples: The new galvanized steel could be lower in quality than the old steel. If the steel is galvanized for a shorter time, it might not be as good for making buildings. The new one might not work as well.</i>	
19	Other correct.	
	Incorrect Response	
70	Mentions only that the new process is shorter or takes 4 hours (less time). [Merely reports information given in stem.] <i>Examples: The new process takes only 4 hours. It is a much shorter process.</i>	

Diagram of rain from sea					Z02
Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Earth Science	Theorizing, Analyzing and Solving Problems	Rubric	2	40	N

Draw a diagram to show how water from the sea can fall as rain on land.

Note: A fully correct response must show clear evidence of the following 4 steps:

- (i) Evaporation of water from the sea
- (ii) Condensation (as clouds)
- (iii) Transportation (from sea to land)
- (iv) Precipitation.

The steps do not have to be indicated on a labeled diagram for full credit, but the drawing and/or accompanying explanatory text must be clear with respect to the direction of water flow. Steps (ii) and (iii) may be clearly indicated as two steps (e.g. formation of clouds and transportation by wind) or as a single step showing a series of clouds extending over land and sea.

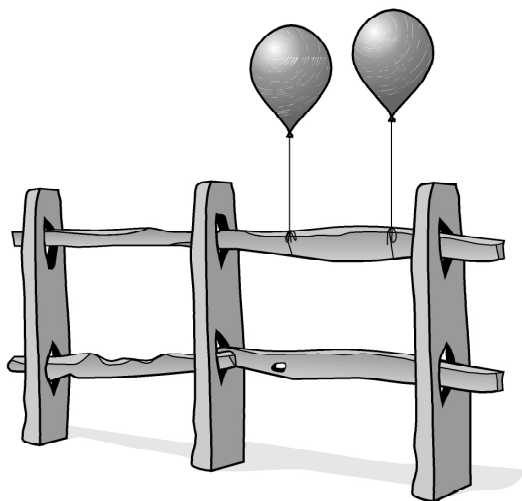
Code	Response	Item: S022090
	Correct Response	
20	Response includes a diagram indicating all 4 steps (i, ii, iii and iv above) and direction of water flow.	
21	No diagram is shown, but response includes a complete and correct textual description of the water cycle. <i>Example: The water evaporates from the sea and forms clouds. Then, when the clouds are blown over the land, it rains.</i>	
29	Other fully correct.	
	Partial Response	
10	As in Code 20 or 21 but evaporation is unclear or omitted.	
11	As in Code 20 or 21 but condensation is unclear or omitted.	
12	As in Code 20 or 21 but transportation is unclear or omitted.	
13	As in Code 20 or 21 but precipitation is unclear or omitted.	
19	Other partially correct.	
	Incorrect Response	
70	Response clearly indicates evaporation and/or condensation only.	
71	Response clearly indicates precipitation only (may also show clouds).	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	

Heat expansion of balloons

Z03

Content Category	Performance Expectation	Item Key	Score Points	International Average Percentage of 8th Grade Students Responding Correctly	Used in 1995
Physics	Theorizing, Analyzing and Solving Problems	Rubric	1	26	N

Balloons filled with helium gas are taken outside on a hot, sunny day and tied to a fence as shown in the diagram.



Over a period of a few hours, the balloons increase in size. Explain why.

Note: A correct response is based on an increase in gas volume (or internal gas pressure) as a result of increased temperature. Credit is given for both higher-level responses relating to the increased kinetic energy of helium atoms as a function of temperature (Code 10) as well as more general responses relating to increased internal gas pressure and/or gas volume (Code 11). An increase in temperature does not have to be explicitly mentioned in order to receive credit. Responses referring ONLY to the **balloon** expanding or to the effect of temperature on the **balloon** without further explanation of the gas behavior are scored as incorrect.

Code	Response	Item: S022048
	Correct Response	
10	Mentions explicitly that (as the gas in the balloon heats up), the helium (gas) atoms (particles, molecules) move faster (collide more frequently) causing the pressure inside the balloon to increase and/or the volume to increase (expand). <i>Examples: As helium is heated the particles move around faster and make the balloon expand. The gas molecules bounce around a lot more when heated, so the volume increases.</i>	
11	Mentions that the pressure of the gas inside the balloon increases and/or the volume of the gas increases (expands). (No mention of gas atoms/molecules). <i>Examples: The balloon expands because of the pressure building up inside. When the heat is added, the gas expands and the balloon stretches. As the temperature goes up, the pressure in the balloon becomes greater than the atmospheric pressure. The volume of gas goes up as the temperature goes up.</i>	
19	Other correct.	
	Incorrect Response	
70	Mentions only that the sun heats the helium (gas) and/or causes the balloon to expand. [No reference to the pressure/volume changes in the gas.] <i>Examples: The heat caused the balloon to expand. The sun heats up the helium and the rubber expands.</i>	
71	Mentions pressure and/or volume with inadequate explanation. <i>Examples: It is because of the great pressure. The volume changes.</i>	
72	Mentions only the effect of heat (from Sun) on the balloon material (rubber, latex). <i>Examples: The heat makes the rubber weaker. The rubber is melted by the sun.</i>	
73	Refers to (individual) atoms or molecules expanding (or growing). <i>Examples: The helium particles grow when they heat up. Because the gas atoms expanded.</i>	
79	Other incorrect (including crossed out/erased, stray marks, illegible, or off task).	
	Nonresponse	
99	BLANK	