

# PHYSICAL SETTING EARTH SCIENCE

Thursday, June 20, 2019 — 1:15 to 4:15 p.m., only

The possession or use of any communications device is strictly prohibited when taking this examination. If you have or use any communications device, no matter how briefly, your examination will be invalidated and no score will be calculated for you.

Use your knowledge of Earth science to answer all questions in this examination. Before you begin this examination, you must be provided with the *2011 Edition Reference Tables for Physical Setting/Earth Science*. You will need these reference tables to answer some of the questions.

You are to answer all questions in all parts of this examination. You may use scrap paper to work out the answers to the questions, but be sure to record your answers on your answer sheet and in your answer booklet. A separate answer sheet for Part A and Part B–1 has been provided to you. Follow the instructions from the proctor for completing the student information on your answer sheet. Record your answers to the Part A and Part B–1 multiple-choice questions on this separate answer sheet. Record your answers for the questions in Part B–2 and Part C in your separate answer booklet. Be sure to fill in the heading on the front of your answer booklet.

All answers in your answer booklet should be written in pen, except for graphs and drawings, which should be done in pencil.

When you have completed the examination, you must sign the declaration printed on your separate answer sheet, indicating that you had no unlawful knowledge of the questions or answers prior to the examination and that you have neither given nor received assistance in answering any of the questions during the examination. Your answer sheet and answer booklet cannot be accepted if you fail to sign this declaration.

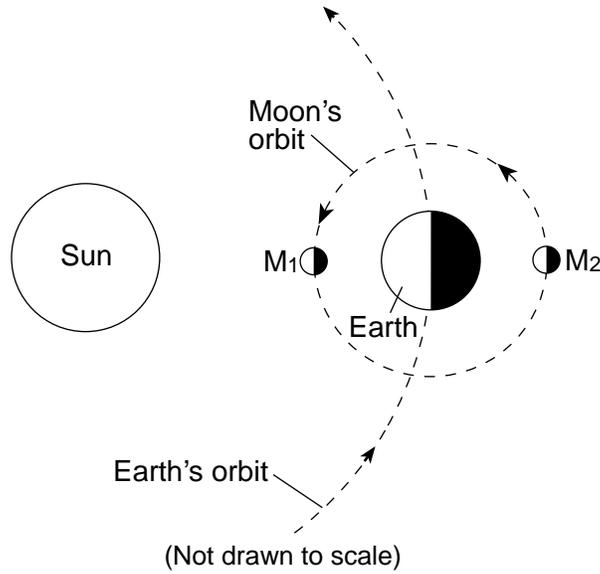
**Notice ...**

A four-function or scientific calculator and a copy of the *2011 Edition Reference Tables for Physical Setting/Earth Science* must be available for you to use while taking this examination.

**DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL THE SIGNAL IS GIVEN.**



3 The diagram below shows Earth in orbit around the Sun, and the Moon in orbit around Earth.  $M_1$  and  $M_2$  indicate positions of the Moon in its orbit where eclipses might be seen from Earth.



Which table correctly matches each type of eclipse with the orbital position of the Moon and the cause of each eclipse?

Type of Eclipse	Moon's Position	Cause of Eclipse
Solar	$M_1$	Earth's shadow falls on Moon
Lunar	$M_2$	Moon's shadow falls on Earth

( 1 )

Type of Eclipse	Moon's Position	Cause of Eclipse
Solar	$M_2$	Earth's shadow falls on Moon
Lunar	$M_1$	Moon's shadow falls on Earth

( 3 )

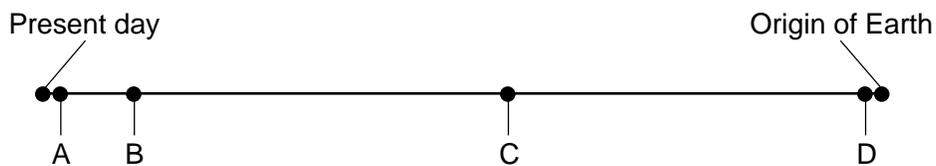
Type of Eclipse	Moon's Position	Cause of Eclipse
Solar	$M_1$	Moon's shadow falls on Earth
Lunar	$M_2$	Earth's shadow falls on Moon

( 2 )

Type of Eclipse	Moon's Position	Cause of Eclipse
Solar	$M_2$	Moon's shadow falls on Earth
Lunar	$M_1$	Earth's shadow falls on Moon

( 4 )

4 The timeline below represents the entire geologic history of Earth. The lettered dots on the timeline represent events in Earth's history.



Which lettered dot best indicates the geologic time when humans first appeared on Earth?

- (1) A
- (2) B

- (3) C
- (4) D

5 Compared to our solar system, the universe is

- (1) younger, smaller, and contains fewer stars
- (2) younger, larger, and contains more stars
- (3) older, smaller, and contains fewer stars
- (4) older, larger, and contains more stars

6 Which motion allows an observer on Earth to view different constellations throughout the year?

- (1) Earth orbiting the Sun
- (2) constellations orbiting Earth
- (3) Earth orbiting the constellations
- (4) constellations orbiting the Sun

7 What is the approximate location of the Tasman Hot Spot in the Pacific Ocean?

- (1) 36° N 160° W
- (2) 36° S 160° E
- (3) 160° N 36° W
- (4) 160° S 36° E

8 Most ozone is found in a region of Earth's atmosphere between 10 and 20 miles above Earth's surface. This temperature zone of the atmosphere is known as the

- (1) thermosphere
- (2) mesosphere
- (3) stratosphere
- (4) troposphere

9 The Coriolis effect, which causes the curving of planetary winds, is a direct result of the

- (1) distance between Earth and the Sun
- (2) inclination of Earth's axis
- (3) orbiting of Earth around the Sun
- (4) spinning of Earth on its axis

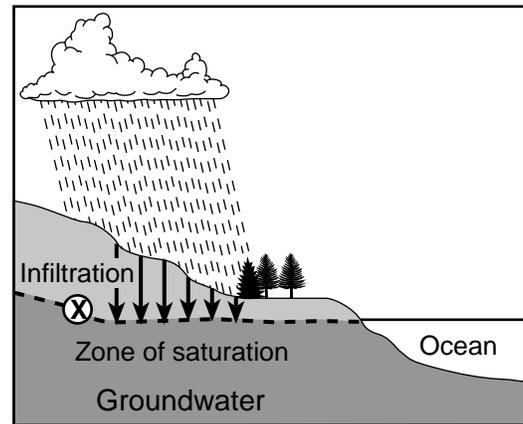
10 What is the dewpoint if the dry-bulb temperature is 18°C and the relative humidity is 64%?

- (1) 14°C
- (2) 11°C
- (3) 9°C
- (4) 4°C

11 When one gram of liquid water at its boiling point is changed into water vapor

- (1) 334 J/g is gained from the surrounding environment
- (2) 334 J/g is released into the surrounding environment
- (3) 2260 J/g is gained from the surrounding environment
- (4) 2260 J/g is released into the surrounding environment

12 The cross section below represents some processes of the water cycle. Arrows represent the infiltration of water. The dashed line labeled X represents the uppermost level of Earth material that is saturated by groundwater.



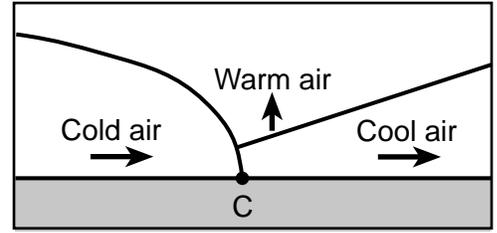
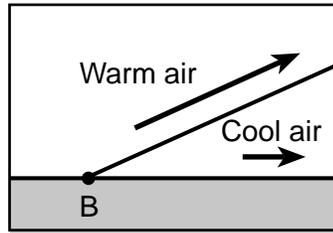
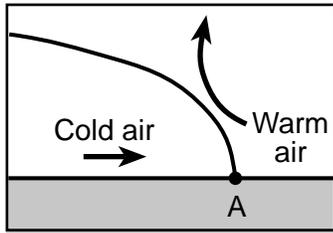
What is indicated by the dashed line labeled X?

- (1) watershed
- (2) water table
- (3) impermeable bedrock
- (4) impermeable soil

13 Which index fossil in sedimentary surface bedrock most likely indicates that a marine environment once existed in the region where the sediments were deposited?

- (1) Mastodont
- (2) Condor
- (3) *Eospirifer*
- (4) *Coelophysis*

14 The three diagrams below represent three frontal boundaries with the surface locations of the fronts labeled A, B, and C. Arrows indicate direction of air movement.



Which table correctly matches each letter with the type of frontal boundary it represents?

Letter	Type of Frontal Boundary
A	Cold Front
B	Warm Front
C	Occluded Front

( 1 )

Letter	Type of Frontal Boundary
A	Cold Front
B	Warm Front
C	Stationary Front

( 3 )

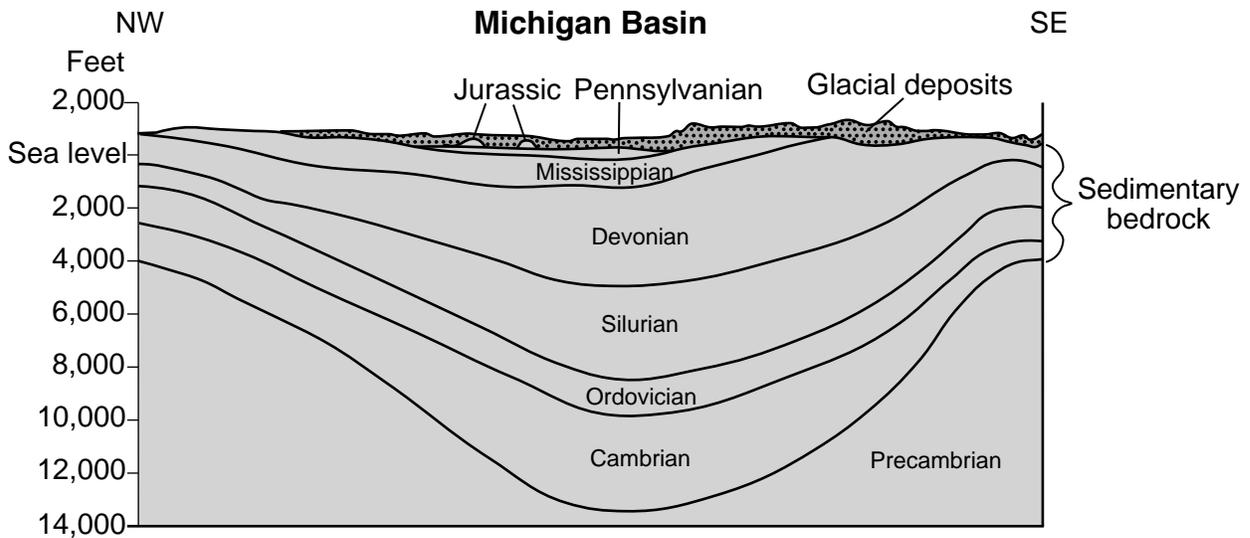
Letter	Type of Frontal Boundary
A	Warm Front
B	Cold Front
C	Occluded Front

( 2 )

Letter	Type of Frontal Boundary
A	Warm Front
B	Cold Front
C	Stationary Front

( 4 )

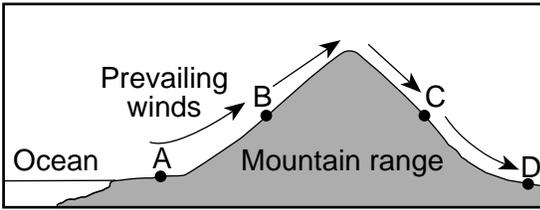
15 The cross section below indicates the geologic ages of the bedrock beneath the state of Michigan. These rocks formed from sediments deposited in an ancient depositional basin. This region is called the Michigan Basin. Glacial deposits cover most of the surface.



Which process most likely caused the formation of the Michigan Basin?

- (1) uplift
- (2) faulting
- (3) metamorphism
- (4) downwarping

- 16 The cross section below represents prevailing winds, shown by arrows, moving over a coastal mountain range. Letters A through D represent locations on Earth's surface.



Which location would most likely have cloud cover and precipitation?

- (1) A (3) C  
 (2) B (4) D
- 17 Which Earth surface would most likely absorb the greatest amount of insolation on a sunny day if all of these surfaces have equal areas?
- (1) blacktop parking lot  
 (2) white sand beach  
 (3) surface of a calm lake  
 (4) snow covered mountain slope

- 18 Most of the infrared radiation given off by Earth's surface is absorbed in Earth's atmosphere by greenhouse gases such as water vapor, carbon dioxide, and
- (1) hydrogen (3) oxygen  
 (2) nitrogen (4) methane

- 19 The X on the map below indicates the region where the state of Washington is located on the present-day North American continent.



During which geologic period was the region of Washington State closest to the equator?

- (1) Cretaceous (3) Mississippian  
 (2) Triassic (4) Ordovician

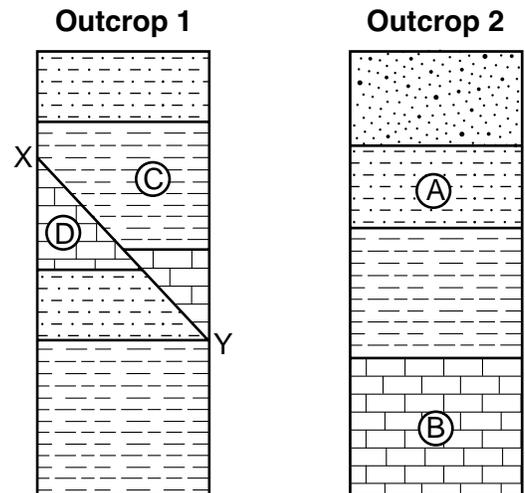
- 20 A climate event that occurs when surface water in the eastern equatorial area of the Pacific Ocean becomes warmer than normal and may cause a warm, dry winter in New York State is

- (1) an air mass formation  
 (2) the Doppler effect  
 (3) an El Niño  
 (4) a monsoon

- 21 In the New York State rock record, there is *no* bedrock from the Permian Period. Which two other entire geologic periods have no sediment or bedrock in the New York State rock record?

- (1) Cretaceous and Quaternary Periods  
 (2) Paleogene and Neogene Periods  
 (3) Triassic and Jurassic Periods  
 (4) Mississippian and Pennsylvanian Periods

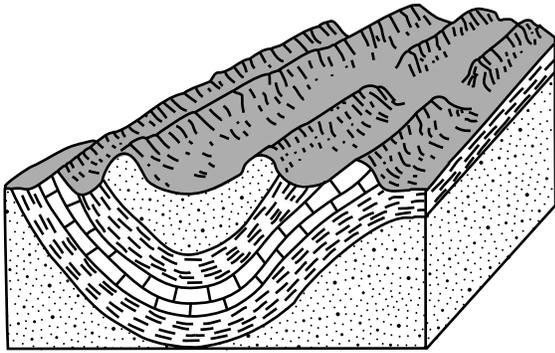
- 22 The cross sections below represent two widely separated bedrock outcrops, 1 and 2. Letters A, B, C, and D identify some rock layers. Line XY represents a fault. The rock layers have *not* been overturned.



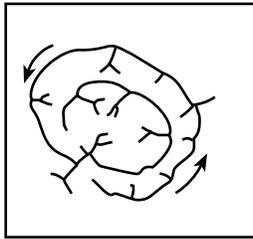
Which lettered rock layer is the youngest?

- (1) A (3) C  
 (2) B (4) D

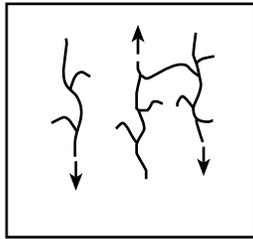
23 The block diagram below represents the surface features in a landscape region.



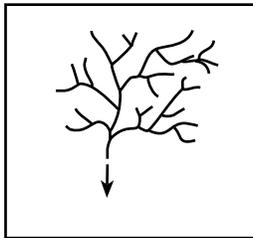
Which diagram best represents the general stream drainage pattern of this entire region?



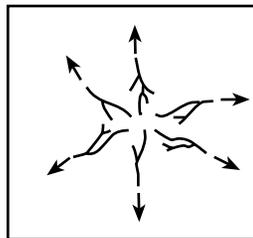
(1)



(3)



(2)



(4)

24 Compared to a landscape that develops in a cool, dry climate, a landscape that develops in a warm, rainy climate will most likely weather and erode

- (1) slower, so the landforms are more angular
- (2) slower, so the landforms are more rounded
- (3) faster, so the landforms are more angular
- (4) faster, so the landforms are more rounded

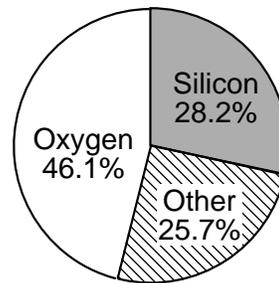
25 Earth's crustal bedrock at the Mid-Atlantic Ridge is composed mostly of

- (1) basalt, with a density of  $2.7 \text{ g/cm}^3$
- (2) basalt, with a density of  $3.0 \text{ g/cm}^3$
- (3) granite, with a density of  $2.7 \text{ g/cm}^3$
- (4) granite, with a density of  $3.0 \text{ g/cm}^3$

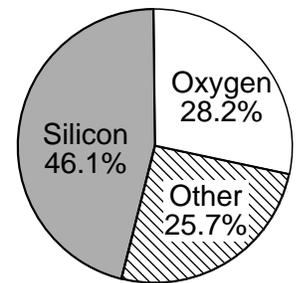
26 A seismic recording station located 4000 kilometers from the epicenter of an earthquake received the first *P*-wave at 7:10:00 p.m. (h:min:s). Other information that could be determined from this recording was that the earthquake occurred at approximately

- (1) 7:03:00 p.m., and the *S*-wave arrived at this station at 7:12:40 p.m.
- (2) 7:03:00 p.m., and the *S*-wave arrived at this station at 7:15:40 p.m.
- (3) 7:17:00 p.m., and the *S*-wave arrived at this station at 7:12:40 p.m.
- (4) 7:17:00 p.m., and the *S*-wave arrived at this station at 7:15:40 p.m.

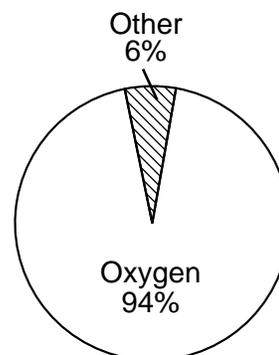
27 Which graph best represents the percentage by mass of elements of Earth's crust?



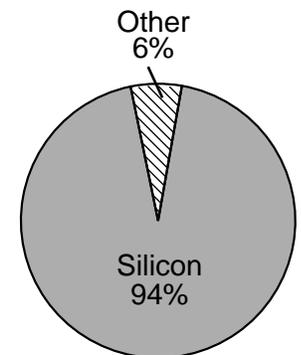
(1)



(3)



(2)



(4)

- 28 The aerial photograph below shows an elongated hill near the Finger Lakes formed by glacial deposition in New York State.



This elongated hill is best identified as a

- (1) kettle (3) sand dune  
 (2) moraine (4) drumlin
- 29 The photograph below shows a valley glacier altering the landscape.



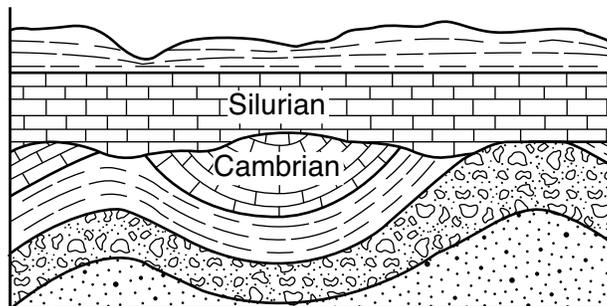
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The result of this glacial action will be a

- (1) U-shaped valley with scratched and grooved bedrock  
 (2) U-shaped valley with well-sorted, rounded sediment  
 (3) V-shaped valley with scratched and grooved bedrock  
 (4) V-shaped valley with well-sorted, rounded sediment
- 30 Which element is always found in bioclastic sedimentary rocks?
- (1) iron (3) carbon  
 (2) sodium (4) sulfur

- 31 What are two major factors that control the development of soil in a given location?
- (1) vegetative cover and slope  
 (2) tectonic activity and elevation  
 (3) erosion and transpiration  
 (4) bedrock composition and climate

- 32 The cross section below represents rock units within Earth's crust. The geologic ages of two of the layers are shown.



Which sequence of geologic events occurred after the formation of the Cambrian limestone and before the formation of the Silurian limestone?

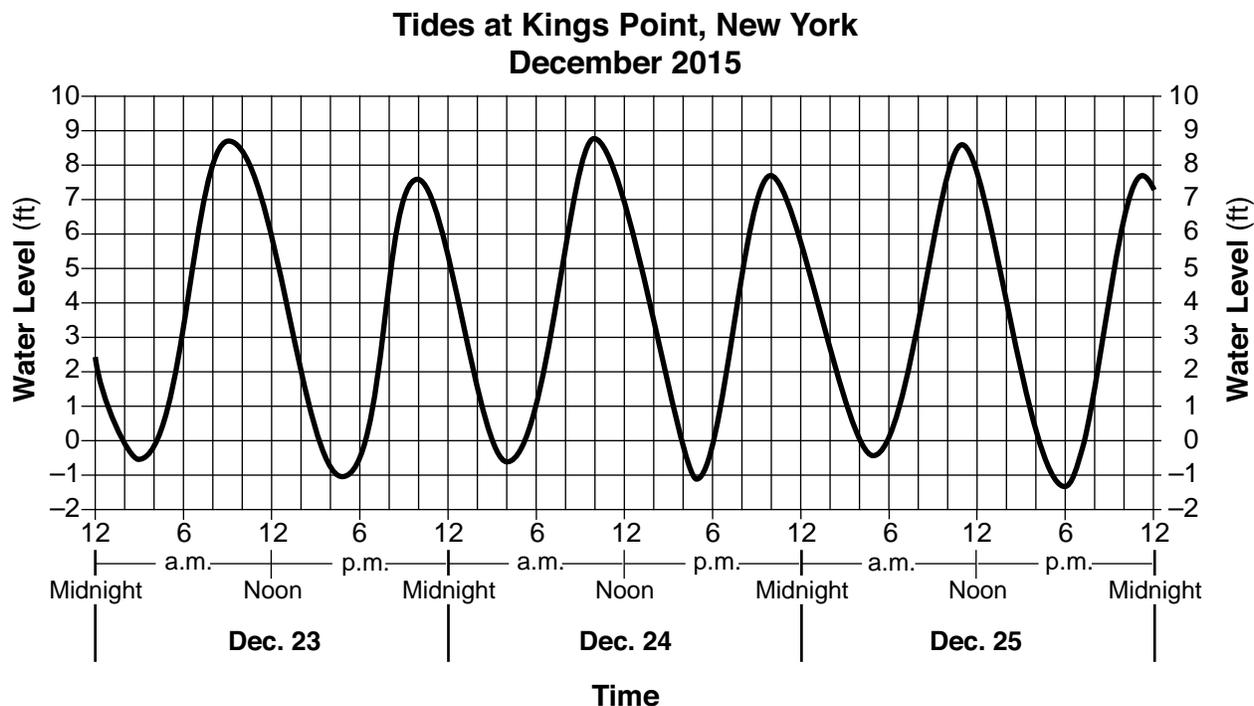
- (1) uplift → weathering → erosion → subsidence  
 (2) uplift → subsidence → erosion → weathering  
 (3) subsidence → weathering → erosion → uplift  
 (4) subsidence → erosion → uplift → weathering
- 33 Which two rocks contain the mineral quartz?
- (1) gabbro and schist  
 (2) dunite and sandstone  
 (3) granite and gneiss  
 (4) pumice and scoria
- 34 Which chemical formula represents the composition of a mineral that usually exhibits fracture, *not* cleavage?
- (1)  $Mg_3Si_4O_{10}(OH)_2$  (3)  $CaCO_3$   
 (2)  $NaCl$  (4)  $(Fe,Mg)_2SiO_4$
- 35 Which mineral is commonly used as the “lead” in pencils?
- (1) pyrite (3) galena  
 (2) graphite (4) fluorite

**Part B-1**

**Answer all questions in this part.**

*Directions (36–50): For each statement or question, choose the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the 2011 Edition Reference Tables for Physical Setting/Earth Science. Record your answers on your separate answer sheet.*

Base your answers to questions 36 and 37 on the graph below and on your knowledge of Earth science. The graph shows changing ocean water levels, over a 3-day period, at a shoreline location at Kings Point, New York on Long Island.



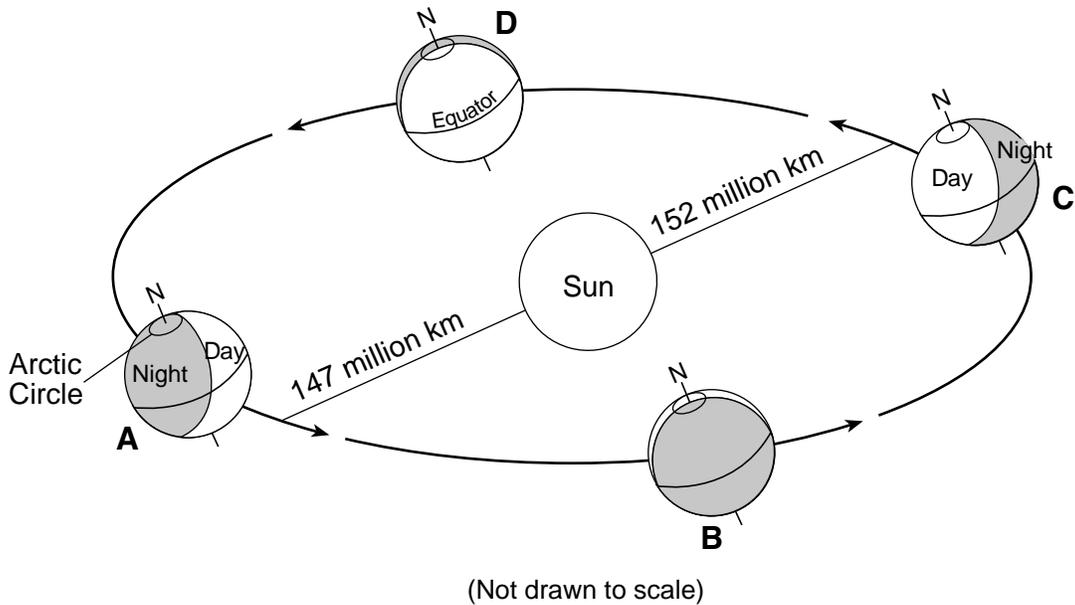
36 Based on the graph, the first low tide on December 26 occurred at approximately

- (1) 6 a.m.
- (2) 11 a.m.
- (3) 6 p.m.
- (4) 11 p.m.

37 These Long Island tides show a pattern that is

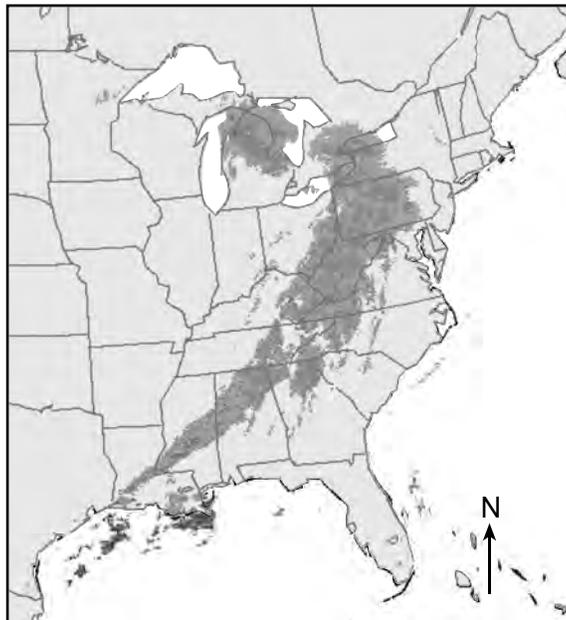
- (1) cyclic and predictable
  - (2) cyclic and unpredictable
  - (3) noncyclic and predictable
  - (4) noncyclic and unpredictable
-

Base your answers to questions 38 through 41 on the diagram below and on your knowledge of Earth science. The diagram represents Earth orbiting the Sun. Four positions of Earth in its orbit are labeled A, B, C, and D. Letter N represents the North Pole. Distances are indicated for aphelion (Earth's farthest position from the Sun around July 4) and perihelion (Earth's closest position to the Sun around January 3). Arrows indicate directions of movement.



- 38 During which season in the Northern Hemisphere is Earth at aphelion?
- |            |            |
|------------|------------|
| (1) winter | (3) summer |
| (2) spring | (4) fall   |
- 39 Between which pair of lettered positions is the Sun's vertical ray moving from the equator southward to the Tropic of Capricorn?
- |             |             |
|-------------|-------------|
| (1) A and B | (3) C and D |
| (2) B and C | (4) D and A |
- 40 Approximately how many times does Earth rotate as it moves in its orbit from position A back to position A?
- |              |               |
|--------------|---------------|
| (1) 1 time   | (3) 24 times  |
| (2) 15 times | (4) 365 times |
- 41 What is the tilt of Earth's rotational axis relative to a line perpendicular to the plane of Earth's orbit?
- |           |           |
|-----------|-----------|
| (1) 15°   | (3) 66.5° |
| (2) 23.5° | (4) 90°   |
-

Base your answers to questions 42 through 44 on the map below and on your knowledge of Earth science. The map shows a composite of Doppler radar images. Darker shadings indicate the precipitation pattern of a large storm system over the eastern United States.

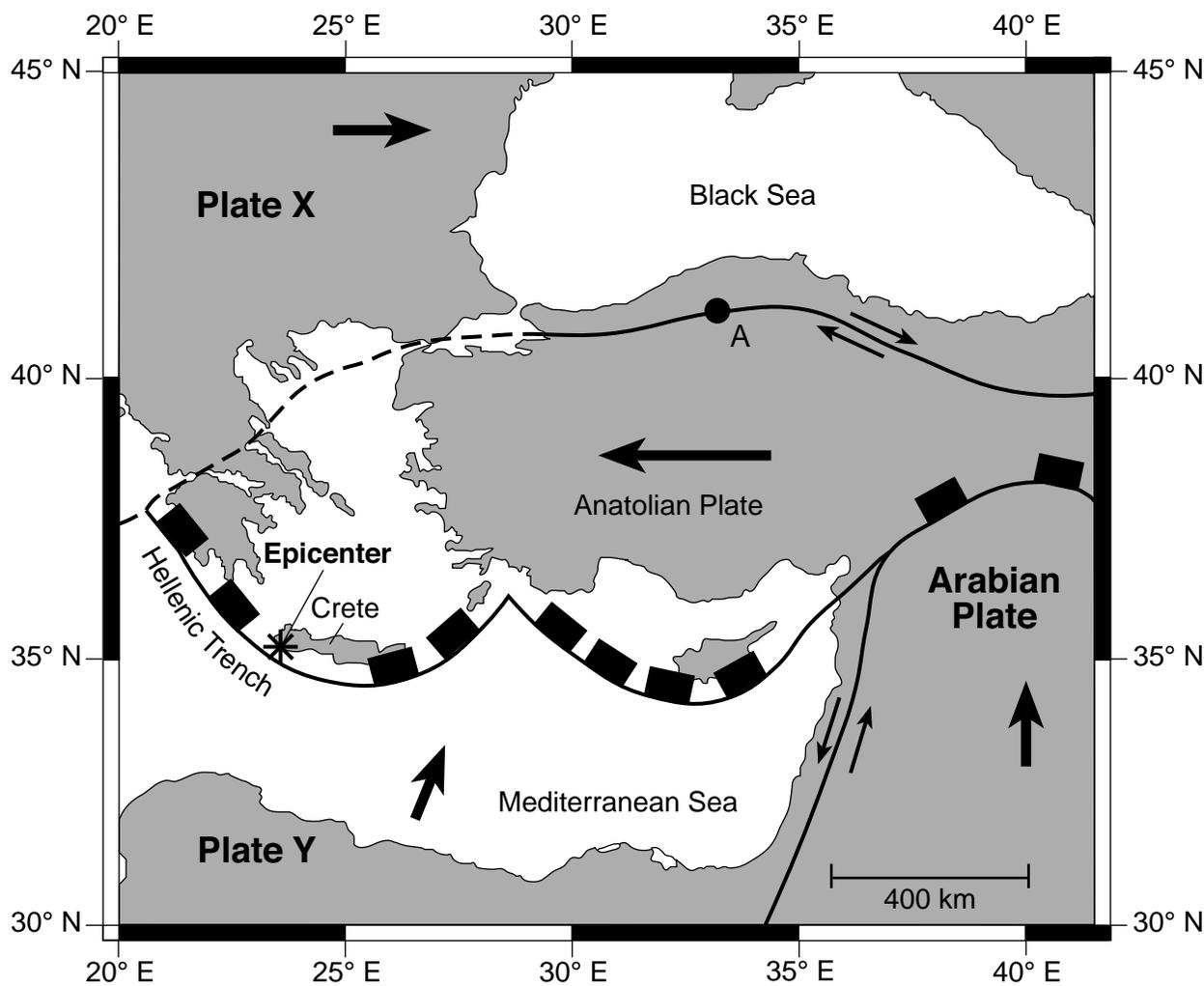


- 42 The surface wind circulation pattern around the center of this storm system is
- |                                 |                                  |
|---------------------------------|----------------------------------|
| (1) inward and clockwise        | (3) outward and clockwise        |
| (2) inward and counterclockwise | (4) outward and counterclockwise |
- 43 The best evidence on a weather map to indicate high-speed winds near the center of this storm system would most likely be
- |                           |                                     |
|---------------------------|-------------------------------------|
| (1) cloud cover of 100%   | (3) temperature and dewpoint values |
| (2) type of precipitation | (4) isobars drawn close together    |
- 44 As this storm system follows a normal storm track, it will most likely move toward the
- |               |               |
|---------------|---------------|
| (1) southeast | (3) northeast |
| (2) southwest | (4) northwest |
-

Base your answers to questions 45 through 48 on the passage and map below and on your knowledge of Earth science. The map shows the location of the epicenter (\*) of a major earthquake that occurred about 1700 years ago. Point A represents a location on a tectonic plate boundary. Plates X and Y represent major tectonic plates. The island of Crete; the Anatolian Plate, which is a minor tectonic plate; and the Hellenic Trench have been labeled. Arrows indicate the relative directions of plate motion.

### Crete Earthquake

Scientists have located the geological fault, off the coast of Crete in the Mediterranean Sea, that likely shifted, causing a huge earthquake in the year 365 that devastated life and property on Crete. The southwestern coastal region of Crete was uplifted, as evidenced by remains of corals and other sea life now found on land 10 meters above sea level. Scientists measured the age of these corals to verify when this event occurred. This earthquake caused a tsunami that devastated the southern and eastern coasts of the Mediterranean Sea. It is estimated that earthquakes along the fault, associated with the Hellenic Trench, may occur about every 800 years.



- 45 Which type of plate boundary is represented at point A?
- |                |               |
|----------------|---------------|
| (1) divergent  | (3) transform |
| (2) convergent | (4) complex   |

- 46 What are the names of the major tectonic plates X and Y?
- (1) X = Eurasian Plate; Y = African Plate
  - (2) X = Eurasian Plate; Y = Arabian Plate
  - (3) X = Indian-Australian Plate; Y = African Plate
  - (4) X = Indian-Australian Plate; Y = Arabian Plate
- 47 Which two New York State index fossils are most closely related to the corals that were radioactively dated in this study?
- (1) *Eucalyptocrinus* and *Ctenocrinus*
  - (2) *Elliptocephala* and *Phacops*
  - (3) *Maclurites* and *Platyceras*
  - (4) *Lichenaria* and *Pleurodictyum*
- 48 Which activity could best prepare residents along the Mediterranean coast to reduce the loss of human life during a future tsunami?
- (1) Board up windows.
  - (2) Remove heavy objects from the walls in homes.
  - (3) Plan evacuation routes to higher ground.
  - (4) Build reinforced basements.
- 

Base your answers to questions 49 and 50 on the photograph below and on your knowledge of Earth science. The photograph shows a sandstone erosional feature that formed near the Grand Canyon, in southwestern United States.



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- 49 Which erosional agent is most likely sandblasting this rock formation?
- (1) wind
  - (2) waves
  - (3) running water
  - (4) moving ice
- 50 What is the range of grain sizes that are most commonly found in rock making up this feature?
- (1) 0.0004 cm – 0.006 cm
  - (2) 0.006 cm – 0.2 cm
  - (3) 0.2 cm – 6.4 cm
  - (4) 6.4 cm – 25.6 cm
-

**Part B–2**

**Answer all questions in this part.**

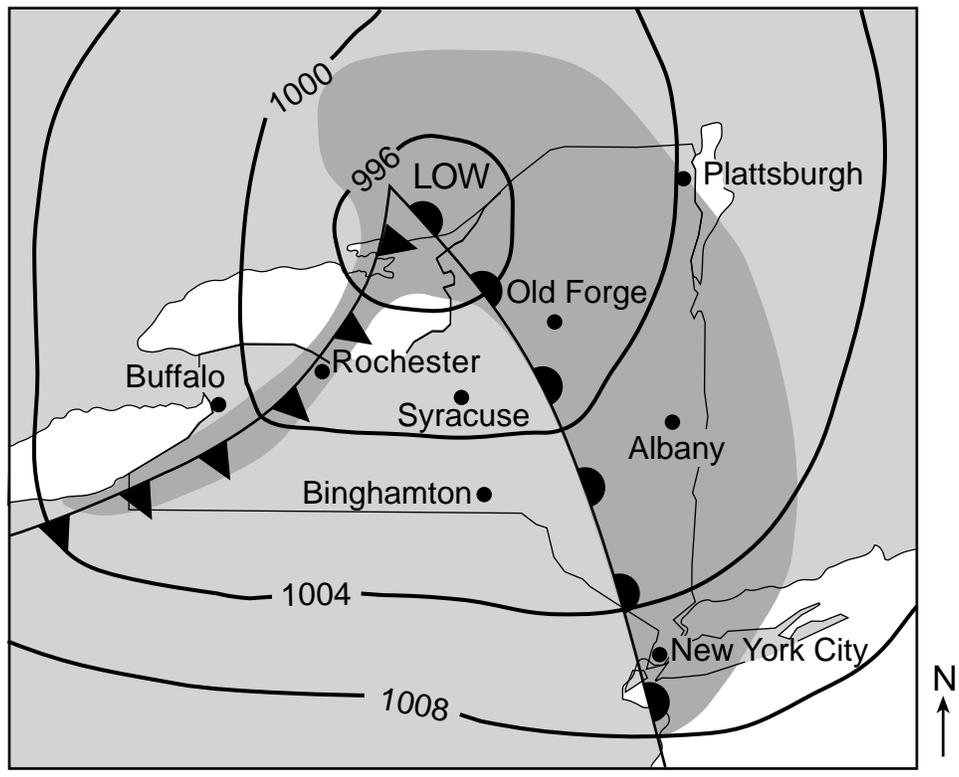
*Directions (51–65):* Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Earth Science*.

Base your answers to questions 51 through 53 on the data table below, on the graph in your answer booklet, and on your knowledge of Earth science. The data table shows the projected percentages of radioactive isotope *X* remaining and its disintegration product *Z* forming over 6.5 billion years. The graph shows the disintegration of radioactive isotope *X*.

<b>Radioactive Isotope X (%)</b>	<b>Disintegration Product Z (%)</b>	<b>Time (billion years)</b>
100	0	0
50	50	1.3
25	75	2.6
12.5	87.5	3.9
6.25	93.75	5.2
3.125	96.875	6.5

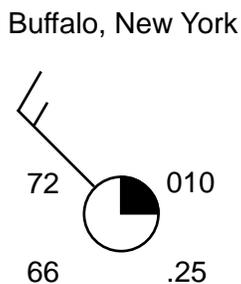
- 51 On the grid *in your answer booklet*, construct a line graph by plotting the percentages of disintegration product *Z* forming over 6.5 billion years. Connect *all six plots* with a line. The percentages of radioactive isotope *X* have already been plotted. [1]
- 52 Identify radioactive isotope *X*. [1]
- 53 Calculate the amount, in grams, of an original 300-gram sample of radioactive isotope *X* remaining after 3.9 billion years. [1]
-

Base your answers to questions 54 through 57 on the weather map below and on your knowledge of Earth science. The map shows the location of a low-pressure system over New York State during summer. Isobar values are recorded in millibars. The darker shading indicates areas of precipitation. Some New York State locations are indicated.



54 Describe the change in air pressure that will most likely occur at Rochester by the time that the cold front has reached Syracuse. Then describe what will most likely happen to the amount of cloud cover in Rochester with this change in air pressure and location of the cold front. [1]

55 The station model below represents the weather conditions at Buffalo, New York, at the time that this map was prepared.



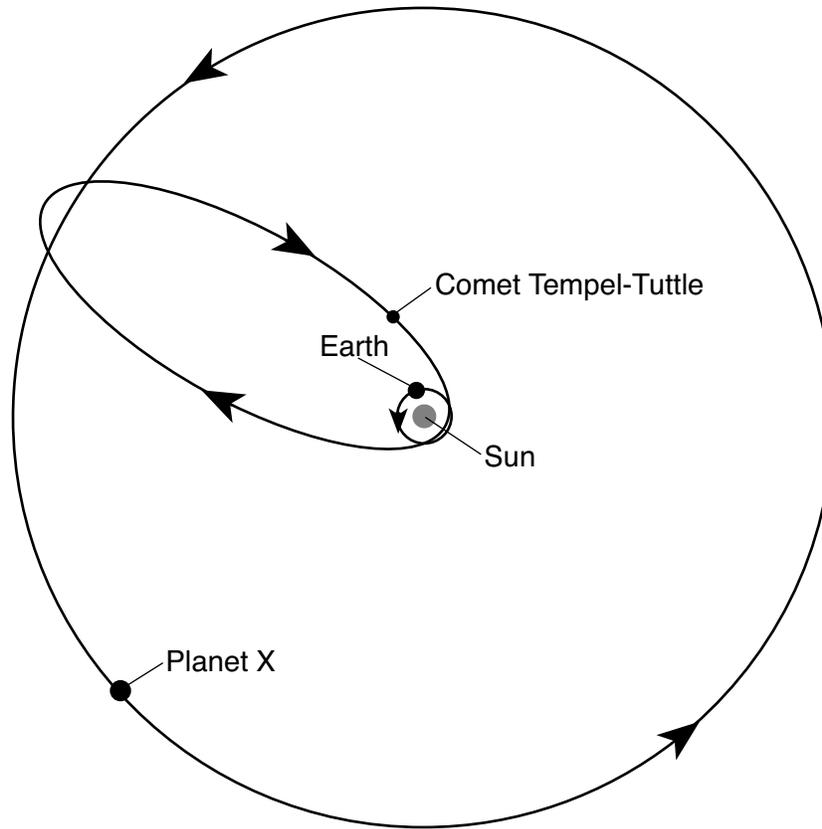
In the table *in your answer booklet*, record the weather data represented on this station model. [1]

56 State the relative humidity at Albany when the air temperature is equal to the dewpoint. [1]

57 Identify the name of the weather instrument used to measure the wind speed at Plattsburgh. [1]

Base your answers to questions 58 through 61 on the diagram and passage below and on your knowledge of Earth science. The diagram represents the orbits of Earth, Comet Tempel-Tuttle, and planet X, another planet in our solar system. Arrows on each orbit represent the direction of movement.

### Orbit of Comet Tempel-Tuttle



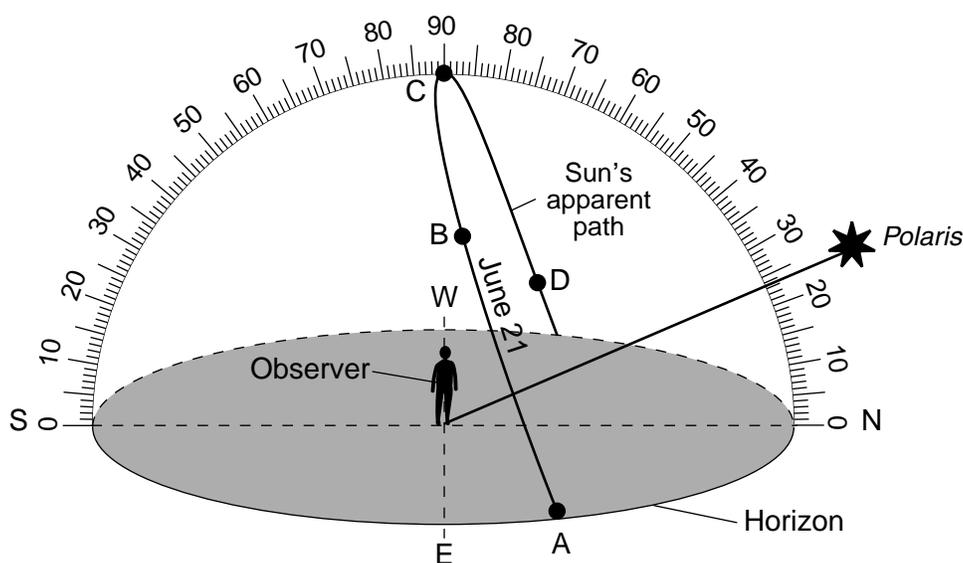
(Not drawn to scale)

### Comet Tempel-Tuttle

Comet Tempel-Tuttle orbits our Sun and is responsible for the Leonid meteor shower event observed from Earth. This meteor shower occurs every year in November and is visible in the night sky as Earth passes through the debris left in space by this comet. The debris from the comet produces meteors that are smaller than a grain of sand, which enter Earth's atmosphere and burn up in the mesosphere temperature zone. Comet Tempel-Tuttle's orbital distance from the Sun ranges from about 145 million kilometers at its closest approach to 2900 million kilometers at its farthest distance. Its two most recent closest approaches to the Sun occurred in 1965 and one revolution later in 1998.

- 58 Identify the name of the object located at one of the foci of the elliptical orbit of Comet Tempel-Tuttle. [1]
- 59 Identify the solar system planet represented by planet X, which orbits near Comet Tempel-Tuttle's farthest distance from the Sun. [1]
- 60 Determine the year in which Comet Tempel-Tuttle will next make its closest approach to the Sun. [1]
- 61 Identify the force that causes debris from the comet to fall through Earth's atmosphere. [1]
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Base your answers to questions 62 through 65 on the diagram below and on your knowledge of Earth science. The diagram represents the apparent path of the Sun across the sky as seen by an observer on Earth's surface on June 21. Points A, B, C, and D represent positions of the Sun at different times of the day. The angle of *Polaris* above the horizon as seen in the nighttime sky is indicated.



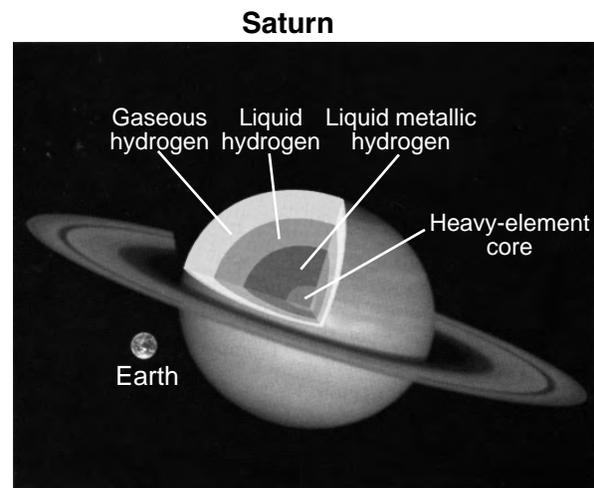
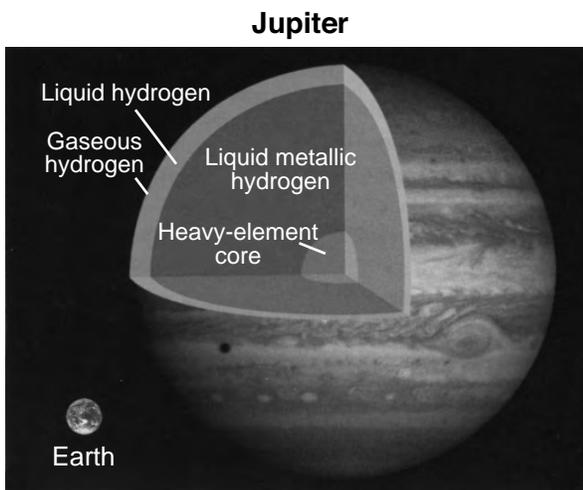
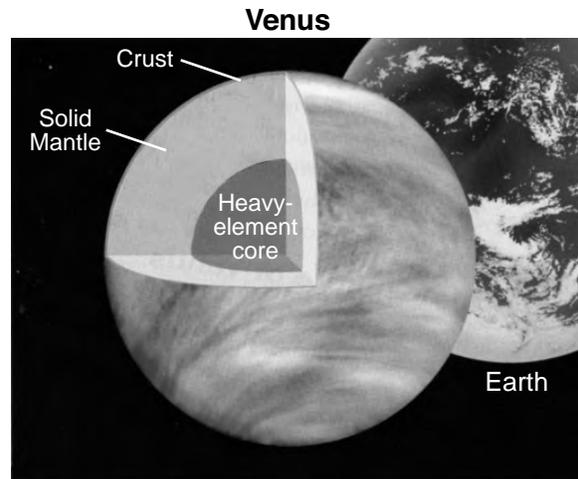
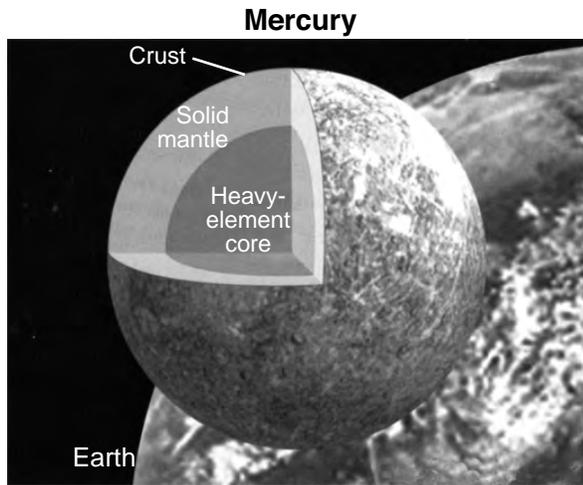
- 62 Describe the changes in the length of the observer's shadow as the Sun appears to move from position A to position D. [1]
- 63 Describe *one* piece of evidence from the diagram that supports the inference that the observer is located at the Tropic of Cancer. [1]
- 64 State the number of daylight hours at this location on September 23. [1]
- 65 The Sun's apparent movement through the sky is caused by Earth's rotation. Identify the device that was used to first demonstrate that Earth rotates. [1]
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## Part C

Answer all questions in this part.

*Directions (66–85):* Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Earth Science*.

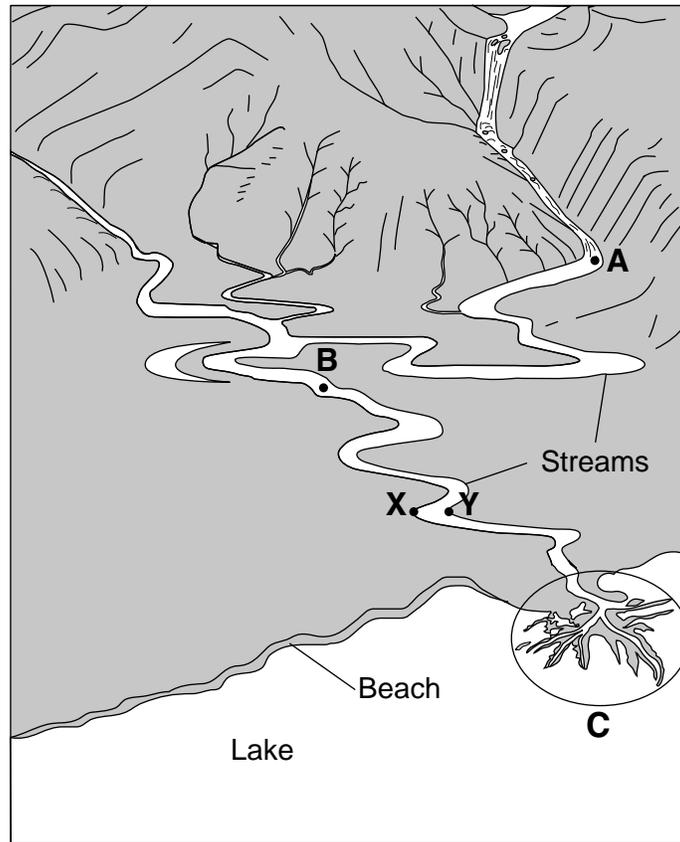
Base your answers to questions 66 through 68 on the models below and on your knowledge of Earth science. The models represent cutaway views of four planets in our solar system, showing their inferred interior structures. Each planet is shown in relation to the size of Earth.



Seeds, Michael and Backman, Dana. 2011. *The Solar System*.

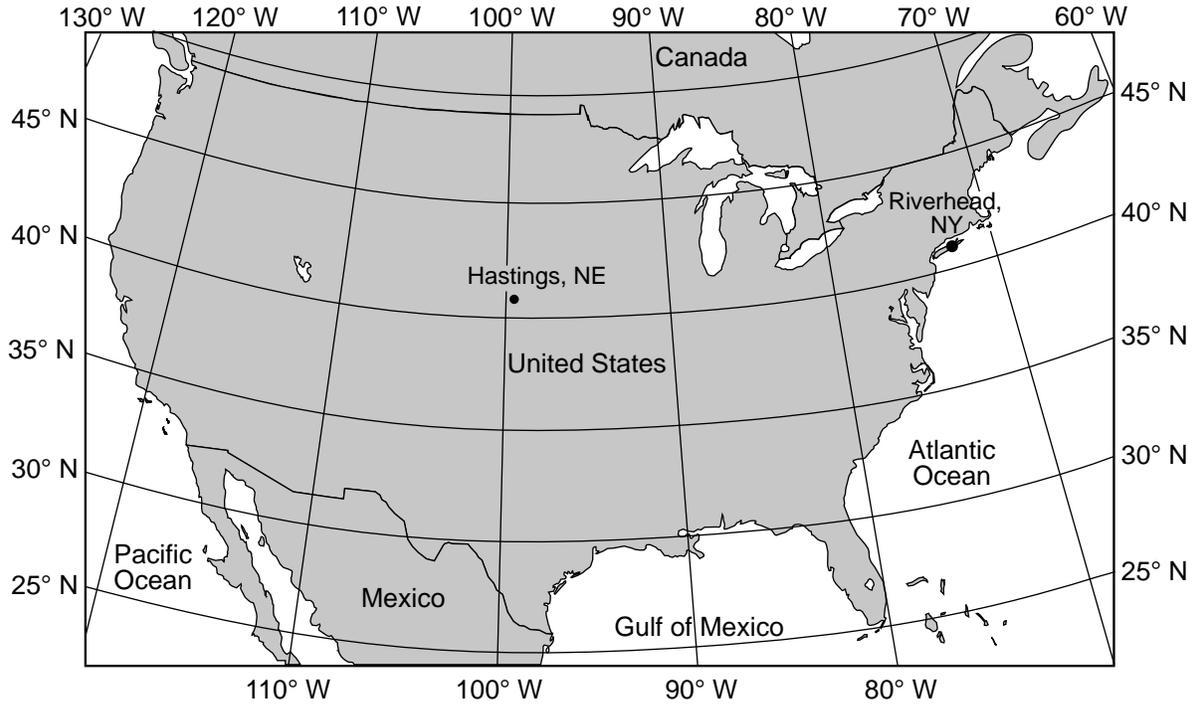
- 66 Determine how many times larger Jupiter's equatorial diameter is, compared to Earth's equatorial diameter. [1]
- 67 Explain why Jupiter appears brighter in the night sky than Mercury, despite Jupiter's greater distance from Earth. [1]
- 68 Identify *two* terrestrial planets shown in the models. Explain why they are considered terrestrial planets. [1]

Base your answers to questions 69 through 72 on the diagram below and on your knowledge of Earth science. The diagram represents several streams converging and eventually flowing into a lake. Points *X* and *Y* indicate locations on either side of a meander in the stream. Points *A* and *B* indicate locations in the streams where the stream discharge was measured in cubic meters per second. The circled region labeled *C* represents a depositional feature.

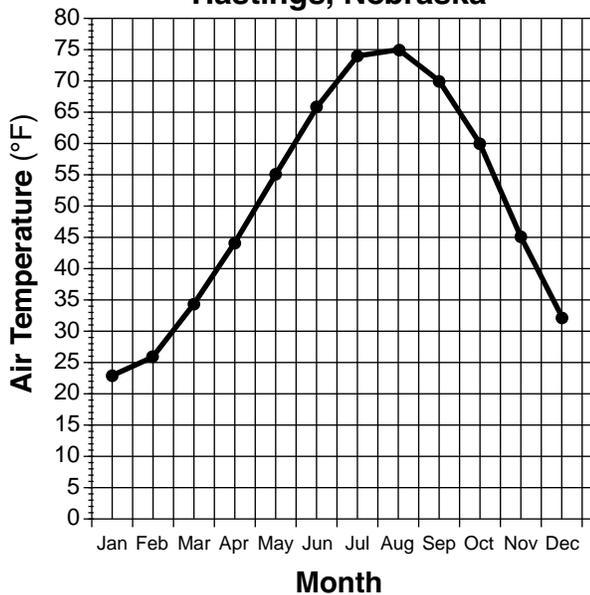


- 69 Identify the name of the depositional feature labeled *C*. [1]
- 70 In the box *in your answer booklet*, draw a cross-sectional view of the general shape of the stream bottom from point *X* to point *Y*. [1]
- 71 Describe how the size and shape of sediments will most likely change as they are transported downstream. [1]
- 72 The stream velocity at location *A* is 100 centimeters per second, and the stream velocity at location *B* is 10 centimeters per second. Identify *one* possible particle diameter that would most likely be deposited between points *A* and *B*. [1]
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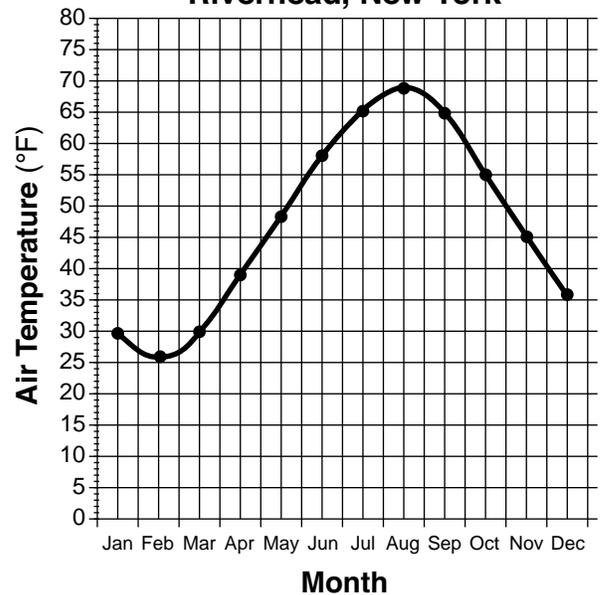
Base your answers to questions 73 through 76 on the map and graphs below and on your knowledge of Earth science. The map shows the locations of two cities, Hastings, Nebraska, and Riverhead, New York. The graphs show average monthly air temperatures for Hastings and Riverhead.



**Average Monthly Air Temperatures  
Hastings, Nebraska**



**Average Monthly Air Temperatures  
Riverhead, New York**



73 Explain why Hastings has a greater annual temperature range than Riverhead. [1]

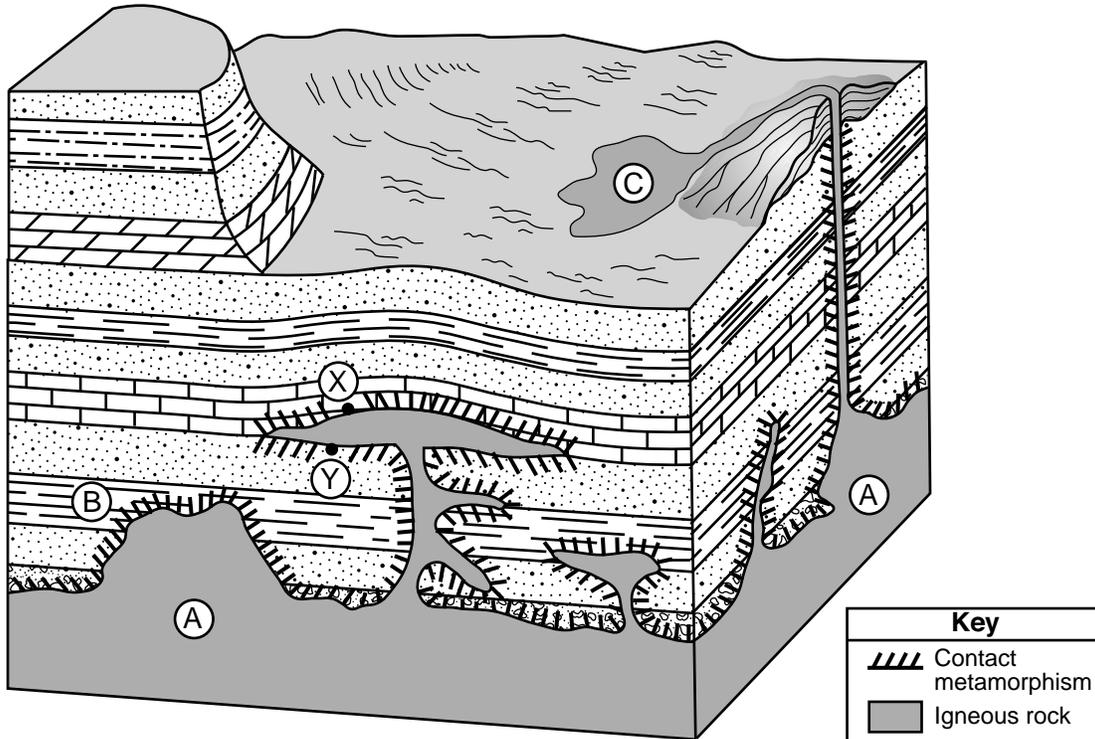
74 Explain why the angle of insolation at both locations is approximately the same at solar noon on any given day. [1]

75 Identify the planetary wind belt that primarily influences the climates of *both* Hastings and Riverhead. [1]

76 Name the ocean current that most likely has the greatest effect on the climate of Riverhead. [1]

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Base your answers to questions 77 through 80 on the block diagram below and on your knowledge of Earth science. The block diagram represents a region of sedimentary rock that has been intruded by magma, which has since solidified. Points *X* and *Y* identify locations at the boundary between the igneous intrusion and surrounding sedimentary rock layers. Letters *A* and *B* represent specific rock units. Letter *C* represents rock formed from the lava flow of the nearby volcano. The rock layers have *not* been overturned.



Adapted from [www.brocku.ca/earthsciences](http://www.brocku.ca/earthsciences)

77 Identify *two* processes that formed the sedimentary rock layers represented in the diagram. [1]

78 Describe *one* piece of evidence shown in the diagram that indicates that rock unit *A* is younger than rock unit *B*. [1]

79 Explain why the igneous rock that formed at location *C* is composed of crystals less than 1 millimeter in size. [1]

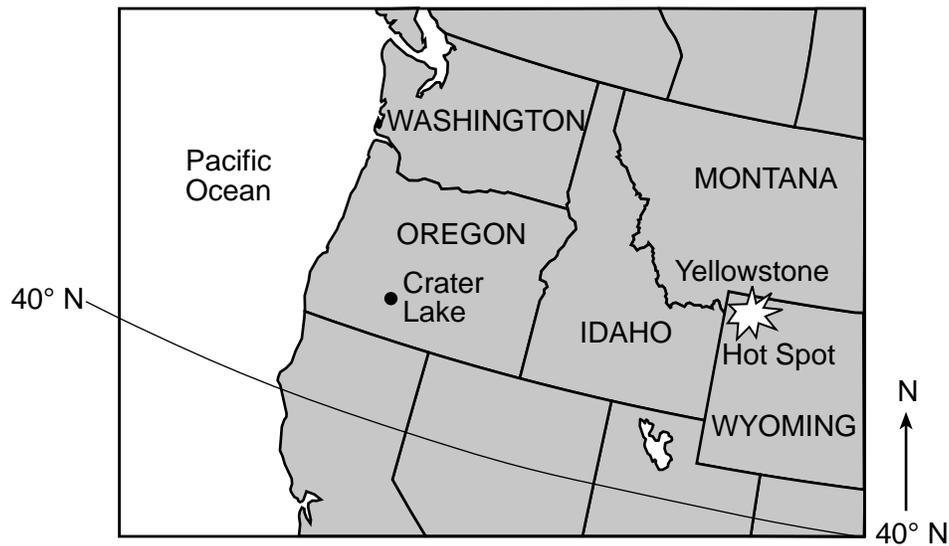
80 State the names of *two different* metamorphic rocks that are most likely found in the zone of contact metamorphism at locations *X* and *Y*. [1]

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Base your answers to questions 81 through 85 on the passage and map below, the field map in your answer booklet, and on your knowledge of Earth science. The map shows the location of Crater Lake in Oregon in the western United States. The field map shows lake depths and some isolines in Crater Lake recorded in meters. Line *AB* and line *CD* are reference lines. Letter *X* represents a location on the lake bottom.

### Crater Lake

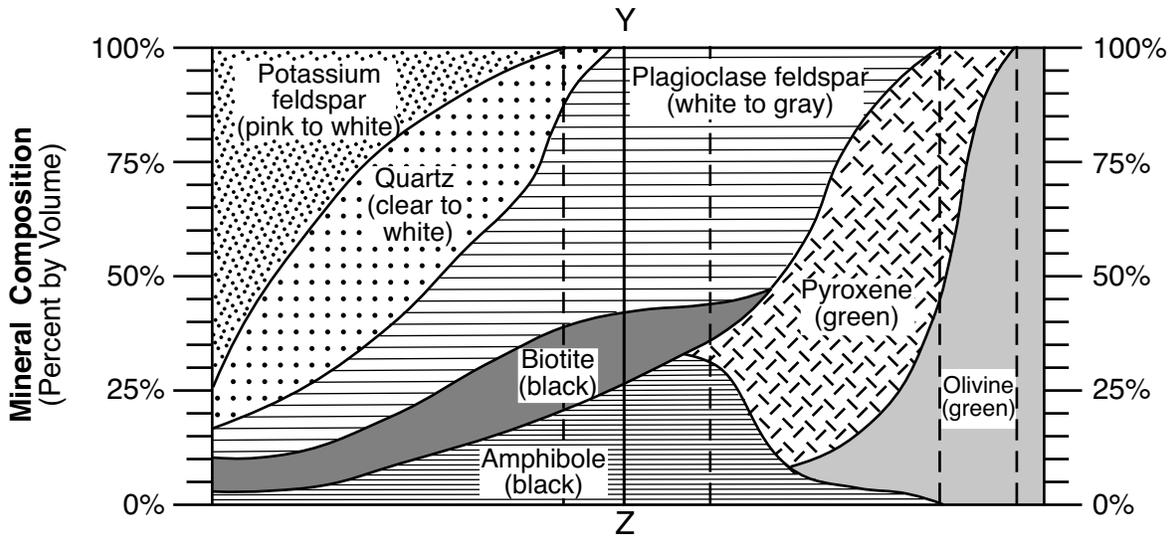
Crater Lake is the deepest lake in the United States. The lake formed in the crater at the top of volcanic Mount Mazama after it exploded in a violent eruption approximately 7700 years ago. The rim of the crater is approximately 2300 meters (7500 feet) above sea level and is mostly composed of the rock andesite. The average yearly air temperature at the lake is 38°F, and snowfall often occurs from October through June. Hydrothermal activity (heating of the water) is ongoing under the lake, indicating that this region is still volcanically active.



- 81 On the field map *in your answer booklet*, draw the 500-meter depth isoline. [1]
- 82 On the grid *in your answer booklet*, construct a profile along line *AB* by plotting the lake depth of each isoline that crosses line *AB*. Connect *all* plots with a line to complete the profile. [1]
- 83 Determine the gradient, in meters per kilometer, between points *C* and *D*. [1]

84 Determine *one* possible depth, in meters, of Crater Lake at location X. [1]

85 Line YZ on the diagram below represents the mineral composition of an andesitic rock taken from the bottom of Crater Lake.



Identify the percent by volume of each of the three minerals in this andesitic rock. [1]

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