

The University of the State of New York  
REGENTS HIGH SCHOOL EXAMINATION

**PHYSICAL SETTING  
EARTH SCIENCE**

**Thursday, January 28, 2016 — 9:15 a.m. to 12:15 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.**

## Part A

### Answer all questions in this part.

*Directions (1–35):* 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.

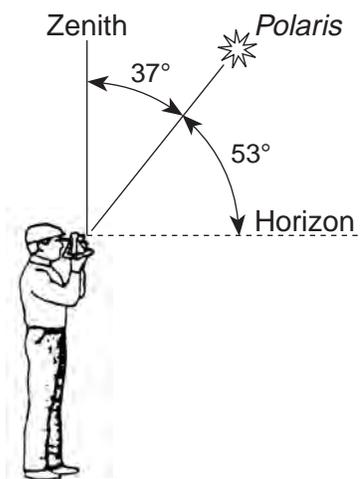
1 The Foucault pendulum and the Coriolis effect both provide evidence of Earth's

- (1) revolution
- (2) rotation
- (3) tilted axis
- (4) elliptical orbit

2 When it is solar noon at a location at  $75^\circ$  W longitude, what is the solar time at a location at  $120^\circ$  W longitude?

- (1) 9 a.m.
- (2) 12 noon
- (3) 3 p.m.
- (4) 12 midnight

3 The diagram below represents an observer measuring the altitude of *Polaris*.



At which latitude is this observer located?

- (1)  $16^\circ$  N
- (2)  $37^\circ$  N
- (3)  $53^\circ$  N
- (4)  $90^\circ$  N

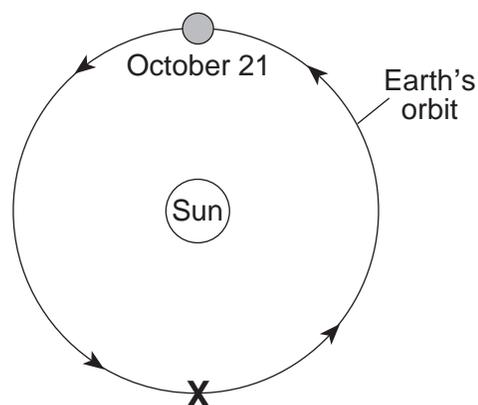
4 Which characteristic of the planets in our solar system increases as the distance from the Sun increases?

- (1) equatorial diameter
- (2) eccentricity of orbit
- (3) period of rotation
- (4) period of revolution

5 New York State's highest peak, Mt. Marcy, is located at approximately

- (1)  $44^\circ 10'$  N  $74^\circ 05'$  W
- (2)  $44^\circ 05'$  N  $73^\circ 55'$  W
- (3)  $73^\circ 55'$  N  $44^\circ 10'$  W
- (4)  $74^\circ 05'$  N  $44^\circ 05'$  W

6 The diagram below represents the orbital position of Earth on October 21.

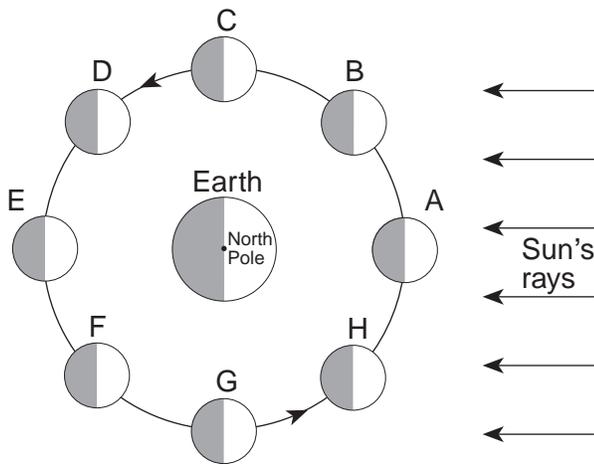


(Not drawn to scale)

Which Northern Hemisphere season is occurring when Earth reaches position X?

- (1) winter
- (2) spring
- (3) summer
- (4) fall

7 The diagram below represents eight positions of the Moon in its orbit.

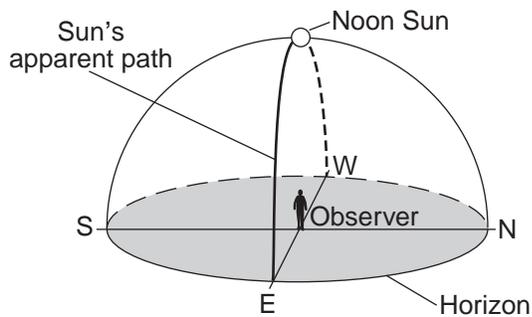


(Not drawn to scale)

Why are high tides on Earth greatest when the Moon is in position A and in position E?

- (1) The Moon is closer to the Sun.
- (2) The Moon is closer to Earth.
- (3) The Moon, the Sun, and Earth are aligned.
- (4) The Moon is in the same phase at both locations.

8 The model below represents the apparent path of the Sun across the sky on March 21 as seen by an observer on Earth.



At which latitude is the observer located?

- (1) 90° N
- (2) 42° N
- (3) 23.5° N
- (4) 0°

9 According to astronomers, the age of the universe is estimated to be

- (1) 1.3 billion years
- (2) 4.6 billion years
- (3) 7.9 billion years
- (4) 13.8 billion years

10 Light from distant galaxies most likely shows a

- (1) red shift, indicating that the universe is expanding
- (2) red shift, indicating that the universe is contracting
- (3) blue shift, indicating that the universe is expanding
- (4) blue shift, indicating that the universe is contracting

11 Which gas is inferred to have been absent from Earth's atmosphere during the Early Archean Era?

- (1) carbon dioxide
- (2) nitrogen
- (3) oxygen
- (4) water vapor

12 How old is a bone that has 12.5% of the original amount of radioactive carbon-14 remaining?

- (1) 5,700 years
- (2) 11,400 years
- (3) 17,100 years
- (4) 22,800 years

13 Which weather instrument is most useful in measuring relative humidity?

- (1) barometer
- (2) anemometer
- (3) psychrometer
- (4) wind vane

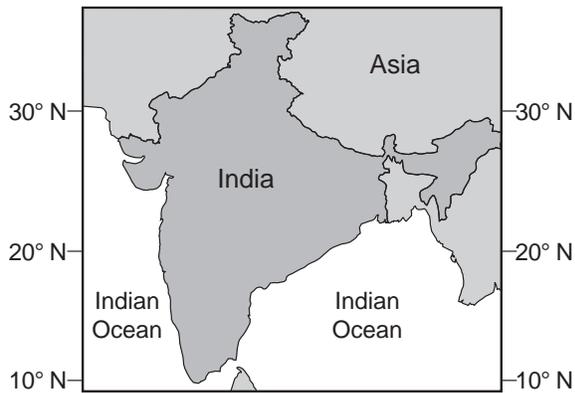
14 If the air temperature is 20°C and the relative humidity is 58%, what is the dewpoint?

- (1) 5°C
- (2) 12°C
- (3) 15°C
- (4) 38°C

15 Equal areas of which type of Earth surface will absorb more insolation and radiate more energy back toward space in the same amount of time?

- (1) light colored and rough
- (2) dark colored and rough
- (3) light colored and smooth
- (4) dark colored and smooth

16 The map below shows the location of India and the Indian Ocean.



Which statement best describes the monsoon winds during the rainy season in India?

- (1) Warm, moist air flows from India to the Indian Ocean.
- (2) Warm, moist air flows from the Indian Ocean to India.
- (3) Cold, dry air flows from India to the Indian Ocean.
- (4) Cold, dry air flows from the Indian Ocean to India.

17 Which ocean current directly warms Western Europe?

- (1) North Atlantic Current
- (2) South Equatorial Current
- (3) Canary Current
- (4) Labrador Current

18 Which group of organisms survived mass extinctions that marked the ends of both the Paleozoic Era and the Mesozoic Era?

- (1) ammonoids
- (2) graptolites
- (3) eurypterids
- (4) gastropods

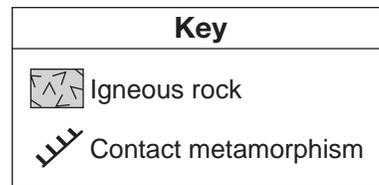
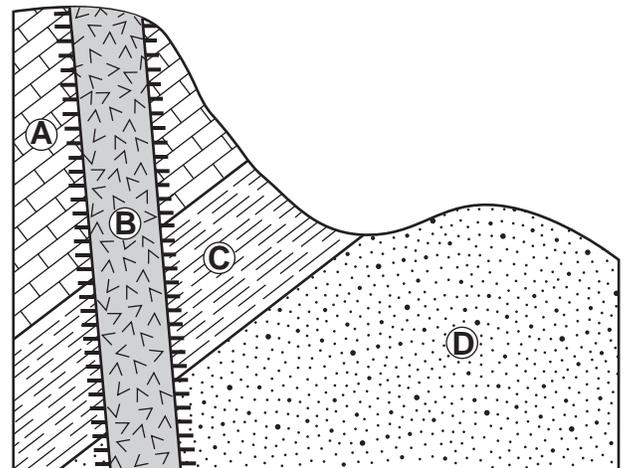
19 In which region of the electromagnetic spectrum is most of Earth's outgoing terrestrial radiation?

- (1) infrared
- (2) visible
- (3) ultraviolet
- (4) x rays

20 Most scientists infer that increasing levels of carbon dioxide in Earth's atmosphere are contributing to

- (1) decreased thickness of the troposphere
- (2) depletion of ozone
- (3) increased absorption of ultraviolet radiation
- (4) increased global temperatures

21 The bedrock cross section below contains rock formations A, B, C, and D. The rock formations have *not* been overturned.



Which sequence represents the relative ages of these rock formations, from oldest to youngest?

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

22 A volcanic ash layer between sedimentary rock layers is used by geologists to

- (1) determine Earth's absolute age
- (2) predict global warming
- (3) locate an earthquake epicenter
- (4) correlate widely separated rock formations

23 The satellite photograph below shows the Mississippi River entering into the Gulf of Mexico. Arrows show the direction of river flow.



This depositional feature in the Gulf of Mexico is best identified as

- (1) a delta
- (2) a sandbar
- (3) a barrier island
- (4) an outwash plain

24 Examination of the fossil record shows a general tendency of organisms to become increasingly more complex through geologic time. This finding supports the theory that living things have undergone

- (1) metamorphism
- (2) evolution
- (3) radioactive decay
- (4) mass extinctions

25 Crustal formation, which may cause the widening of an ocean, is most likely occurring at the boundary between the

- (1) African Plate and the Eurasian Plate
- (2) Pacific Plate and the Philippine Plate
- (3) Indian-Australian Plate and the Antarctic Plate
- (4) South American Plate and the North American Plate

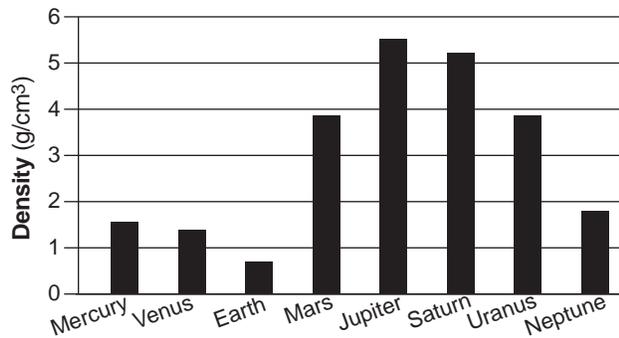
26 How long after receiving the first *P*-wave from an earthquake centered 4000 kilometers away does a seismic station receive its first *S*-wave from the same earthquake?

- (1) 1 minute
- (2) 5 minutes 35 seconds
- (3) 7 minutes
- (4) 12 minutes 40 seconds

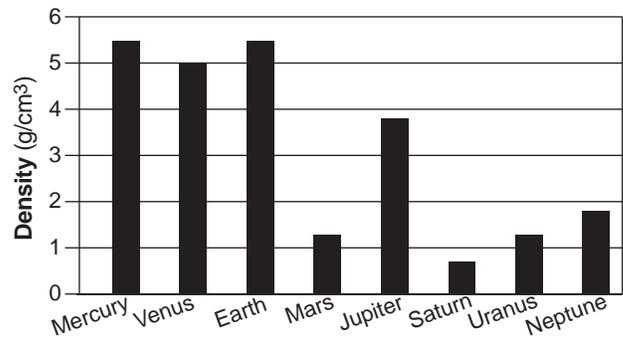
27 Which evidence recorded at seismic stations following an earthquake supports the inference that Earth's interior changes from solid rock to molten iron and nickel at the mantle-core boundary?

- (1) *P*-waves arrive earlier than *S*-waves.
- (2) *P*-waves and *S*-waves are both recorded at all stations.
- (3) Only *S*-waves are recorded at all stations.
- (4) Only *P*-waves are recorded on the opposite side of Earth.

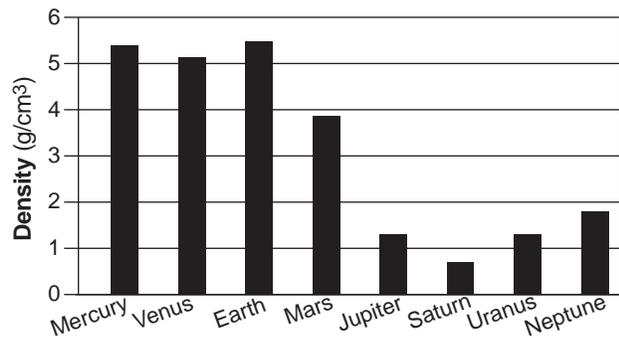
28 Which graph best indicates the densities of the planets in our solar system?



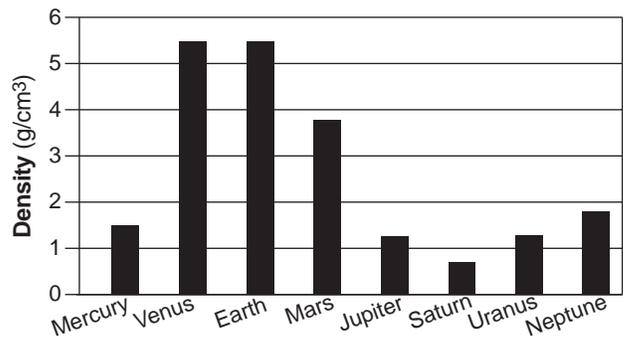
(1)



(3)

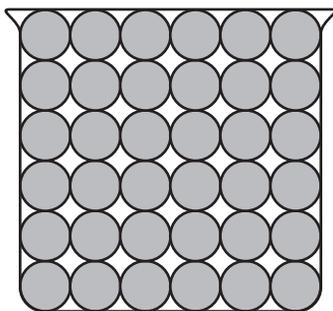


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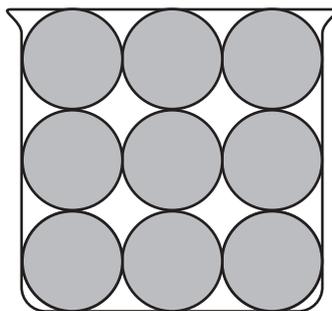


(4)

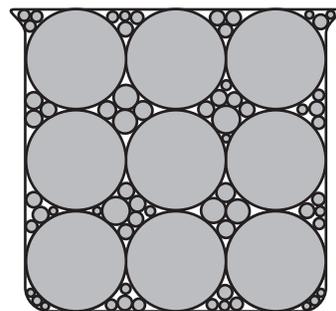
29 The diagram below represents cross sections of equal-size beakers A, B, and C filled with beads.



A



B

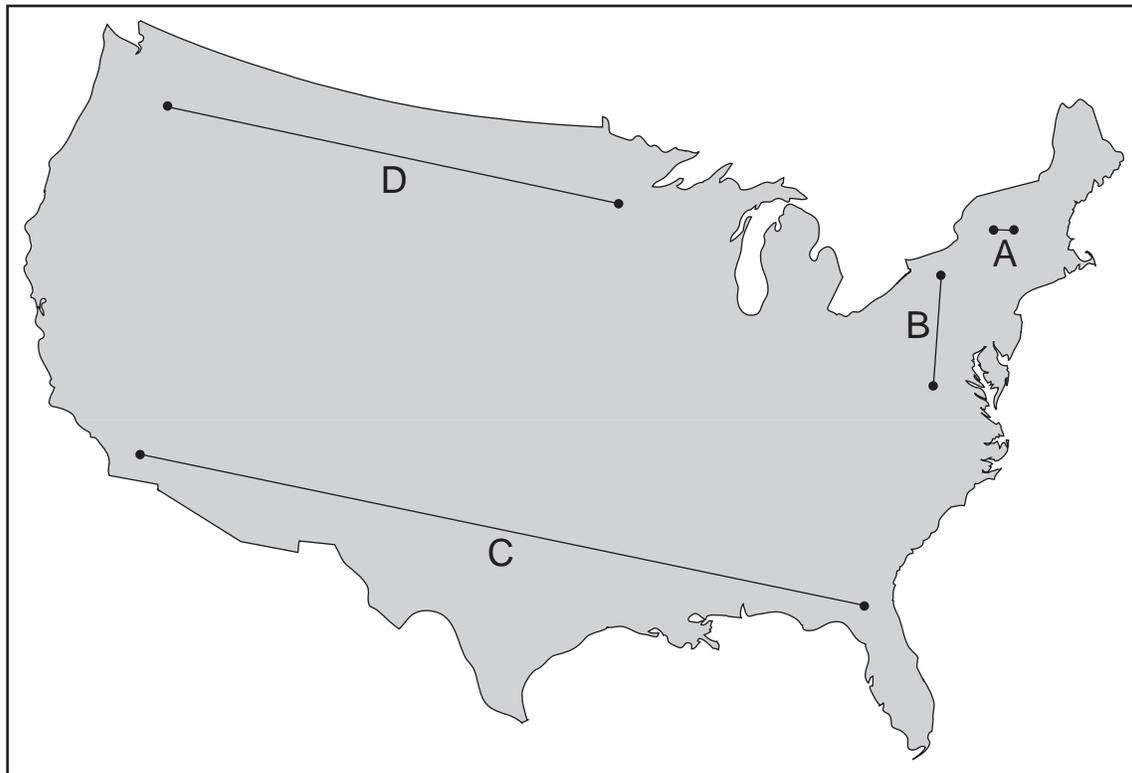


C

Which statement best compares the porosity in the three beakers?

- (1) Beaker A and beaker B have the same porosity, and beaker C has the least porosity.
- (2) Beaker A and beaker B have the same porosity, and beaker C has the greatest porosity.
- (3) Beaker B has the greatest porosity, beaker A has less porosity, and beaker C has the least porosity.
- (4) Beaker C has the greatest porosity, beaker B has less porosity, and beaker A has the least porosity.

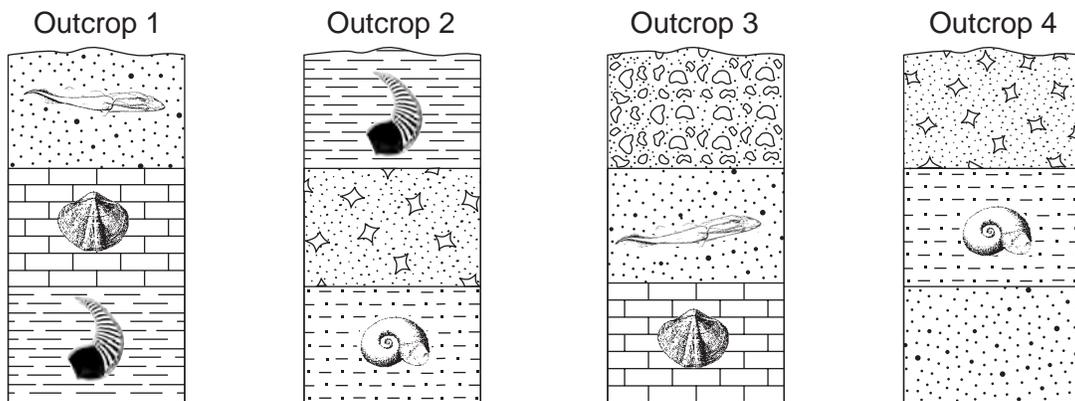
30 On the map of the United States shown below, four lines have been drawn and labeled A, B, C, and D.



The length of which line best represents the distance from Earth's surface to the top of the mesosphere?

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

31 Four rock outcrops, labeled 1, 2, 3, and 4, found within the same plateau, are represented below. Index fossils found in some of the rock layers are shown. The rock layers have *not* been overturned.



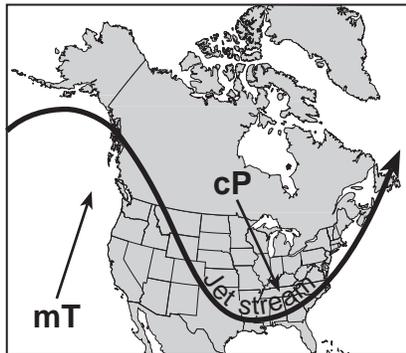
Which rock layer is the youngest?

- (1) sandstone in outcrop 1
- (2) breccia in outcrop 2
- (3) conglomerate in outcrop 3
- (4) sandstone in outcrop 4

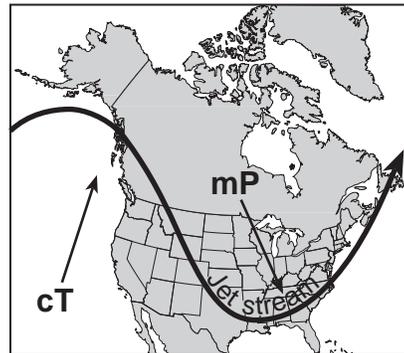
32 The map below shows a position of the polar jet stream over North America in January.



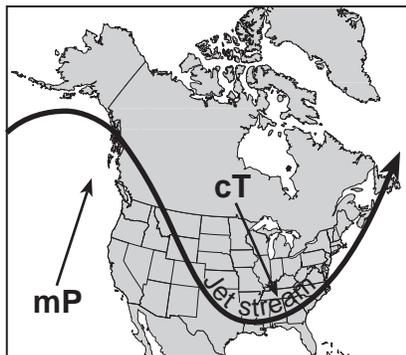
Which map best shows the air-mass movements associated with this jet stream position?



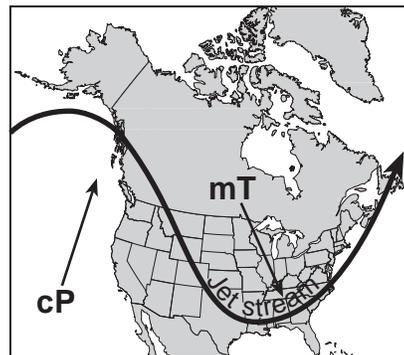
(1)



(3)

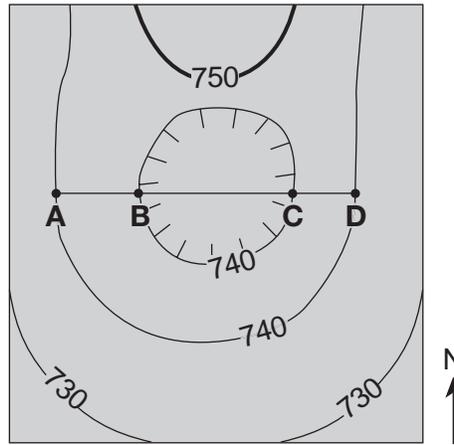


(2)



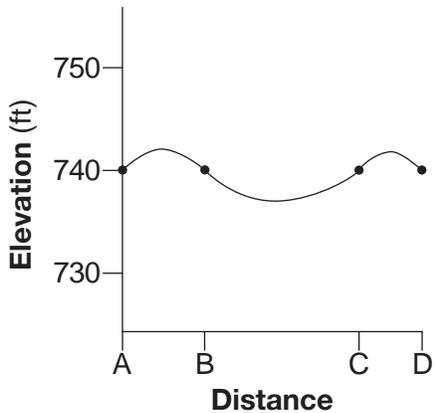
(4)

33 The topographic map below shows a depression contour line (⊖) on Earth's surface. Points A, B, C, and D represent surface locations. Contour line elevations are in feet.

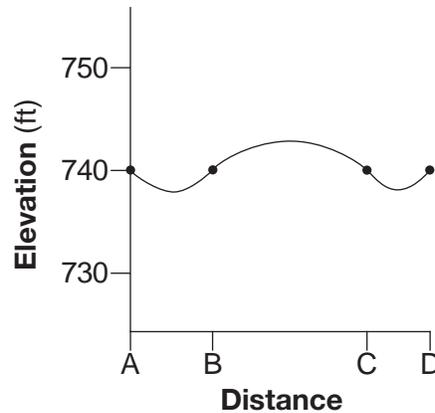


Contour interval = 10 ft

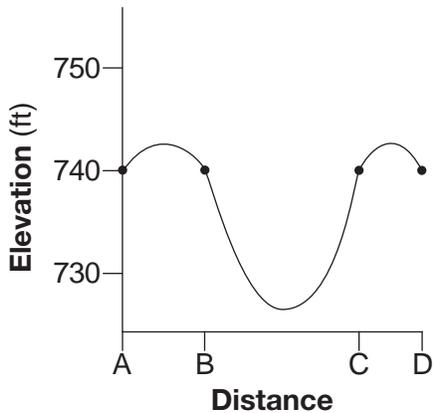
Which profile best shows the topography along line AD?



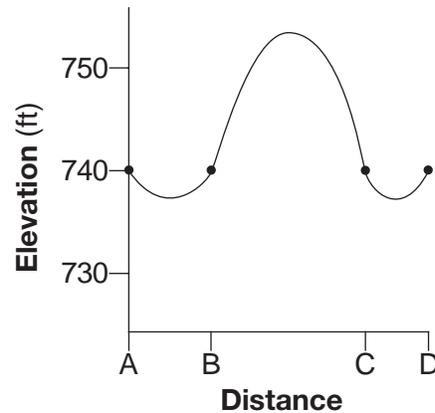
(1)



(3)



(2)



(4)

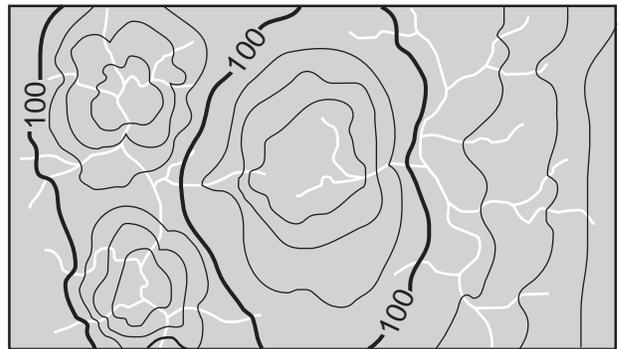
34 The map below shows part of a stream drainage pattern.



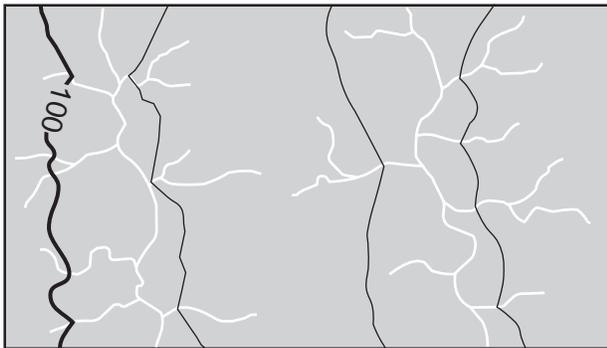
Which topographic map best shows the contour lines for this stream drainage pattern?



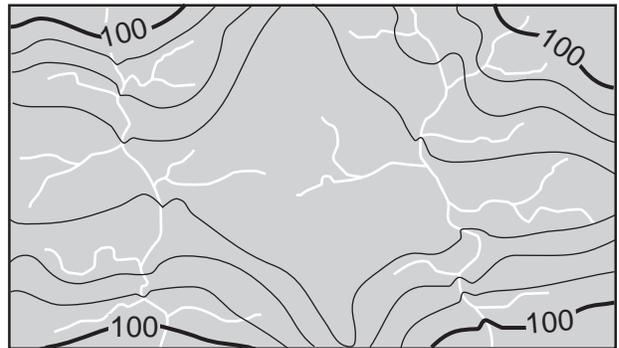
(1)



(3)



(2)

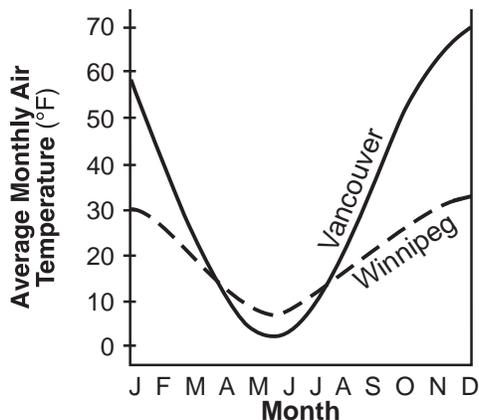


(4)

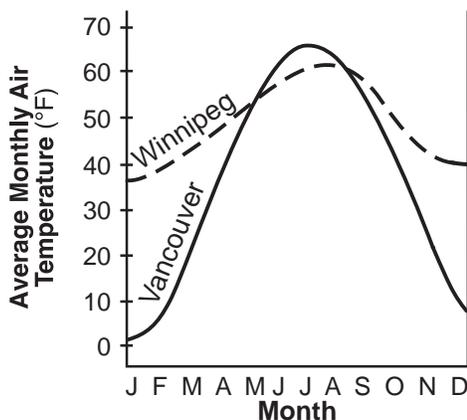
35 The map below shows a portion of the western United States and Canada. Two cities in Canada, Vancouver and Winnipeg, are labeled on the map.



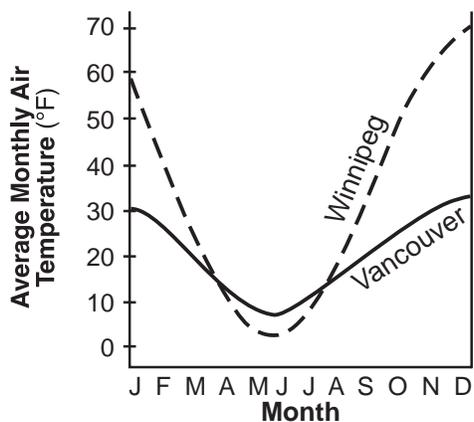
Which graph best represents the average monthly air temperatures for Vancouver and Winnipeg?



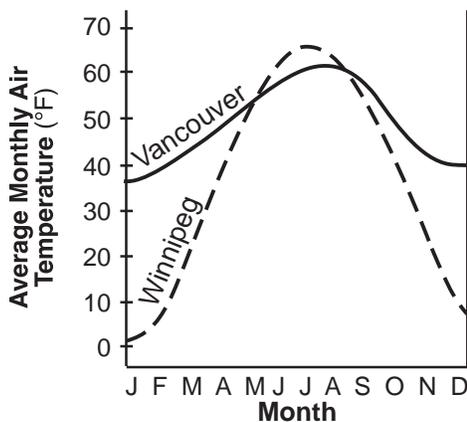
(1)



(3)



(2)



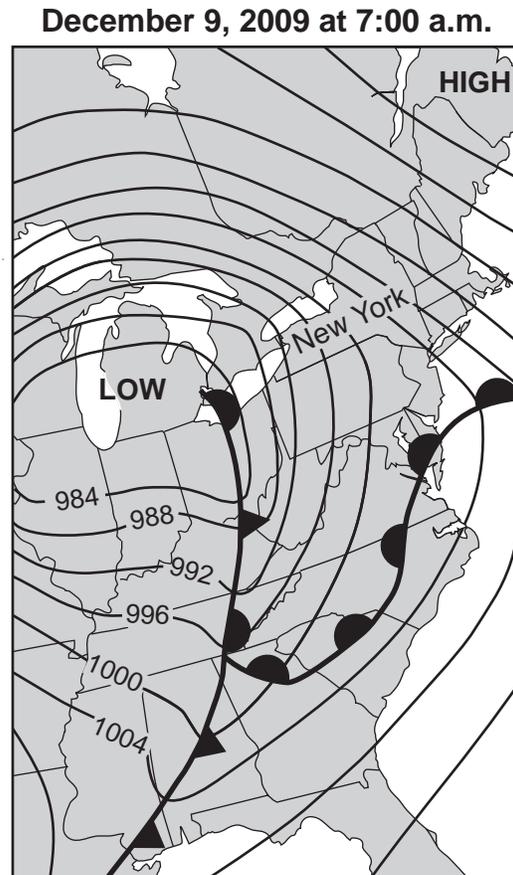
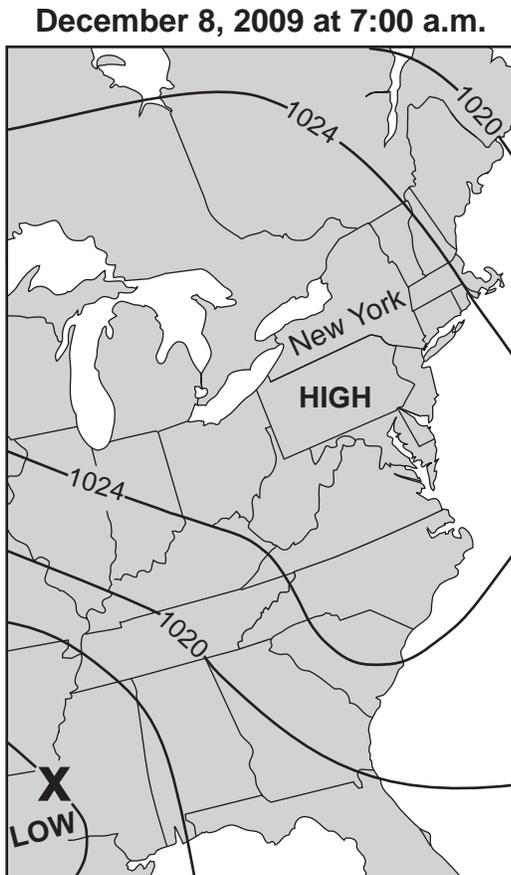
(4)

**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.*

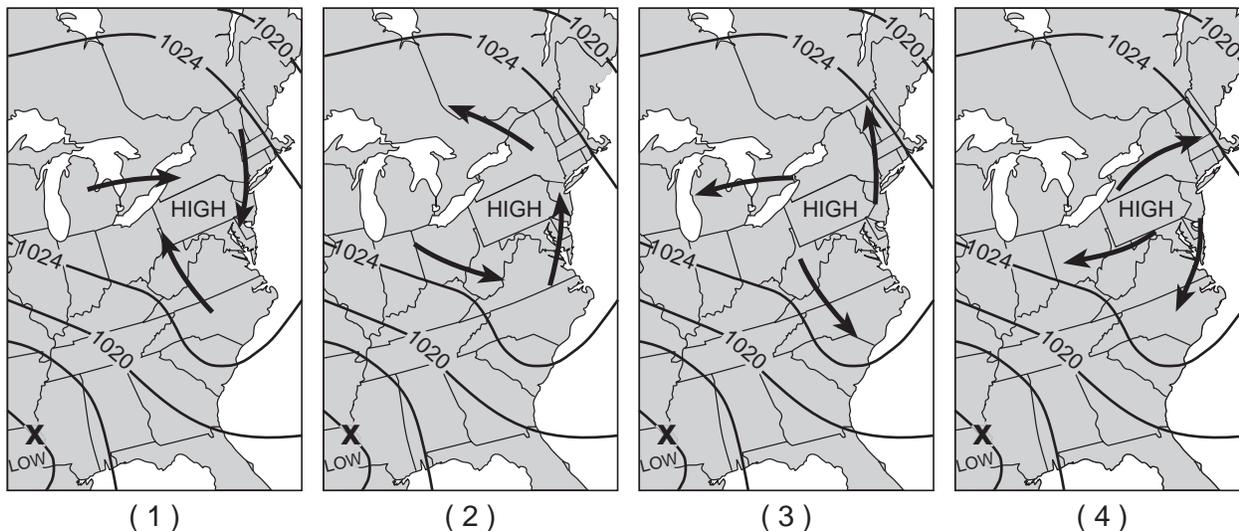
Base your answers to questions 36 through 40 on the weather maps below and on your knowledge of Earth science. The weather maps show the eastern United States on two consecutive days. Some isobars are labeled in millibars (mb). Letter X represents a location on Earth's surface on December 8, 2009.



36 What was the barometric pressure for location X on December 8?

- (1) 1016 mb
- (2) 1012 mb
- (3) 1008 mb
- (4) 1004 mb

37 Which map best shows the general surface wind pattern around the high-pressure system on December 8?



38 In which direction did the high-pressure center move from December 8, 2009, to December 9, 2009?

- (1) southwest
- (2) southeast
- (3) northwest
- (4) northeast

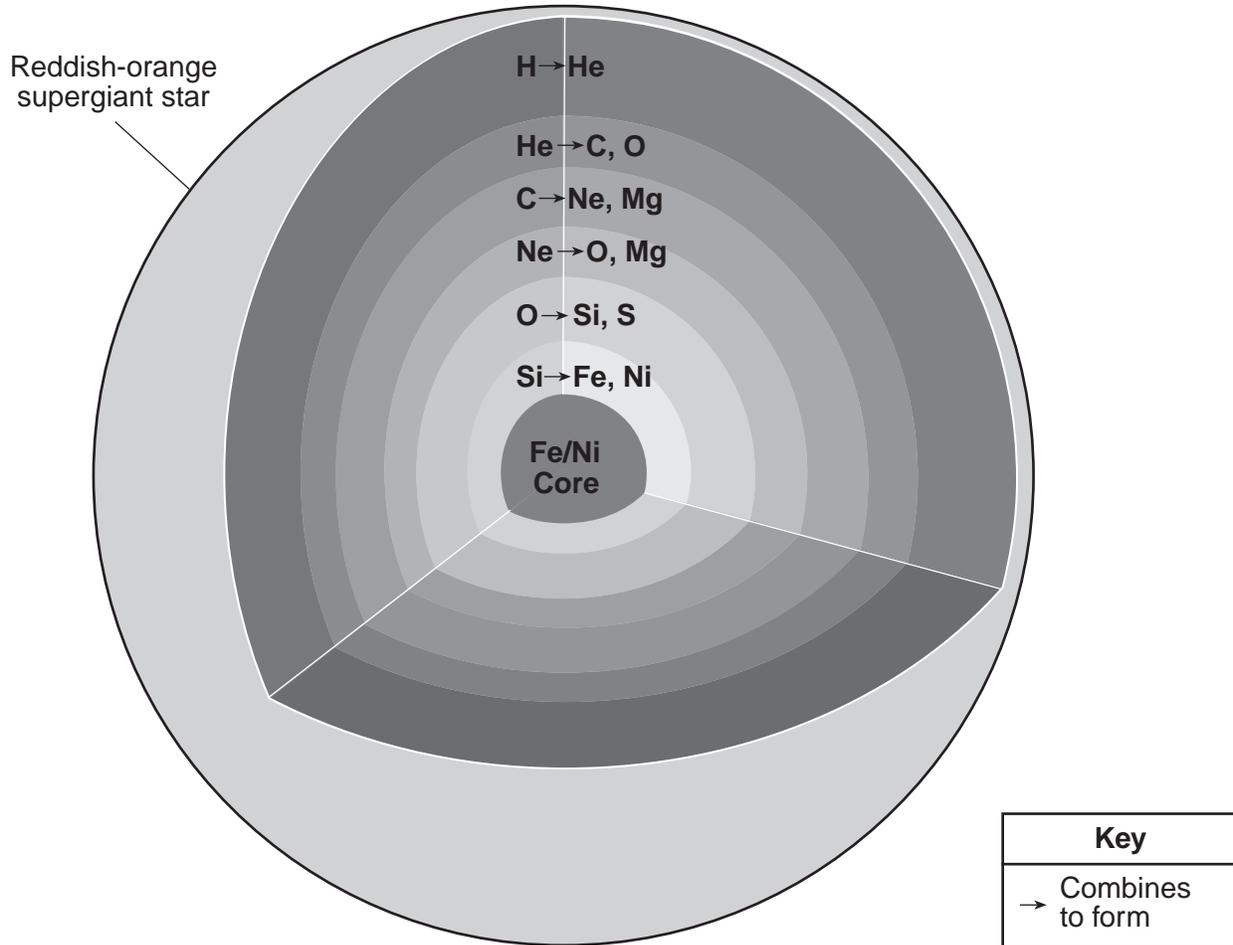
39 Which type of front was located just south of New York City on December 9?

- (1) cold
- (2) warm
- (3) stationary
- (4) occluded

40 Which information shown on the weather maps best indicates that wind speeds in New York State were greater on December 9 than on December 8?

- (1) The isobars were closer together on December 9.
- (2) The fronts were closer together on December 9.
- (3) The air pressure over New York State was lower on December 9.
- (4) The air pressure over New York State was higher on December 9.

Base your answers to questions 41 through 43 on the cross-sectional model below and the table on the following page, and on your knowledge of Earth science. The model shows a reddish-orange supergiant star. The layers in the model indicate where new chemical elements are forming from existing elements as temperature and pressure conditions increase with depth within the star. In each layer, atomic nuclei of the existing chemical element combine to form the new elements shown to the right of the arrow. The table shows the chemical symbols and names of selected elements in the star.



(Not drawn to scale)

### Elements in the Star

Chemical Symbol	Name
H	hydrogen
He	helium
C	carbon
O	oxygen
Ne	neon
Mg	magnesium
Si	silicon
S	sulfur
Fe	iron
Ni	nickel

- 41 Which process represented in the model is occurring in each layer of this star to produce the new chemical elements?
- (1) contact metamorphism  
(2) internal crystallization  
(3) nuclear fusion  
(4) radioactive decay
- 42 What is the approximate surface temperature of this star during this stage of development?
- (1) 3,200 K  
(2) 6,000 K  
(3) 10,500 K  
(4) 18,000 K
- 43 The luminosity of this star can best be described as
- (1) less than the luminosity of the Sun  
(2) greater than the luminosity of most stars in the main sequence  
(3) approximately the same luminosity as a white dwarf  
(4) approximately the same luminosity as *Aldebaran*
-

Base your answers to questions 44 through 47 on the reading passage below and on your knowledge of Earth science.

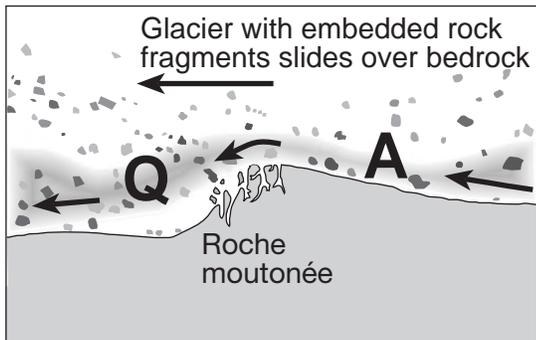
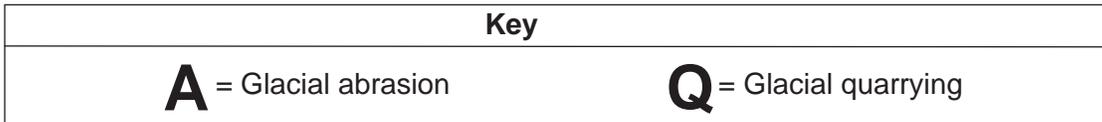
### Roche Moutonnée

A roche moutonnée is a glacial landscape feature produced as an advancing glacier slides over a hill of surface bedrock. As the glacier advances up the side of the hill, the surface bedrock is abraded and smoothed by rock fragments carried within the base of the glacial ice, creating a more gentle hillslope. As the glacier advances down the opposite side of the hill, chunks of bedrock are broken off and removed by the ice, a process called glacial quarrying (plucking), making this side of the hill steeper. The resulting hill resembles a drumlin, except it is often smaller and is composed of solid bedrock.

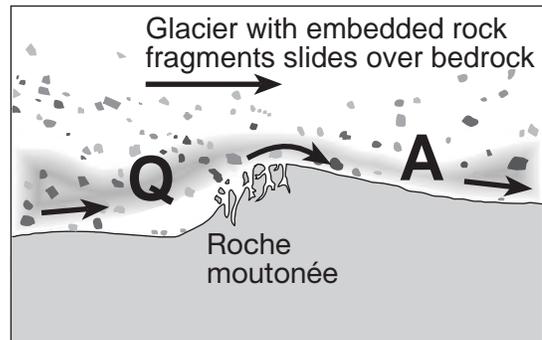
44 The formation of a roche moutonnée by glaciers is best described as an example of

- (1) chemical weathering
- (2) physical weathering
- (3) sediment deposition
- (4) mass movement

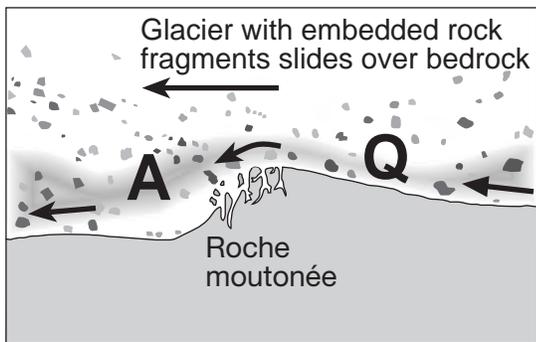
45 Which side-view model best shows the direction of ice movement and the locations of glacial abrasion and glacial quarrying that form a roche moutonnée?



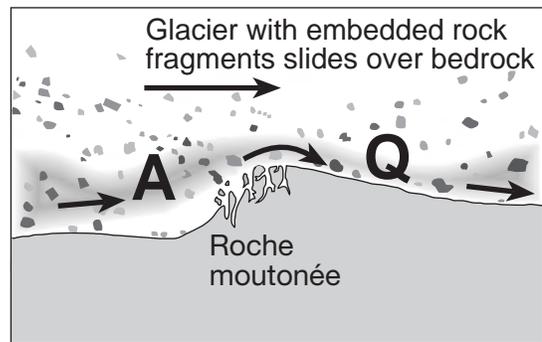
(1)



(3)



(2)



(4)

46 A drumlin differs from a roche moutonnée because a drumlin is

- (1) formed by glaciers
- (2) dome shaped

- (3) deposited by glacial meltwater
- (4) composed of loose sediments

47 The chunks of bedrock removed by glacial quarrying and transported by the glaciers most likely produce

- (1) terminal outwash plains
- (2) kettle lake depressions

- (3) V-shaped valleys
  - (4) parallel scratches in surface bedrock
- 

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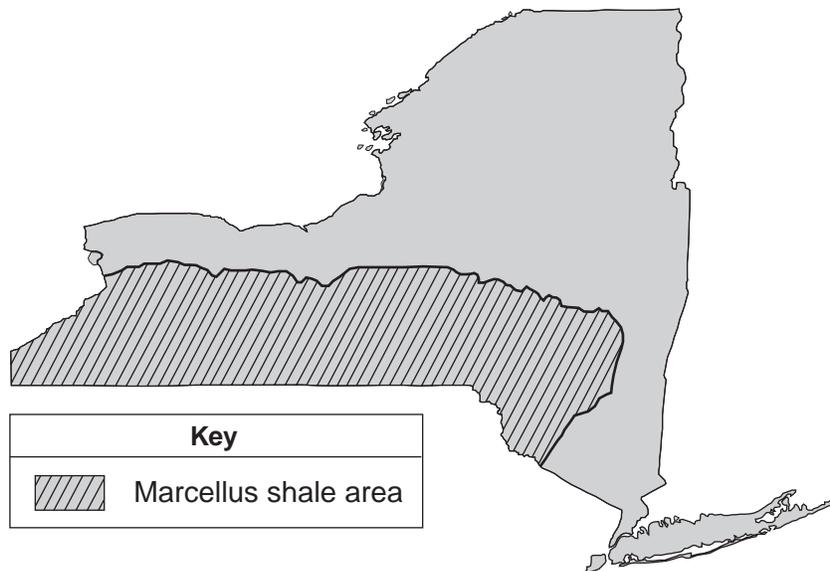
Base your answers to questions 48 through 50 on the passage and map below and on your knowledge of Earth science. The map shows the location of the Marcellus shale formation in New York State.

### The Marcellus Shale

The Marcellus shale is a black shale formation that was formed during the Middle Devonian Period. The shale extends from New York State as far south as Alabama. The Marcellus shale is exposed at the surface in the northern Finger Lakes region, and is buried 2.1 kilometers below the surface along the New York-Pennsylvania border.

Geologists estimate that the Marcellus shale contains hundreds of trillions of cubic feet of natural gas. Most of the Marcellus shale does not allow fluids (gases and liquids) to flow through the rock. In order to obtain the natural gas trapped in the rock, the shale is fractured. This hydraulic fracturing consists of drilling a well, then pumping in large amounts of water containing chemicals and sand under high pressure to create cracks in the gas-bearing rock. Although this process can allow the trapped gas to be removed from the shale, opponents of hydraulic fracturing argue that the chemicals used in the process may lead to groundwater contamination.

### Marcellus Shale Formation in New York State



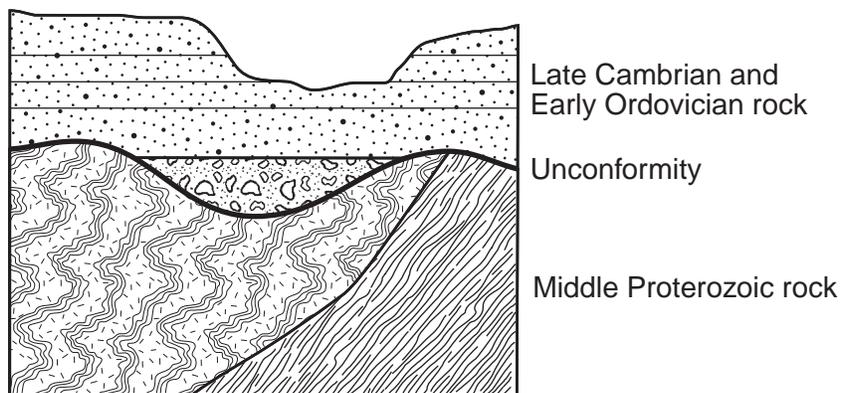
- 48 In New York State, the Marcellus shale is generally found in which type of landscape region?
- (1) plain (3) mountains  
(2) plateau (4) lowlands
- 49 The reading passage states, “Most of the Marcellus shale does not allow fluids (gases and liquids) to flow through the rock.” This statement suggests that the Marcellus shale is
- (1) clastic (3) porous  
(2) coarse grained (4) impermeable
- 50 Why might people living near Elmira, New York, be opposed to energy companies using the hydraulic fracturing process?
- (1) It could lower their energy costs.  
(2) The injected water could cause flooding in the area.  
(3) There is the potential for the pollution of groundwater.  
(4) There is an increased risk of volcanic activity.

**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 and 52 on the cross section below and on your knowledge of Earth science. The unconformity is located at the boundary between Middle Proterozoic rock and Late Cambrian and Early Ordovician rock.



51 Identify *one* geologic process that occurred in this region that produced the unconformity in this outcrop. [1]

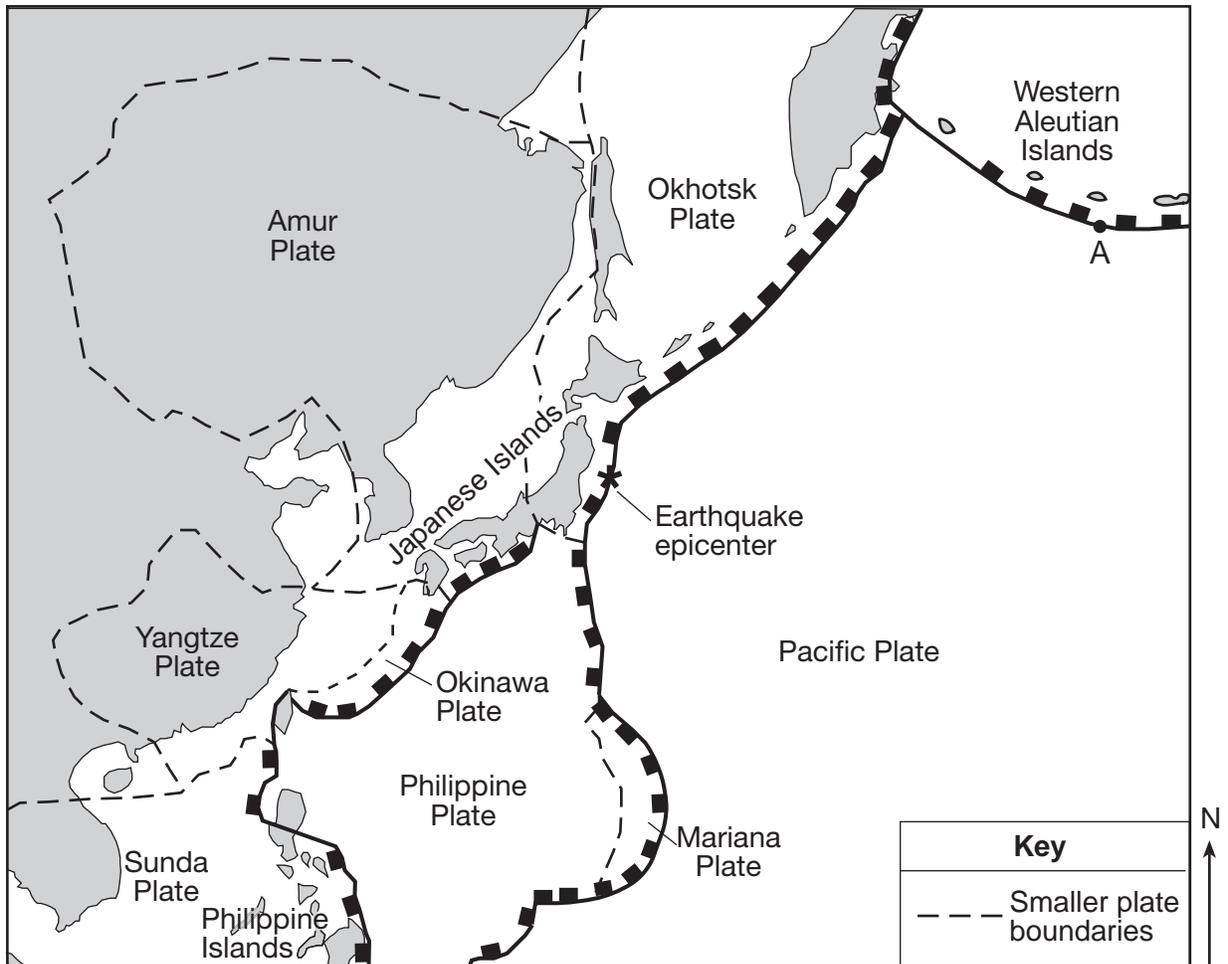
52 Identify by name the oldest New York State index fossil that could be found in the Early Ordovician bedrock. [1]

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Base your answers to questions 53 through 56 on the passage and the map below and on your knowledge of Earth science. The map indicates the epicenter (★) of a major earthquake that occurred at 38° N 142° E. This map also shows some smaller plates believed to be part of the major tectonic plates shown in the *Earth Science Reference Tables*. Letter A represents a location on a plate boundary.

### Devastating Tsunami

On March 11, 2011, one of the largest earthquakes ever recorded (magnitude 9.0) produced a 7-meter-high tsunami that devastated Japan's eastern coast. Thousands of people died and billions of dollars in damage occurred. Several hours after the earthquake, the tsunami reached the Hawaiian Islands and parts of North America's west coast.



- 53 Identify by name the *two* tectonic plates labeled on the map above that are located directly on each side of the earthquake epicenter. [1]
- 54 On the cross section of the tectonic plate boundary *in your answer booklet*, draw *one* arrow in *each* circle to indicate the general direction of plate motion near the earthquake epicenter. [1]
- 55 Describe *one* immediate action that was most likely taken in the Hawaiian Islands to prevent the loss of life as the tsunami approached. [1]
- 56 Identify *one* geologic feature that was most likely produced by plate interaction at point A. [1]

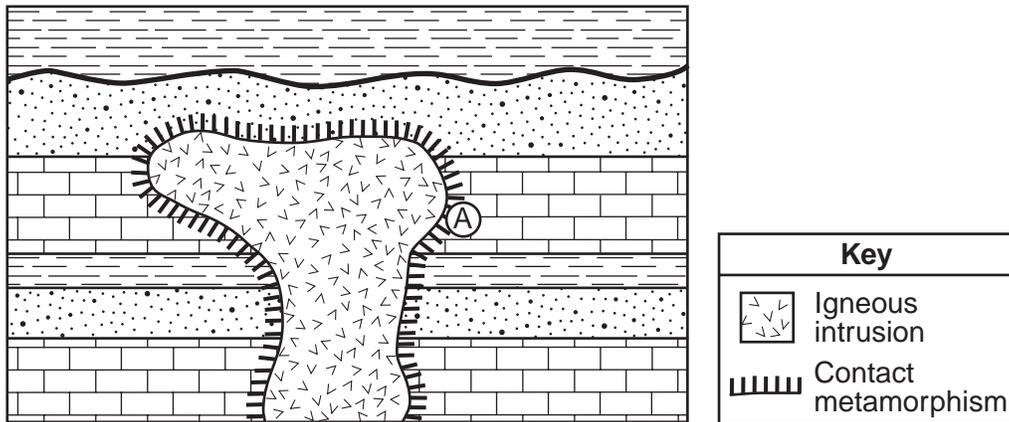
Base your answers to questions 57 through 61 on the data table below and on your knowledge of Earth science. The table shows the distances from Earth to the Moon for certain days during December 2010. The percent of the Moon illuminated by the Sun as seen from Earth is also given.

**Moon Data December 2010**

<b>Date December 2010</b>	<b>Approximate Earth–Moon Distance (<math>\times 10^3</math> km)</b>	<b>Illuminated Moon Seen from Earth (%)</b>
2	371	12.3
4	375	1.5
6	383	1.2
8	393	10.2
10	401	25.5
12	404	44.0
14	403	63.3
16	396	81.0
18	386	94.3
20	377	100.0
22	373	99.0
24	368	80.4
26	369	70.1
28	371	47.0
30	375	24.8

- 57 On the grid in *your answer booklet*, the Earth–Moon distance data from December 2 to December 12 have already been plotted. Complete the line graph by plotting the Earth–Moon distances from December 14 to December 30. Continue the line from December 12 through *all nine* of your plotted points. [1]
- 58 Explain how the Earth–Moon distance data support the inference that the Moon’s orbit is an ellipse. [1]
- 59 On which date shown in the data table was the gravitational attraction between the Moon and Earth the greatest? [1]
- 60 Identify *one* date during December 2010 when the Moon was at its mean distance from Earth as indicated on the *Earth Science Reference Tables*. [1]
- 61 A lunar eclipse occurred during December 2010. On which date did this eclipse most likely occur? [1]
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Base your answers to questions 62 and 63 on the geologic cross section shown below and on your knowledge of Earth science.



62 State the name of the metamorphic rock at location A. [1]

63 Identify *one* characteristic that could be used to determine if the intrusive igneous rock has a mafic composition or a felsic composition. [1]

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Base your answers to questions 64 and 65 on the diagram in your answer booklet and on your knowledge of Earth science. The diagram represents a beaker of water being heated. The curved lines around letters A and B represent convection cells that have developed in the water.

64 On the diagram *in your answer booklet*, draw *six* arrowheads, one on *each* of the curved lines of the convection cells, to indicate the direction of water movement around letters A and B. [1]

65 State the amount of heat energy gained by each gram of water that evaporates from the surface of the boiling water in the beaker. [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 data table below, which shows the length of a shadow, in centimeters, made by an object at different times during the day in New York State.

**Shadow Lengths**

<b>Time</b>	<b>Length of Shadow (cm)</b>
9:00 a.m.	185
10:00 a.m.	129
11:00 a.m.	100
12:00 noon	89
1:00 p.m.	101
2:00 p.m.	124

66 Predict the length of the object's shadow at 2:30 p.m. [1]

67 Explain what causes the length of the shadow to change during the day. [1]

68 Toward which compass direction from the object does the shadow point at solar noon? [1]

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Base your answers to questions 69 through 71 on the snowfall map of the Tug Hill Plateau region of New York State in your answer booklet and on your knowledge of Earth science. A lake-effect snowstorm occurred on November 16–19, 2008. Snow depths are indicated in inches at several points and by two labeled isolines. Dashed line *AB* is a reference line on the map between two recorded snow depths.

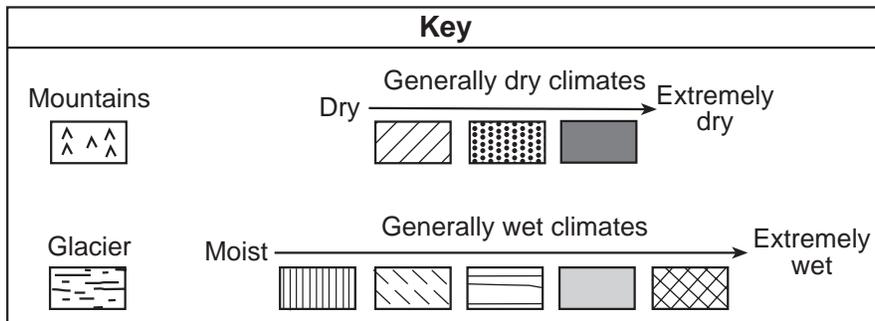
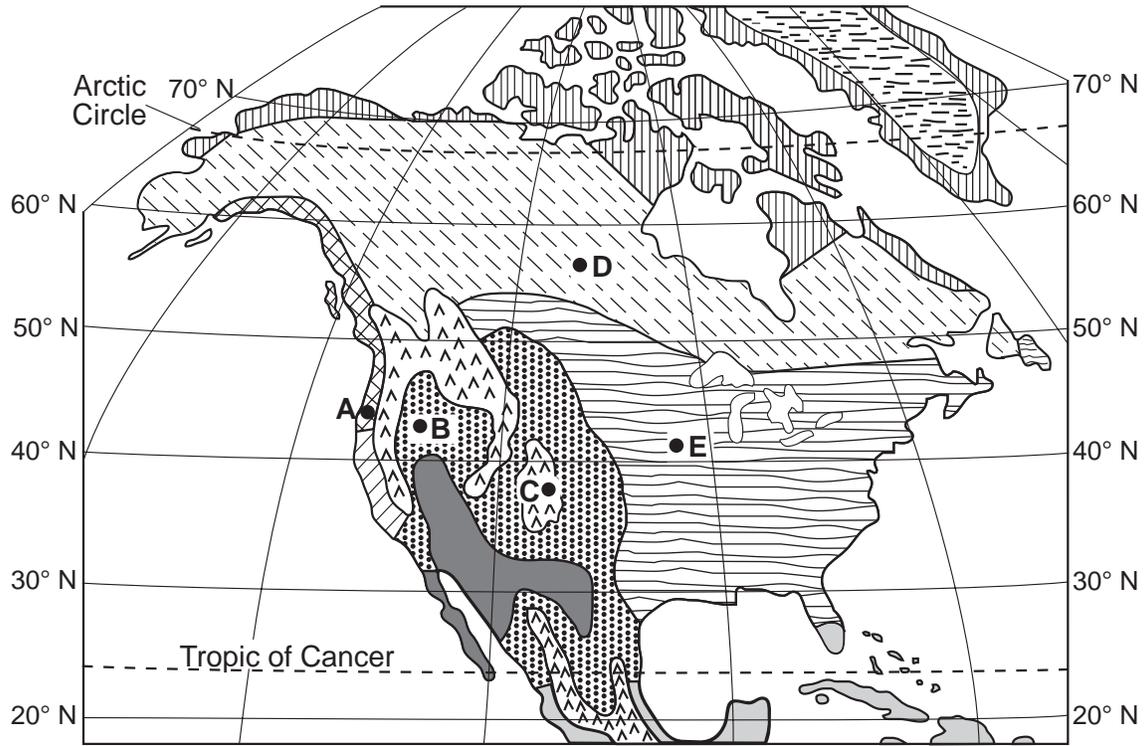
69 On the map *in your answer booklet*, draw the 9-inch and 12-inch snow depth isolines. [1]

70 Calculate the snow depth gradient between point *A* and point *B*, in inches per mile. [1]

71 This storm occurred while Lake Ontario was *not* frozen. Explain why snowfall amounts would have been *less* if the lake had had significant ice cover. [1]

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Base your answers to questions 72 through 74 on the generalized climatic moisture map of North America below and on your knowledge of Earth science. Areas are classified as generally dry or generally wet, and then ranked by relative moisture conditions. Glacial and mountain climate areas are also shown on the map. Points A, B, C, D, and E indicate locations on Earth's surface.



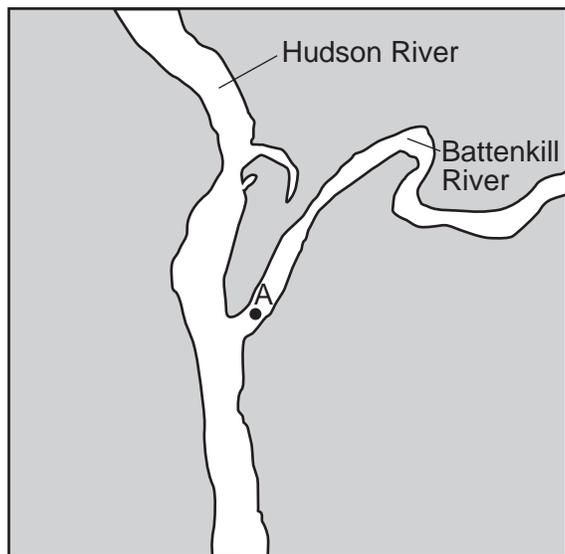
72 Explain why the climate at location A is more moist than the climate at location B. [1]

73 State the climate factor that causes a cold climate at location C. [1]

74 Explain why location D has a cooler climate than location E. [1]

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Base your answers to questions 75 through 79 on the map and table below and on your knowledge of Earth science. The map shows the area where the Battenkill River flows into the Hudson River north of Albany, New York. Point A indicates a location within the Battenkill River. The table shows the densities of four common minerals found in Hudson River sediments.

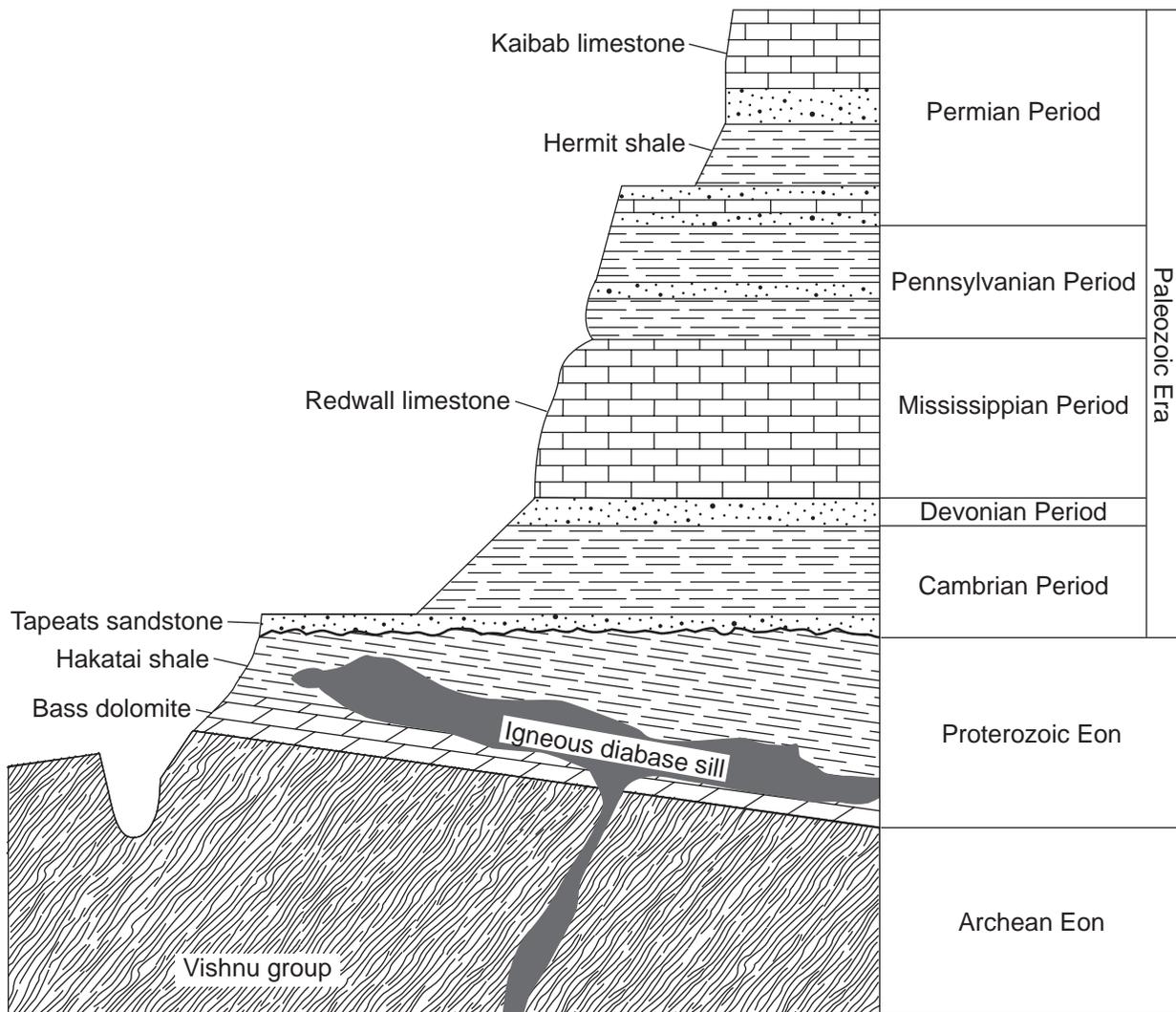


Mineral Density	
Mineral Name	Density (g/cm <sup>3</sup> )
amphibole	3.3
feldspar	2.6
garnet	4.2
quartz	2.7

- 75 Identify the diameter of the largest particle that would be carried at point A when the velocity of the Battenkill River is 50 cm/s. [1]
- 76 Describe the most likely changes in the size and shape of individual particles of sediment as they are transported downstream by the Battenkill and Hudson Rivers. [1]
- 77 Describe the arrangement of the sediments being deposited by these rivers. [1]
- 78 Some of the sediments transported by the Hudson River came from metamorphic rock. Identify *one* foliated metamorphic rock that contains all four minerals listed in the mineral density table. [1]
- 79 Samples of minerals listed in the mineral density table with the same shape and size were removed from the Hudson River and placed in a jar of water. After the jar was shaken, the sediments were allowed to settle. *In your answer booklet*, write the mineral name from the table next to the layer in the diagram where *each* mineral is most likely found. [1]

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Base your answers to questions 80 through 82 on the generalized cross section of the Grand Canyon represented below and on your knowledge of Earth science. Some rock layers have been labeled. The rock layers have *not* been overturned.



80 The Vishnu group is composed mostly of schist. Explain how this rock formed. [1]

81 State the approximate age of the Redwall limestone, in million years. [1]

82 Describe how the calcite that composes the Redwall limestone can be distinguished from the quartz that composes the Tapeats sandstone. [1]

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Base your answers to questions 83 through 85 on the table below and on your knowledge of Earth science. The table shows the elements and their percent compositions by mass in the five minerals present in a rock sample.

**Elements and Their Compositions by Mass in Five Minerals**

Minerals Present in Rock Sample	Element (percent by mass)									
	Al	Ca	Fe	H	K	Mg	Na	O	Si	Ti
Amphibole	6.2	3.0	29.7	0.2	–	3.7	1.8	31.7	12.8	10.9
Plagioclase feldspar	9.7	–	–	–	14.2	–	–	46.3	29.8	–
Garnet	10.9	–	33.8	–	–	–	–	38.7	16.6	–
Muscovite mica	20.3	–	–	0.5	9.8	–	–	48.2	21.2	–
Quartz	–	–	–	–	–	–	–	53.2	46.8	–

83 Identify *one* use for the mineral garnet. [1]

84 Identify *one* mineral in this rock sample that can scratch the mineral olivine. [1]

85 All five of the minerals listed in the table are silicate minerals because they contain the elements silicon and oxygen. State the name of *one* other mineral found on the “Properties of Common Minerals” chart that is a silicate mineral. [1]

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